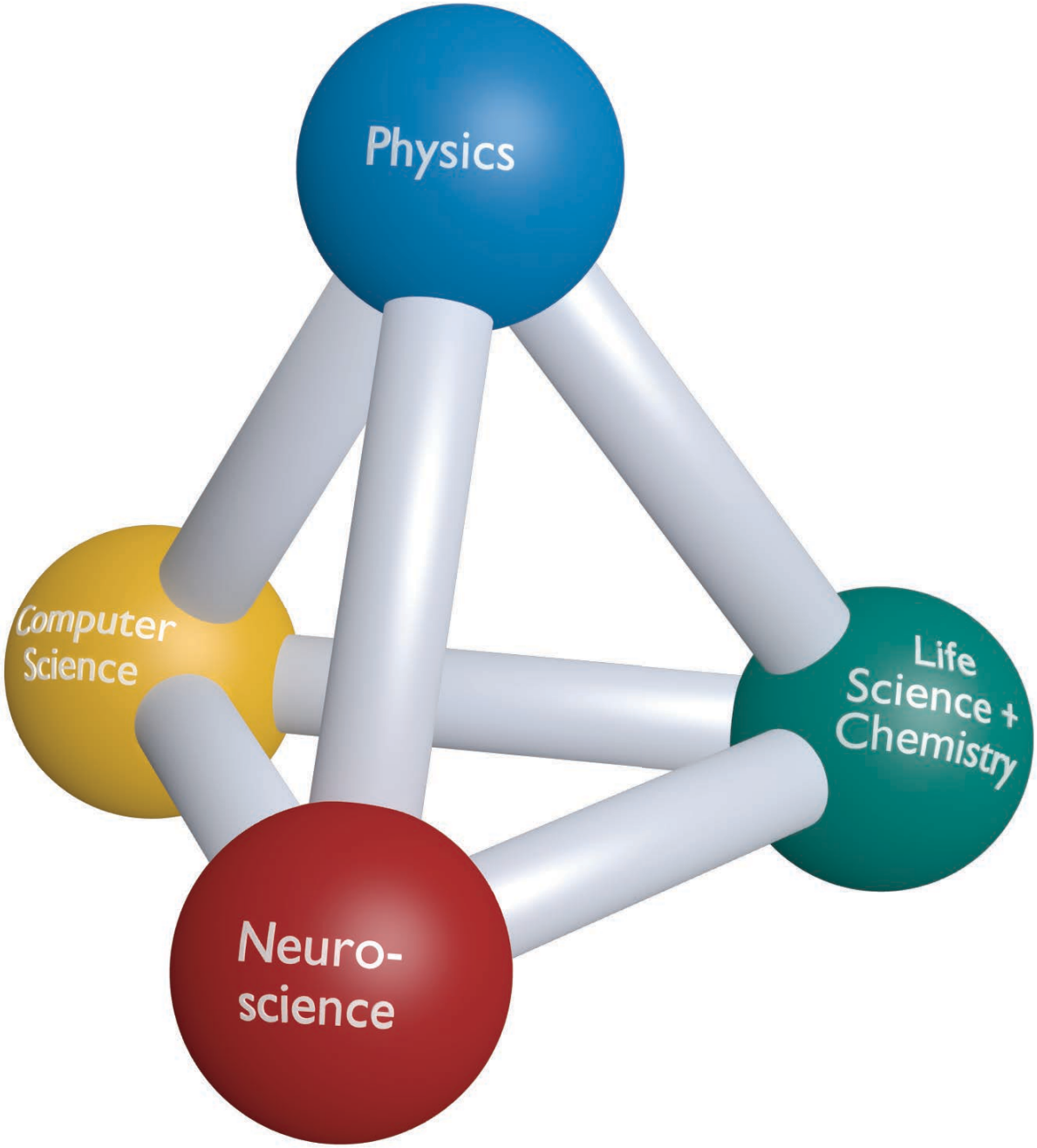
FIAS Frankfurt Institute for Advanced Studies



FIAS Scientific Report 2013

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FIAS Scientific Report 2013

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Preface

In the past year FIAS has followed a path of continuity, combining its pursuit of leading-edge research in the natural sciences with the education of doctoral students from many countries, and with an active and inspiring academic life. As customary, this report will document these activities. It accounts for the activities of partner institutions, for doctoral training within the framework of the Frankfurt International Graduate School of Science (FIGSS), for the organized colloquia and conferences, and for the lecturing and publication activities of the FIAS scientists. The bulk of the report consists of a collection of one-page descriptions of individual research projects which give an overview – although not exhaustive – of the current research activities pursued at FIAS.

As in previous years, in 2013 FIAS has organized a considerable number of scientific meetings. In addition to a number of smaller specialized workshops and an Ernst Strüngmann Forum on child development, international conferences on topics ranging from various aspects of nuclear physics to general relativity and atomic cluster collisions were organized in Germany, Switzerland, Turkey, and China.

FIAS feels a responsibility to reach out to the general public and to foster the interest in current scientific research also among non-scientists. In addition to the by now well established public lecture series of the "FIAS Forum", in 2013 we had the opportunity to host the lecture series "Science and Society" financed by Deutsche Bank AG. In collaboration with its partner institute "Helmholtz International Center for FAIR" FIAS in the winter semester 2013/14 arranged a series of evening lectures under the heading "From the Big Bang into the laboratory – Matter under extreme conditions". Six senior scientists delivered talks on topical research in astrophysics, nuclear physics, and particles physics. These lectures were highly successful, drawing audiences of up to 1000 visitors.

A number of organizational matters should be mentioned here. In keeping with the recommendations of major science organizations, FIAS in 2013 has adopted a set of "Rules of good scientific practice" to ensure that the standards of proper scientific conduct are abided at the institute. For the resolution of conflicts an ombudsman has been appointed, Senior Fellow Prof. Karlheinz Langanke (Darmstadt), and an Ethics Committee has been established.

The last year saw the long-awaited relaunch of the FIAS website. With this new design, which is still evolving, FIAS presents a fresh modern face to the outside world.

As in the previous years, in 2013 a number of scientists have joined or left FIAS or have changed their status. Prof. Dirk Rischke has left FIAS and no longer is Senior Fellow and member of the Board of Directors. Former Research Fellow Elena Bratkovskaya has been promoted to Fellow status after having been appointed APL professor at the Physics Department of Goethe University. Hannah Petersen, leader of a Helmholtz Young Investigator Group and recently appointed FIAS Fellow, has received a W2 professorship.

Dr. Hermann Cuntz, recipient of the 2013 Bernstein prize for Computational Neuroscience, is going to build up a research group located jointly at the Ernst Strüngmann Institute (ESI) and at FIAS.

The terms of many of the Adjunct Fellows of FIAS have been renewed in the year 2013. Two new Adjunct Fellows have been named: Prof. Constantin Rothkopf (TU Darmstadt) and Prof. Luciano Rezzolla, newly appointed professor of Theoretical Astrophysics at Goethe University who came from the Max-Planck-Institute for Gravitational Physics, Potsdam, and in 2013 was awarded with one of the prestigious Synergy Grants of the European Research Ccouncil.

There has been a turnover in the composition of the Scientific Advisory Board since the mandates of several of its members had expired. Newly appointed members are Prof. Andreas Herz (LMU Munich), Prof. Thomas Lippert (Jülich Research Center) and from Goethe University Profs. Irene Burghardt, Anna Starzinski-Powitz, and Roser Valentí. The Scientific Advisory Board convened on Nov. 25-26, 2013 under the chairmanship of Prof. Wolfgang Bauer to evaluate and counsel the institute.

FIAS is proud to report on the academic careers of its former members. In 2013 quite a number of alumni

have been appointed to professorships worldwide. Former Research Fellow Jörg Lücke has been appointed to a W2 professorship in Machine Learning at the Department for Medical Physics and Acoustics at Carl von Ossietzky University Oldenburg. Similarly, Constantin Rothkopf has joined the Department of Psychology at the Technical University of Darmstadt as a W2 professor. Former PhD student Veronica Dexheimer was appointed assistant professor at Kent State University, Ohio, USA after having served as visiting professor at Gettysburg College, Pennsylvania. Former PhD student and postdoc Ilia Solov'yov has been appointed assistant Professor at the University of Southern Denmark in Odense, Denmark, where he heads a research group on Quantum Biology and Nanophysics. Former postdoc Catalin Rusu has returned to his home contry Romania and obtained an assistant professorship at the Computer Science Department of Babes-Bolyai University in Cluj-Napoca, one of the country's leading universities.

FIAS is proud of its recent achievements but it also needs to face challenges in the upcoming years. The lack of a significant endowment implies the constant need for procuring new funds to finance the activities of the institute. This is particularly true at present since in the not-too-far future a number of current research projects will reach the end of their funding.

As reported before, it is planned to establish a new professorship at FIAS, made possible by the donation of Dr. Helmut Maucher. The efforts now seem to come to fruition and it is expected that in the near future it will be possible to appoint a junior professor in the field of "Systemic risk in financial and economical systems". This will be one of several initiatives to further broaden the diversity of research and the interdisciplinary spirit at FIAS.

Research highlights 2013

Physics

The group of Elena Bratkovskaya has studied the *non-equilibrium dynamics of heavy-ion collisions* from SIS to LHC energies within the Parton-Hadron-String Dynamics (PHSD) transport approach, which incorporates explicit partonic degrees of freedom in terms of strongly interacting quasiparticles (quarks and gluons) as well as the dynamical hadronization and hadronic collision dynamics in the final reaction phase. It was found that electromagnetic probes (such as dileptons and direct photons) can be used as a sensitive "thermometer" of the reaction: the photons produced in the QGP provide information about the QGP 'effective' temperature. The photon v_2 puzzle (the photons show experimentally almost the same elliptic flow as hadrons) can be understood after accounting for all background sources. The goup also has investigated the *equilibrium properties of strongly-interacting infinite parton-hadron matter*: the equilibration of different observables for light and strange partons and their fluctuations as well as transport coefficients (shear and bulk viscosity, electric and heat conductivity). The PNJL model and PHSD show acceptable results for the high temperature phase, too, and thus can be used for the evaluation of the QGP properties.

The group of Ch. Sasaki and I. Mishustin investigated the *thermal properties of strongly interacting gluonic matter*. The main features of SU(3) Yang-Mills thermodynamics have been reproduced within an effective model, implementing two major symmetries, the center symmetries and scale invariance, and their dynamical breaking. This naturally allows a mixing between the Polyakov loop and the dilaton field. The obtained behavior of the interaction measure with temperature qualitatively agrees with the latest data from lattice QCD. The conclusion is made that the condensation of magnetic gluon could be an alternative to the Hard Thermal Loop (resummed perturbation theory) contribution.

In the field of relativistic astrophysics the group of S. Schramm investigated the *effect of extreme magnetic fields on the structure of neutron stars*. It was possible to show that there are only moderate increases in star masses even for maximally possible magnetic field strengths but that there occurs a significant ellipsoid deformation of the star. These results are in stark contrast to a number of publications claiming a large increase of star masses due to field effects, Furthermore, a code package was developed to simulate dynamically *the crust in neutron stars*. A better understanding of the crust and its transport properties is crucial for modeling stellar cooling and interpreting observations of stellar temperatures. The code allows for a significant increase of simulated system sizes, which owes its speed-up of more than a factor of 100 to the porting of crucial sections of the program to graphical processors.

The group of P. Nicolini has investigated a new physical effect extending the standard model of elementary particle physics. "Un-particles" have been conjectured by Georgi as an additional sector of the standard model, exhibiting a continuous particle number and properties of fractal self-similarity. Un-particles are supposed to show up at a yet unspecified scale, exceeding the current probed scales in particle detectors. Contrarily to previous proposals, the Nicolini group showed that the *un-Casimir effect* opens the possibility of setting the value of the un-particle scale without ambiguities. In particular, the calculation offers, for the first time, results that are independent on the effective coupling constant describing the interaction between the un-particle sector and ordinary matter.

In the field of nuclear structure physics D.N. Poenaru and W. Greiner investigated the *decay modes of superheavy nuclei*. While in the region $Z = 104 \ldots 118$ either alpha emission of spontanous fission is the dominant decay mode, for heavier nuclei ($Z = 118 \ldots 124$ it is possible that cluster radioactivity has the shortest half life. This result is important for future experiments aiming to produce new superheavy elements.

Neuroscience

The groups of C. Rothkopf and J. Triesch, together with their collaborator B.E. Shi from Hong Kong University of Science and Technology have formulated a new learning framework for the efficient encoding of sensory information during active perception. It explains how sensory representations and movements of

the sense organs can develop jointly to maximize the efficiency of information processing. This framework offers an explanation for the development of active binocular vision in the primate brain and it allows robots to autonomously learn how to, e.g., follow objects with their eyes and become better and better at it.

The group of J. Triesch has studied the self-organization of neural circuits through the interaction of different forms of neuronal plasticity. The model developed allows to explain recent findings on the statistics and fluctuations of synaptic connection strengths. It was shown how the distribution of synaptic strengths and their pattern of fluctuations can be explained by self-organization in a recurrent spiking network model combining spike-timing-dependent plasticity (STDP), synaptic scaling, structural plasticity, and intrinsic plasticity. In this network, STDP induces a rich-get-richer mechanism for excitatory synapses, while synaptic scaling induces competition between them.

In collaboration with the Max Planck Institute for Brain research D. Nikolić, W. Singer and collaborators made new discoveries on how populations in primary visual cortex encode visual stimuli through their coordinated activity. They employed a linear decoding technique to reconstruct visual stimuli from ensemble responses in area 17 of anesthetized cat and awake monkey. Then they evaluated the amount of stimulus information contained in neuronal responses while making minimal assumptions about how neurons encode particular stimulus features. Alphabet letters and abstract shapes could be accurately reconstructed using short integration intervals (50 ms) of evoked activity. The decoders were able to generalize across stimuli and could reconstruct images omitted from the training set. These results suggest that in addition to the well studied parametric features of single cells in primary visual cortex, the response of populations may encode stimuli in a more distributed, complex fashion.

Life Science and Chemistry

In the year 2013 the long-running resarch on *heavy-ion tumor therapy* has been continued. The Monte Carlo model for Heavy-Ion Therapy (MCHIT), created in FIAS (I. Mishustin, I. Pshenichnov, L. Burigo, M. Bleicher), has been applied for simulation of microdosimetry spectra measured with neutron, proton, and nuclear beams. Recently MCHIT was coupled with the Microdosimetric Kinetic (MK) model for estimation of relative biological effectiveness (RBE) of therapeutic ion beams. As demonstrated by MCHIT+MK calculations, helium and lithium nuclei present similar biological dose profiles as carbon nuclei, but lead to lower doses in the tail region. This makes helium and lithium beams to be promising options for ion-beam cancer therapy.

The Meso-Bio-Nano-Science (MBN) group at FIAS (A. Solov'yov) has studied the formation and dynamics of animate and inanimate matter for a wide range of systems. In 2013 the MBN group has made progress in a variety of fields. In the study of *nanoscale phase transitions* Molecular Dynamics simulations were performed for the melting and solidification processes of large Nickel clusters. Previous studies of the *folding-unfolding transition* of biological macromolecules have been continued and applied to the enzyme staphylococcal nuclease. A semiempirical model has been developed for calculating the *electron emission from biological targets* after ion impact. Various projects have studied *clustering, self-organization and structure formation* in MBN systems including, e.g., morphological transitions of dendritic silver clusters or the behaviour of nanostructured biocompatible materials. As in previous years, the MBN group also has contributed to the research on ion-beam cancer therapy, further developing its multiscale approach to the assessment of biodamage resulting upon irradiation of biological media with ions. In particular, a model for the energy deposition by proton beams in subcellular compartments was developed.

Computer Science

I. Kisel and collaborators have continued their successful work to develop efficient algorithms for track finding and event reconstruction in heavy ion collision experiments. A fast and Cellular Automaton (CA) track finder has been developed which is intended to be used both for the online and offline track reconstruction in the CBM experiment at FAIR. Paralellisation leads to massive speed up factors. Similarly, a CA track finder was developed for STT and barrel MVD detectors of the PANDA experiment which has to deal with up to $2 \cdot 10^7$ antiproton-proton or antiproton-nucleus collisions per second.

1. Partner Research Centers

HIC for FAIR
Helmholtz International Center

HIC for FAIR in 2013

by Marcus Bleicher, Gabriela Meyer, Peter Kreutz

In the past year HIC for FAIR has built up a leading role in research and development related to the international research center FAIR at Darmstadt by focusing and strengthening the expertise of the participating Hessian institutions. Together with its local partners, it provided a guiding light not just regionally but worldwide.

HIC for FAIR developed new concepts and methods for the construction, operation and scientific exploitation of FAIR, covering all research areas of FAIR:

- A research program on nucleus-nucleus collisions investigates highly compressed nuclear matter as it exists in neutron stars and in the core of supernova explosions. In the laboratory, super-dense nuclear matter can be created in the reaction volume of relativistic heavy-ion collisions and used to explore the QCD phase diagram.
- Antiproton beams will probe aspects of the strong force not investigated before.
- Beams of unstable nuclei will be used for precision studies of the nuclear structure and the origin of the elements in the Universe.
- Heavy ion beams will be employed for studying high-energy radiation effects on biological systems and materials.
- Powerful beam pulses will create of volumes of dense plasma with energy densities similar to those found in stars and giant planets.
- The demanding experiments to be carried out at FAIR require technological innovation like new superconducting magnet designs to steer highest possible intensities of particles or novel methods of accurately controlling the beam energies.
- The extremely high data rate will require new hard- and software solutions and technologies for processing, accessing and storing the results.

Expertise and funding was provided for the development of these experiments, the required equipment, theoretical investigations and large-scale computing via LOEWE - CSC (Center for Scientific Computing).

HIC for FAIR provided high-level training of outstanding junior scientists and promoted their careers in a unique interdisciplinary environment among world experts in experimental and theoretical physics, applied physics and computer science. HIC for FAIR facilitated a comprehensive, well-known and established forum for the international scientific community. This is underlined by the highly visible guest scientist program and a post-doctoral program with researchers from more than 40 nations. An extensive conference program has been continued with major international conferences, workshops and schools organized by HIC for FAIR scientists. During 2013 HIC for FAIR members publish 40 papers and 20 conferences and workshops were (co-)organized by FIAS members.

Between November 2013 and February 2014 HIC for FAIR@FIAS organized the public Lecture Series “Vom Urknall ins Labor” with funding provided by the Deutsche Bank. Nearly 2000 people came to FIAS to listen to the lectures.

ExtreMe Matter Institute EMMI

by Carlo Ewerz

The Extreme Matter Institute EMMI was founded in 2008 in the framework of the Helmholtz Alliance 'Cosmic Matter in the Laboratory' and is funded by the Helmholtz Association. The institute, which is managed by the GSI Helmholtz Center for Heavy Ion Research in Darmstadt, is dedicated to research in the area of matter at the extremes of density and temperature, ranging from the coldest to the hottest and densest forms of matter in the Universe. This comprises in particular the four key areas a) quark-gluon plasma and the phase structure of strongly interacting matter, b) neutron matter, c) electromagnetic plasmas of high energy density, d) cold quantum gases and extreme states in atomic physics. This research is done with a special emphasis on interdisciplinary aspects and common underlying concepts connecting the different research areas.

EMMI research is carried out in close collaboration with its 13 national and international partner institutions; the German partners are the universities of Darmstadt, Frankfurt, Heidelberg and Münster, the Forschungszentrum Jülich, the Max-Planck-Institut for Nuclear Physics in Heidelberg, and FIAS. To the latter EMMI has particularly close ties. The Scientific Director of EMMI, Prof. Peter Braun-Munzinger, is also a Senior Fellow of FIAS. The four EMMI Fellows (leaders of EMMI Fellow Groups) are also Fellows at FIAS.

In 2013, more than 400 scientist contributed to the activities in EMMI, among them more than 150 doctoral students and more than 100 postdocs. The structured graduate education of doctoral students within EMMI is organized in close collaboration with the surrounding graduate schools, among them the Helmholtz Graduate School for Hadron and Ion Research (HGS-HIRe), the Heidelberg Graduate School of Fundamental Physics (HGSFP), and the Helmholtz Research School Quark Matter Studies (H-QM).
EMMI members have published more than 300 papers in refereed journals, and more than 100 contributions to conference proceedings during 2013. EMMI runs an active workshop program. 5 EMMI workshops with strong international participation were organized in 2013. In addition, 18 'EMMI Seminars' were organized in 2013 in which external experts and guest scientists present their work on subjects related to EMMI. These seminars, mostly taking place in Darmstadt, form a nucleus for frequently attracting EMMI members from the nearby partner institutions. 8 renowned experts have visited EMMI partner institutions for extended periods in 2013 as EMMI Visiting Professors, and have made progress in their collaborations with EMMI members. These and further EMMI activities are listed at www.gsi.de/emmi.

In 2013, EMMI organized 3 EMMI Rapid Reaction Task Force Meetings. The EMMI Rapid Reaction Task Force meetings are a new instrument which allows EMMI to bring together a group of about 15 to 20 world-leading experts in order to address a focussed scientific problem in intense discussions. These meetings can be organized on a very short timescale. This allows EMMI to react flexibly and quickly to new and emerging developments in the EMMI research areas. Usually, the results of EMMI Rapid Reaction Task Forces are published in a summary paper.

EMMI organized or supported several outreach events in 2013. Among them was a masterclass event for highschool students organized by EMMI. There the students analyzed actual data from the ALICE experiment at the Large Hadron Collider at CERN.

Bernstein Focus Neurotechnology Frankfurt

by Visvanathan Ramesh and the BFNT PI team

The Bernstein Focus Neurotechnology (BFNT) Frankfurt project is aimed at bringing together an interdisciplinary team to design and implement a cognitive vision framework that demonstrates autonomous learning and multiple cue fusion in the context of specific applications such as security, surveillance and robotics. The essence of our platform builds upon the systems engineering viewpoint on computer vision system design; i.e. visual cognition involves context-dependent hypotheses generation followed by detailed estimation via deliberation or iteration. This view is analogous to the dual-system model articulated in the psychology literature (i.e. Brain processes can be divided into two systems: system 1 – subconscious processes of the brain that use fast heuristics to generate hypotheses, and system 2 – processes that deliberate on system 1's output, and uses declarative facts and rules to come to conclusions). The systems engineering design framework thus maps formal models of application contexts, sensor types and configurations, task descriptions and performance specifications to dual-system architectures and respective modules. These dual system architectures have parallels to brain-inspired dynamical systems architectural views advocated at FIAS by Prof. Christoph von der Malsburg.

Further findings during the last year indicate that the architectural views for visual cognition motivated from a dynamic systems perspective align very well with the designs motivated from systems engineering perspective. This alignment in perspective, along with the fact that we have validation from industrial practice about our design methodology, allows us to focus on key open challenges in increasing the degree of automation in construction of intelligent vision systems. Our current work is still far away from a biologically plausible implementation and can be viewed as a technical system developed via influence from biology. A key long-term research issue is to identify how a brain-like architecture with homogeneous components along with specific learning mechanisms can lead to a range of intelligent functions and behaviors. In collaboration with the Goethe University where the systems engineering effort is undertaken, core advances have been made in the cognitive systems development platform, cognitive architecture, models and scientific components for physics based modeling, machine learning, and their incorporation into a prototype for video surveillance, automotive and robotics settings.

Our research in scientific components involves autonomous learning, self-organization, cue-integration fusion and simulation for learning and cognition. Some of the highlights of this year's scientific efforts at FIAS include the following:

a) A comprehensive *review of spatial interactions of feature detectors in the visual cortex*. It highlights differences across species and hypothesizes how these could affect visual perception. The insights are being applied to design and evaluation of object recognition modules.

b) A novel *algorithm for global scene classification* was designed by incorporating local image statistics imposed by the imaging device. Our results show significant improvements over the state of the art computer vision algorithms.

c) Our *research in sparse coding with nonlinear models* that addressed visual occlusions was published in PLOS Computational Biology this year.

We have published several peer-reviewed papers at international conferences and journals and we had several posters in Bernstein conference 2013, and CoSyne 2013.

In summary, we have made systematic progress in executing towards the goals of the project. Some key lessons that we learned during the last few years point to the need for an integrated systems science and engineering graduate curriculum focusing on intelligent systems. We intend to explore this aspect in more detail in the coming years.

2. Graduate Schools

Helmholtz Graduate School for Hadron and Ion Research

and

Helmholtz Research School for Quark Matter Studies

by Henner Büsching and Gerhard Burau

The HGS-HIRe Graduate Days 2013, held in Worms on October 24 and 25, celebrated the fifth anniversary of our Helmholtz Graduate School for Hadron and Ion Research (HGS-HIRe for FAIR). On this occasion a broad overview of the participants' doctoral projects has been presented by scientific talks and poster sessions organized and chaired by the students. Plenary talks on current physics highlights complemented the scientific program of the event. This year's HGS-HIRe Excellence Awards went to Lucas Burigo (FIAS & U Frankfurt) and Michael Reese (GSI & TU Darmstadt) for their outstanding achievements during their doctoral studies.

Supported by the Initiative and Networking Fund of the Helmholtz Association, HGS-HIRe for FAIR was established in October 2008 as a joint endeavor of the GSI Helmholtzzentrum für Schwerionenforschung together with the Frankfurt Institute for Advanced Studies (FIAS) and the universities at Darmstadt, Frankfurt, Giessen, Heidelberg and Mainz to promote and support structured doctoral education for research associated with GSI and the Facility for Antiproton and Ion Research (FAIR). An integral part of HGS-HIRe is the Helmholtz Research School for Quark Matter Studies (H-QM) to specially support a selected group of highly talented doctoral students performing research in the field of heavy-ion physics, which is the largest field of research within the graduate school. HGS-HIRe has very positively been evaluated by the Helmholtz Association in March 2013. The referees appreciated very much the program and spirit of our graduate school and everyone involved.

More than 320 doctoral students in 10 fields of research relevant for GSI and FAIR are participating in the program of HGS-HIRe by the end of 2013. Likewise impressive is the number of 133 participants who finished their doctoral thesis so far and became alumni of our graduate school. More than 40 of them graduated in 2013. Altogether more than 140 participants and alumni (> 30%) are of international origin.

The great popularity of HGS-HIRe and H-QM allowed for a consequent continuation of our structured doctoral program.

An essential pillar of this structure is our doctoral education program. Numerous HGS-HIRe and H-QM events on various topics, which addressed both, scientific and soft skills training, have been organized in 2013: eight lecture weeks, five power weeks, and a total of eleven

courses on transferable skills courses. Special events, as the third Joint Helmholtz-Rosatom School for young scientists at FAIR, the HGS-HIRe Graduate Days, Perspectives events to facilitate the career planning of the students after finishing the doctoral thesis, and the HGS-HIRe Summer Student Program at GSI with 39 participating students from 18 GSI/FAIR partner countries complemented the educational program of HGS-HIRe and H-QM in 2013.

Another important pillar of HGS-HIRe is the scientific travel program for our participants consisting of the individual travel budgets for the doctoral students to attend conferences, workshops etc. and the HGS-HIRe Abroad program which offers participants a limited number of grants, awarded in a competitive process several times per year, for a one to three months research stay abroad to facilitate their thesis project and to intensify research collaborations. Moreover, our graduate school serves, strongly supported by FIAS, as central contact and care center for our doctoral students, their supervisors and the administration of our partner institutions. Administrative and social aspects are handled here as, for example, the administration of more than 320 individual PhD committees, help with student status issues and visa/residence permits. Within the activities of this contact and care center, HGS-HIRe provides and centrally organizes the successful doctoral scholarship programs of GSI, HIC for FAIR and EMMI.

Last but not least HGS-HIRe continued its public outreach activities with strong involvement of our participants: Primary School Program in collaboration with the Polytechnische Gesellschaft Frankfurt, national and international Masterclass Program within the BMBF-initative "Netzwerk Teilchenphysik", and participation in the campaign “Hessen schafft Wissen” by, e.g., experimental stations at “Hessentag 2013” in Kassel and “Night of Science” at Goethe University Frankfurt.

FIGSS

The Frankfurt International Graduate School for Science

by Jochen Triesch

The Frankfurt International Graduate School for Science (FIGSS) is the graduate school of FIAS. It provides a framework for doctoral education at FIAS, while PhD degrees are officially granted by Goethe University. The students are expected to obtain their PhDs within three years. Typically, they are funded by research grants to their advisors, since FIGSS does not receive any direct funding.

In 2013, a comparatively large number of 19 FIGSS students obtained their PhDs. This makes up for the small number of only 5 graduations in 2012. The distribution across the different disciplines was as follows: Neuroscience: 7, Physics: 6, Computer Science: 3, Life Sciences: 3. Partly due to the large number of awarded PhDs, the total number of students enrolled in FIGSS at the end of 2013 was lower than that of last year: 44 in December 2013 compared to 61 in December 2012.

The fraction of female students was 18%, about the same as last year (15%). The student population remains quite international with 45% of our students being foreign nationals (54% last year). The composition of FIGSS with respect to the different research disciplines was as follows (numbers in parentheses are from the previous year; reference month is always December): Physics: 52% (39%), Neuroscience: 18% (25%), Computer Science: 20% (21%), Life Sciences: 9% (15%).

A core activity of FIGSS continues to be its weekly lunch seminar held in the FIAS Faculty Club on Mondays. Each week a FIGSS student or post-docs reports on the status of their research, while the audience enjoys pizza. Care is taken that the talks are of high quality and understandable to an interdisciplinary audience. To this end, we use feedback forms that attendees fill in after every presentation. In addition, the talks are videotaped to give speakers feedback about their presentation style. The best talk of each semester is awarded a bottle of Champagne. The 2013 winners were:

- Andrei Korol: „Crystalline undulator as a novel light source“, winter semester 2012/2013
- Viola Priesemann: „Self-organized criticality as a universal brain state from wakefulness to deep sleep?“, summer semester 2013.

Courses offered at FIGSS

Summer Semester 2013

J. Triesch	Reinforcement learning, 2+2h
I. Mishustin	Dynamical models for relativistic heavy-ion collisions, 2h
A. Solov'yov	Theoretical and computational methods in Meso-Bio-Nano Science, 2h
T. Burwick	Visual system - Neural structure, dynamics, and function, 2h
S. Schramm	Quantum theory on the lattice, 2+1h
C. Gros	Complex adaptive dynamical systems, 2+2h
P. Nicolini	Classical and quantum physics of black holes, 2+1h
E. Engel	Density functional theory, 3h
D. Schuch	Nonlinearities and dissipation in classical and quantum physics, 2h
J. Lücke	Advances in Machine Learning and Computer Vision (Seminar), 2h
J. Lücke	Current topics in Machine Learning and Computational Neuroscience (Seminar), 2h
M. Wibral	Information theory and coding - with applications to neural systems, 2h

Winter Semester 2013/14

M. Kaschube	Theoretical neuroscience, 2+2h
T. Burwick	Brain dynamics: From neuron to cortex, 2h
I. Mishustin E. Bratkovskaya	Physics of strongly interacting matter, 2h
A. Solov'yov	Theoretical and computational methods in Meso-Bio-Nano Science, 2h
C. Sasaki	Introduction to chiral effective field theories, 2h
P. Nicolini	Classical and quantum physics of black holes, 2+1h
S. Schramm	Nuclear and neutrino astrophysics, 2h
H. van Hees	From Quantum Field Theory to (semi)classical transport equations I, 2h
E. Engel	Quantum many-particle theory, 2+2h
D. Schuch	Is Quantum Theory intrinsically nonlinear?, 2h

Regularly held seminars

FIGSS Seminar	FIAS Fellows
Interdisciplinary FIAS Colloquium	FIAS Fellows
Seminar on Meso-Bio-Nano-Science	Solov'yov
Current topics in theoretical neuroscience	Triesch
NeuroBio Theory seminar series	Kaschube, Triesch
Nuclear/Heavy ion group meeting	Mishustin
Astro meeting	Mishustin, Schramm
Journal club in high-energy physics	Nicolini
Journal club on relativistic heavy ion physics	Petersen

Ph.D. degrees received by FIAS/FIGSS students in the year 2013

1	N	Mark Henniges	10.01.2013	Unsupervised Learning in Generative Models of Occlusion
2	I	Sergey Gorbunov	14.03.2013	On-line reconstruction algorithms for the CBM and ALICE experiments
3	L	Harald Kempf	25.04.2013	In silico optimisation of cancer treatment schedules
4	N	Daniel Krieg	27.05.2013	A unifying functional approach towards synaptic long-term plasticity
5	L	Mareike Müller	24.06.2013	Effects of ionizing radiation on organotypic slice cultures
6	P	Anton Lymanets	26.06.2013	Development of prototype components for the Silicon Tracking System of the CBM experiment at FAIR
7	P	Vitalii Ozvenchuk	10.07.2013	Dynamical equilibration and transport coefficients of strongly interacting matter
8	I	Jochen Gerhard	25.07.2013	Refactoring the UrQMD Model for Many-Core Architectures
8	N	Quan Wang	26.07.2013	Learning Sequences of Actions: Infant Experiments and Neural Network Models
10	P	Gunnar Gräf	29.07.2013	Hanbury-Brown-Twiss Interferometry Within the UrQMD Transport Approach
11	P	Thomas Lang	23.08.2013	Heavy Quark and Charmonium Dynamics in Heavy-Ion Collisions
12	N	Viola Priesemann	23.09.2013	Subsampling in Critical Systems
13	P	Philip Rau	10.10.2013	Chiral Effective Model for the QCD Equation of State and Medium Properties from Heavy Ion Collisions
14	P	Christoph Herold	16.10.2013	Signals for the QCD phase transition in nonequilibrium chiral fluid dynamics
15	I	Sebastian Kalcher	31.10.2013	An Erasure-Resilient and Compute-Efficient Coding Scheme for Storage Applications integrated into a Multi-Purpose Computing Facility

16	N	Zhenwen Dai	12.11.2013	Unsupervised Learning of Invariant Object Represe-nations – A Probabilistic Generative Modeling Ap-proach
17	L	Cathrin Wälzlein	16.12.2013	Nanometer scale description of electron transport and damage in condensed media using the TRAX Monte Carlo Code
18	N	Jörg Bornschein	17.12.2013	Large-scale parallelized learning of nonlinear sparse coding models
19	N	Luca Lonini	20.12.2013	Autonomous Learning of Active Binocular Vision on a Humanoid Robot

Fields

I	Information/Computer Science	3
L	Life Science	3
N	Neuroscience	7
P	Physics	6

3. FIAS Scientific Life

Seminars and Colloquia at FIAS in the year 2013

The organization of common colloquia and seminars has played an inportant role for fostering an interdisciplinary spirit at FIAS. From the beginning, in the weekly "Interdisciplinary FIAS Colloquium" distinguished speakers were invited to give overview talks covering all scientific areas represented at FIAS. Since 2006 the "FIGSS Student Seminar" has been held, mainly as a platform for Ph.D. students to present their work. These events are addressing the 'general public' at FIAS and bring together the researchers and students from all scientific branches. In addition, various group seminars are held with a more focussed specialization. Their schedules are not listed in the following.

17.01.2013 **Dr. Christian Pohl,** Buchmann Institute for Molecular Life Sciences, Goethe University
The origin of organismal homochirality: Insights from left-right symmetry breaking in the C. elegans embryo

24.01.2013 **Dr. Deniz Savran,** EMMI Fellow, Extreme Matter Institute, GSI, Darmstadt
The quest for pygmies in nuclei: Low-lying collective dipole strength

31.01.2013 **Prof. Dr. Dieter Schuch,** Institut for Theoretical Physics, Goethe University, Frankfurt
Is quantum theory intrinsically nonlinear?

07.02.2013 **Prof. Dr. Lorenz Cederbaum,** Institute of Physical Chemistry, University of Heidelberg
Intermolecular Coulombic decay and ultrafast energy transfer

14.02.2013 **Prof. Dr. Peter Güntert,** Goethe University, Institute of Biophysical Chemistry and FIAS; Graduate School of Science, Tokyo Metropolitan University
What can computation do for NMR with proteins?

21.02.2013 **Prof. Dr. Roderich Tumulka,** Department of Mathematics, Rutgers University, Piscataway NJ
The major disagreement about the definition of thermal equilibrium (and of entropy)

18.03.2013 **Prof. Dr. Bikash Sinha,** Saha Institute and VECC, Kolkata
The India – FAIR programme

20.03.2013 **Prof. Dr. Kazuyuki Aihara,** Institute of Industrial Science, The University of Tokyo, Tokyo, Japan
Complex systems modelling for personalised medicine

18.04.2013 **Prof. Dr. Reinhard Genzel,** Max Planck Institute for Extraterrestrial Physics, Garching and University of California, Berkeley
Massive black holes and galaxies

23.05.2013 **Dr. Nils Bertschinger,** Max Planck Institute for Mathematics in the Sciences, Leipzig
Predicting behavior: Game theory meets machine learning

06.06.2013 **Dr. Andreas Döring,** Dept. of Computer Science, University of Oxford
The Topos approach to quantum theory

13.06.2013 **Prof. Dr. Victor Flambaum,** School of Physics, University of New South Wales, Sydney, Australia
Violation of fundamental symmetries (parity, time reversal) in atoms, molecules and

nuclei and test of unification theories

20.06.2013 **Dr. Szabolcs Horvat,** Notre Dame University, Indiana, USA and Max-Planck-Institute für Physik komplexer Systeme, Dresden
A gentle introduction to the statistical mechanics of networks and exponential random graph models

27.06.2013 **Christopher Coleman-Smith,** Duke University, Durham, USA
Using Gaussian Proccesses for calibration and exploration of complex computer models, with examples from physics and astronomy

04.07.2013 **Prof. Dr. Michael Maziashvili,** Ilia State University, Tbilisi, Georgia
Planck-length deformed quantum theory: Issues and problems

11.07.2013 **Prof. Dr. Harald Schwalbe,** Institute for Organic Chemistry and Chemical Biology, Center for Biomolecular Magnetic Resonance (BMRZ), Goethe University, Frankfurt
NMR to monitor dynamic transitions in RNA and protein

25.07.2013 **Prof. Dr. Leonard Susskind,** Department of Physics, Stanford University
(Online lecture)
A new principle for Quantum Gravity: ER = EPR

29.08.2013 **Prof. Dr. Brian Robson,** Australian National University, Canberra
Progressing beyond the Standard Model of particle physics

05.09.2013 **Prof. Dr. Cliff Abraham,** University of Otago, New Zealand
Astrocyte-mediated BCM-like metaplasticity: a challenge for computational models?

10.10.2013 **Prof. Dr. Kwabena Boahen,** Brain in Silico Laboratory, Stanford University
Neuromorphic architectures

18.10.2013 **Prof. Dr. Gerhard Hummer,** Department of Theoretical Biophysics, Max Planck Institute of Biophysics, Frankfurt
Motions in the molecular machinery powering life

31.10.2013 **Prof. Dr. Stéphane Lucas,** Namur Research Institute for Life Science, University of Namur, Belgium
A journey to in-vitro hadrontherapy

05.12.2013 **Dr. Dominik Heide,** German Aerospace Center, Institute of Technical Thermodynamics Systems Analysis & Technology Assessment, Stuttgart
A systems analysis view of the transition to a renewable energy system

12.12.2013 **Prof. Dr. Thomas Haberer,** Heidelberger Ionenstrahl-Therapiezentrum
Novel techniques and challenges in ion beam therapy

FIGSS Seminar

14.01.2013 **Torsten Schürhoff**
Applications of a chiral model in nuclear and astrophysics

21.01.2013 **Philip Rau**
Effective model approach to the phase diagram of nuclear matter

28.01.2013 **Dr. Andrei Korol**

Crystalline Undulator as a novel light source

04.02.2013 **Daniel Yueker**
Modeling cosmic phase transitions in dynamical environments

22.04.2013 **Jörg Bornschein**
Nonlinear unsupervised learning and it's parallelization

29.04.2013 **Sebastian Kalcher**
Efficient erasure coding for storage applications

06.05.2013 **Pablo de Vera**
Slowing down of energetic ion beams and electron production in biomaterials: from liquid water to more realistic targets

27.05.2013 **Sally Mc Kinnon,** University of Wollongong, Australia
Translational research at the Centre for Medical Radiation Physics

03.06.2013 **Daniel Cabrera**
Heavy quark relaxation in strongly interacting matter: a necessary insight into the Quark-Gluon Plasma

10.06.2013 **Gwendolyn Lacroix**
From a white to a coloured world: Quark-Gluon Plasma within a quasiparticle approach

17.06.2013 **Viola Priesemann**
Self-organized criticality as a universal brain state from wakefulness to deep sleep?

24.06.2013 **Prof. Dr. Marcus Bleicher**
A mini-review on Mini-Back Holes from the Mini-Big Bang

01.07.2013 **Dr. Maximilian Attems**
Weibel instabilities and thermalization in quantum chromodynamics

08.07.2013 **Céline Teulière**
Learning to see efficiently

15.07.2013 **Dr. Raul Vicente**
Neuronal oscillations: fundamental or epiphenomenon?

21.10.2013 **Sarah Becker**
What can transmission do for a fully renewable Europe?

28.10.2013 **Jan Steinheimer-Froschauer**
Spinodal decomposition in relativistic nuclear collisions

11.11.2013 **Gareth Bland**
Illusion of cognitive modularity in the motor cortex

18.11.2013 **Bernhard Nessler**
Thinking is Sampling: A Bayesian model of the mind

02.12.2013 **Felix Bauer**
Role of area V1 architecture in visual texture recognition

16.12.2013 **Janus Weil**
Dilepton production and hadrons in medium

Conferences and meetings (co)organized by FIAS in the year 2013

▷ **Workshop on *Brain-Inspired Systems*,**
FIAS, Frankfurt, January 29 - 30, 2013

▷ **Mind Group, *"The Wandering Mind"***, 19. Meeting of the Junior Research Group "Philosophy of Mind", Zurich, March 25-26, 2013
`fias.uni-frankfurt.de/mindgroup/index.php/meeting-19.html`

▷ **International Conference on *Nuclear Physics: Presence and Future*,**

Boppard, May 29 – June 05, 2013

▷ **Workshop on "*Transport Theory in Heavy Ion Collisions*",**

Schmitten, July 15 - 17, 2013

`fias.uni-frankfurt.de/de/physics/conferences/transport-2013/`

▷ **ISACC 2013, *"Sixth International Symposium Atomic Cluster Collisions"*,**

Wuhan-Chongqing, China, July 18 - 23, 2013

`isacc2013.csp.escience.cn/`

▷ **Workshop on "*Sampling Particles on the Cooper-Frye Transition Surface*",**

Schmitten, July 18 - 20, 2013

`fias.uni-frankfurt.de/de/physics/conferences/sampling-2013/`

▷ ***KSM 2013, "First Karl Schwarzschild Meeting 2013",***

FIAS, Frankfurt, July 22 - 26, 2013

`fias.uni-frankfurt.de/de/ksm2013/`

▷ **Mini-Meeting *"QCD Phase Diagram and Holography"*,**

FIAS, Frankfurt, July 27 - 28, 2013

`fias.uni-frankfurt.de/~nicolini/holography.html`

▷ **ICCMNM - 2013, *"International Conference on Computational Modelling of Nanostructured Materials"*,**

FIAS, Frankfurt, September 3 - 6, 2013

`www.risoecampus.dtu.dk/Research/sustainable_energy/new_energy_technologies/projects/AFM_vinat/CMNM.aspx`

▷ **NUFRA 2013, *"Fourth International Conference on Nuclear Fragmentation"*,**

Kemer (Antalya), Turkey, September 29 - October 6, 2013

`fias.uni-frankfurt.de/nufra2013/`

▷ **EMMI Rapid Reaction Task Force Meeting *"Quark Matter in Compact Stars"*,**
FIAS, Frankfurt, October 7-10, 2013
`indico.gsi.de/conferenceDisplay.py?confId=2420`

▷ **Ernst Strüngmann Forum, *"Formative Childhoods: A Path to Peace?"*,**
FIAS, Frankfurt, October 13-19, 2013
`www.esforum.de/forums/esf15_formative_childhoods.html`

▷ ***International Symposium on Supercritical Fields*,**
FIAS, Frankfurt, November 4 – 5, 2013

In addition, members of FIAS were involved in the organization of various other conferences and workshops.

Public lectures at FIAS in the year 2013

The public-outreach activities of FIAS strive to strengthen the understanding of scientific issues in the general public and at the same time to raise the awareness level of the Institute in Frankfurt and the Rhein-Main area. With this goal in mind the *FIAS Forum*, which was initiated in the year 2009, organizes public evening lectures (mostly in German) on a wide variety of scientific topics addressed to a broader audience of interested citizens. In the winter semester 2013/14 the FIAS Forum has been supplanted by a lecture series dedicated to the topic "Vom Urknall ins Labor – Materie unter extremen Bedingungen" financed by Deutsche Bank AG and the Helmholtz Center HIC for FAIR.

16.01.2013 **Prof. Dr. Wolfgang Bauer,** Michigan State University, Biomedical Physical Sciences
Neue Wege in der Bioenergie - Lösungsansätze zur Energiewende

27.02.2013 **Prof. Dr. Ingo Bechmann,** Universität Leipzig, Direktor des Instituts für Anatomie
Multiple Sklerose: Entzündungen im Gehirn als Drahtseilakt

17.04.2013 **Prof. Dr. Dr. Jürgen Debus,** Ärztlicher Direktor der Klinik für Radioonkologie und Strahlentherapie, Universitätsklinikum Heidelberg
Therapie von Tumoren mit Ionenstrahlen: Präzision und biologische Wirksamkeit

06.06.2013 **Prof. Dr. Peter König,** Universität Osnabrück, Institut für Kognitionswissenschaft
Erweiterung der Sinneswahrnehmung: Lernen eines sechsten Sinnes

31.10.2013 **Prof. Dr. Paolo Palazzi,** CERN, Geneva, Switzerland
The Early Days of the WWW at CERN – a personal recollection

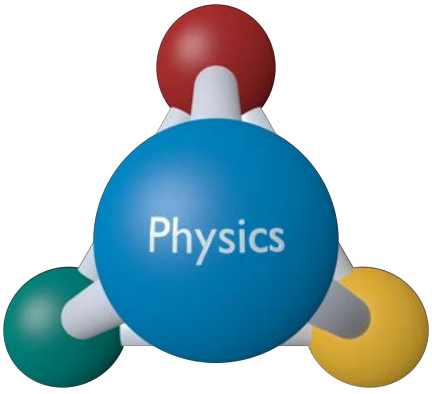
14.11.2013 **Prof. Dr. Steffen Bass,** Duke University, Durham, USA
Der Urknall im Labor – Schwerionenkollisionen als Sonden der Frühgeschichte des Universums

28.11.2013 **Prof. Dr. Robert Harlander,** Bergische Universität Wuppertal
Wieviel wiegt ein Punkt? Das Higgs-Teilchen und die Natur der Masse

12.12.2013 **Prof. Dr. Thomas Haberer,** Heidelberger Ionenstrahl-Therapiezentrum
Das Ionenskalpell – Schwerionenbeschleuniger im Dienst der Tumortherapie

4. Research Reports

4.1 Nuclear Physics, Particle Physics, Astrophysics



Phase transition signatures in hydrodynamic simulations of heavy-ion collisions at NICA-FAIR energies

Collaborators: A. V. Merdeev[2], L. M. Satarov[1,2], and I. N. Mishustin[1,2]

[1] Frankfurt Institute for Advanced Studies, [2] National Research Center "Kurchatov Institute", Moscow, Russia

We have applied (3+1)-dimensional ideal hydrodynamics to simulate central Au+Au and Pb+Pb collisions at bombarding energies $E_{\rm lab} = 10$ and 40 GeV/nucleon. In these calculations we have used an equation of state (EoS–PT) with the first-order deconfinement phase transition, described in our earlier publications. To probe sensitivity to the phase transition, we also made calculations with the equation of state of a hadron resonance gas (EoS–HG). The simulations of the collision process are performed from the early stage when two cold Lorentz contracted nuclei approach each other.

Parameters of collective flows and hadronic spectra are determined by using the Cooper–Frye formula assuming the isochronous freeze-out at the time when the energy density in the central box ε becomes lower than 0.3 GeV/fm^3. Observable characteristics are calculated taking into account decays of hadronic resonances with masses up to 2 GeV.

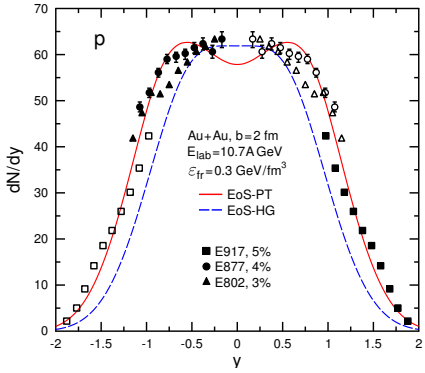


Fig. 1: Rapidity distributions of protons in 10 A GeV Au+Au collision ($b = 2$ fm). Solid and dashed lines are calculated with EOS–PT and EOS–HG, respectively. Full dots are AGS data, emty dots are obtained by reflection with respect to midrapidity.

In Fig. 1 we show proton rapidity distributions in central 10 A GeV Au+Au collisions. As compared to the EoS–HG, the calculation with the phase transition predicts a noticeably broader distribution. According to our analysis, this broadening is caused by the "extra-push" due to the deflagration wave.

Figure 2 shows the results for the proton and pion directed flows v_1. For both considered reactions the calculations with the EoS–PT predict the formation of pion antiflow, i.e. the negative slope of $v_1(y)$ in the central rapidity region. Our calculations are in a qualitative agreement with NA49 data for 40 A GeV Pb+Pb collisions. On the other hand, simulations with EoS–HG predict a positive slop of directed flow. We conclude that the sensitivity to the equation of state is stronger at lower bombarding energies, 10 A GeV, which will be available in FAIR and NICA experiments.

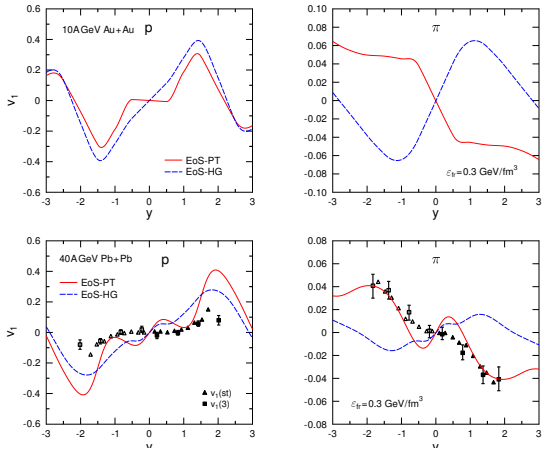


Fig. 2: Directed flow of protons (left panels) and pions (right panels) in 10 A GeV Au+Au and 40 A GeV Pb+Pb collisions. Solid (dashed) lines are calculated with EoS–PT (EoS–HG) Full symbols are experimental data, while the open ones are obtained by reflection.

Related publications

A.V. Merdeev, L.M. Satarov, I.N. Mishustin, *http://theor.jinr.ru/twiki/pub/NICA/NICAWhitePaper/NICA-V1.pdf*

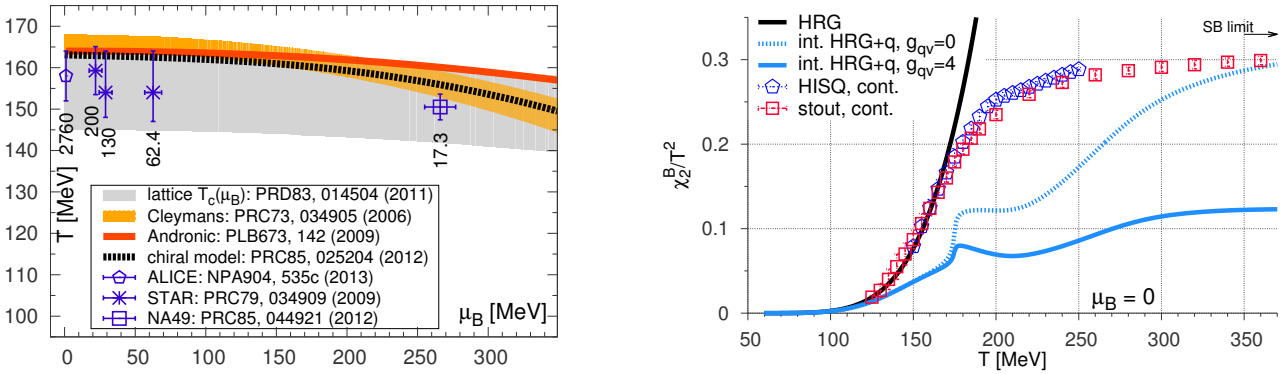
QCD Phase Structure and Conserved Charge Fluctuations in a Chiral Effective Model

Collaborators: Philip Rau[1,2], Jan Steinheimer[1], Stefan Schramm[1], Horst Stöcker[1,4]

[1] FIAS, [2] Institut für Theoretische Physik, Goethe Universität Frankfurt, [4] GSI – Helmholtzzentrum für Schwerionenforschung, Darmstadt.

Using the well-established chiral effective model for QCD matter, which includes all known hadrons up to $m = 2.6$ GeV and quarks, this study examines the phase structure of QCD matter and fluctuations of conserved charges focussing on the chiral and deconfinement phase transition. At small baryochemical potentials the effective model shows a smooth cross over in both order parameters and, at larger potentials, does not give indications for the existence of a first order phase transition and a critical end point. Compared to lattice QCD and thermal model fits of experimental data the chiral transition from the effective model is in line with recent data (Fig. 1(a)).

At the phase transition conserved charges show large fluctuations which can be measured by susceptibility coefficients χ. Baryon number fluctuations are largely suppressed by the finite volume of hadrons and the suppressive particle interactions with vector fields (Fig. 1(b)). It shows that in the hadronic phase below T_c coupling strengths are of the order of the nucleon couplings. However, in the quark sector above T_c, large fluctuations found in lattice QCD restrain quark vector couplings close to zero and particles at $T > T_c$ are almost acting like an ideal gas. With this model a realistic equation of state has been compiled which can be used for studying heavy ion collisions in dynamic models as well as neutron star properties.



(a) (b)

Figure 1: **(a)**: Chiral transition at small μ_B from lattice QCD (gray band) and from the chiral model (black line) contrasted to freeze-out curves from statistical and thermal model fits for SPS to LHC energies ($\sqrt{s_{\rm NN}}$ in GeV). **(b):** Second-order baryon number susceptibility of the hadron resonance gas (black line) and of the full model including hadrons and quarks (blue lines). Strong vector couplings suppress fluctuations and the Stefan-Boltzmann limit at high T may only be reached for vanishing quark vector couplings $g_{\rm qv}$ (dashed blue line).

Related publications in 2013:

1. P. Rau, J. Steinheimer, S. Schramm and H. Stöcker, *Chiral Hadronic Mean Field Model including Quark Degrees of Freedom*, J. Phys. G **40**, 085001 (2013)

2. P. Rau, J. Steinheimer, S. Schramm and H. Stöcker, *Conserved Charge Fluctuations in a Chiral Hadronic Model including Hadrons and Quarks*, arXiv:1308.4319 [hep-ph] (to be published in PLB)

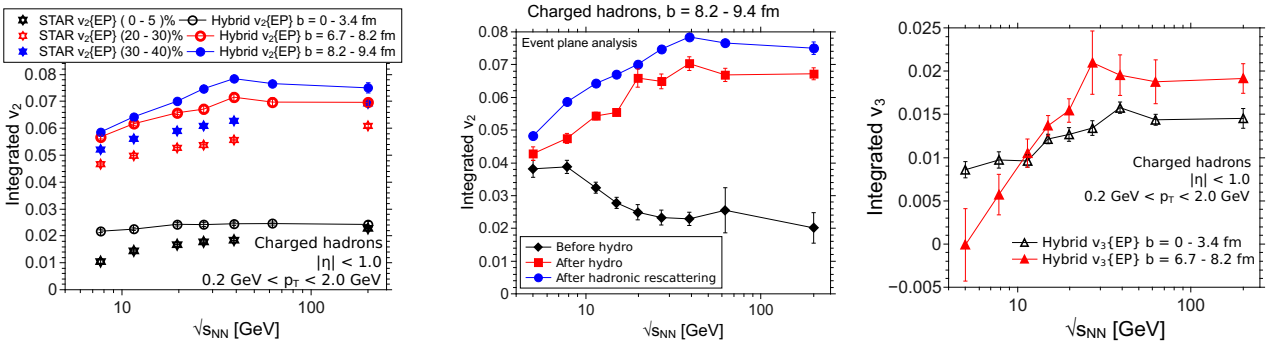
Collision Energy Evolution of Elliptic and Triangular Flow in a Hybrid Model

Collaborators: Jussi Auvinen[1], Hannah Petersen[1,2]

[1] Frankfurt Institute for Advanced Studies, [2] Institut für Theoretische Physik, Goethe Universität Frankfurt

We have studied the collision energy dependence of elliptic flow v_2 and triangular flow v_3 in Au+Au collisions within the energy range $\sqrt{s_{NN}} = 5 - 200$ GeV, utilizing a transport + hydrodynamics hybrid model. The transport part is described by the Ultrarelativistic Quantum Molecular Dynamics (UrQMD), combined with an intermediate (3+1)-dimensional ideal hydrodynamical evolution phase using a chiral model equation of state. This approach provides a consistent framework for investigating both high-energy heavy ion collisions with negligible net-baryon density and a large hydrodynamically evolving medium, and the collisions at smaller energies with finite net-baryon density, where the hydrodynamics phase is very short-lived or does not exist at all.

The hybrid model reproduces the qualitative behavior of the experimentally measured elliptic flow (see Fig. 1(a)). While v_2 produced by hydrodynamics is considerably diminished at lower collision energies, this decrease is partially compensated by the transport dynamics, as shown in Fig. 1(b). The pre-hydrodynamics transport phase is of particular importance for understanding the collision energy evolution, while the hadronic rescatterings after the hydrodynamical phase contribute more systematically $\sim 10\%$ to the total flow at all energies. However, the viscous matter described by transport dynamics is unable to produce triangular flow, which consequently shows a significantly larger relative decrease in midcentral collisions with decreasing $\sqrt{s_{NN}}$ (Fig. 1(c)). Our conclusion is that the triangular flow provides the clearer signal for the formation of low-viscous fluid in heavy ion collisions.



(a) (b) (c)

Figure 1: a): Integrated elliptic flow $v_2\{\mathrm{EP}\}$ for charged hadrons with $0.2 < p_T < 2.0$ at midrapidity $|\eta| < 1.0$ in Au+Au -collisions, for collision energies $\sqrt{s_{NN}} = 7.7 - 200$ GeV and three different impact parameter ranges, compared with the STAR data [1,2]. b): Magnitude of $v_2\{\mathrm{EP}\}$ in midcentral collisions ($b = 8.2 - 9.4$ fm) at the beginning of hydrodynamical evolution (diamonds), immediately after the end of hydrodynamics phase (squares) and after the full simulation (circles). c): Integrated $v_3\{\mathrm{EP}\}$ in central collisions ($b = 0 - 3.4$ fm, open triangles) and midcentral collisions ($b = 6.7 - 8.2$ fm, solid triangles).

Related publications in 2013:

1) J. Auvinen and H. Petersen, *Collision Energy Evolution of Elliptic and Triangular Flow in a Hybrid Model*, PoS CPOD 2013, 034 (2013) [arXiv:1306.0106 [nucl-th]]

2) J. Auvinen and H. Petersen, *Evolution of elliptic and triangular flow as a function of collision energy in a hybrid model*, Phys. Rev. C 88, 064908 (2013) [arXiv:1310.1764 [nucl-th]]

References:

[1] L. Adamczyk *et al.* [STAR Collaboration], Phys. Rev. C 86, 054908 (2012)

[2] J. Adams *et al.* [STAR Collaboration], Phys. Rev. C 72, 014904 (2005)

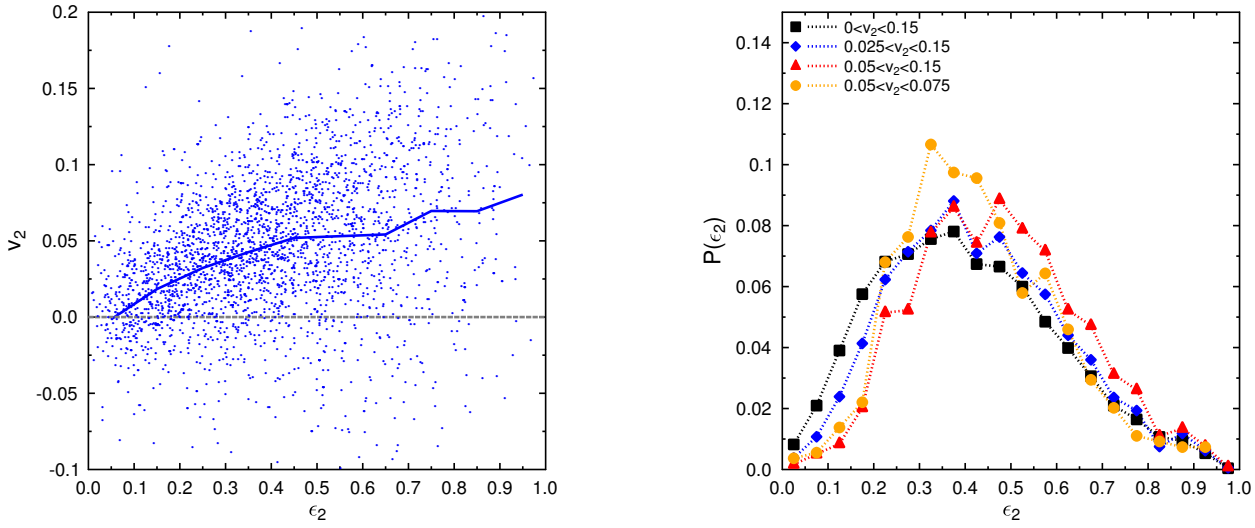
On the Possibility of Event Shape Selection in Relativistic Heavy Ion Collisions

Collaborators: Hannah Petersen[1,2], Berndt Müller[3]

[1] Frankfurt Institute for Advanced Studies, [2] Institut für Theoretische Physik, Goethe Universität Frankfurt, [3] Duke University, Durham, NC, USA

We investigate the possibility of selecting heavy ion collision events with certain features in the initial state ("event engineering"). Anisotropic flow measurements in heavy ion reactions have confirmed the almost ideal fluid dynamical behaviour of the hot and dense quark gluon plasma state. As a consequence, it is intriguing to pursue the idea of selecting collisions with a certain special initial geometry, e.g., a large ellipsoidal deformation, by classifying events by the value of their final observed flow coefficients. This procedure could be especially interesting for azimuthally dependent jet energy loss studies.

To obtain a realistic estimate on how well one is able to constrain the initial state geometry by selecting certain values of final state anisotropic flow values an event-by-event hybrid approach based on nearly ideal fluid dynamics for the hot and dense stage and hadron transport for the later dilute stage of the reaction. The scatter plot shown in Fig. 1(a) is helpful to examine the correlation between final state flow observables and initial state eccentricities. The full lines showing the mean values exhibit the expected approximately linear relationship between v_2 and ε_2. On the other hand, the fluctuations imply very large ranges of initial eccentricity or triangularity that correspond to selected elliptic flow values. Fig. 1(b) shows the probability distribution of



(a) (b)

Figure 1: a): Scatter plot of $v_2(\varepsilon_2)$ within the hybrid approach, the mean is indicated by the full line. b): Probability distributions of the initial eccentricity in events with high elliptic flow values.

eccentricities ε_2 in minimum bias events with certain cuts on the final elliptic flow values. Overall, one can see that event selection by restrictions on elliptic flow changes the distribution of initial state eccentricities, but they remain rather broad and not narrow enough to select a well defined initial state configuration.

Related publications in 2013:

1) H. Petersen and B. Müller, *On the Possibility of Event Shape Selection in Relativistic Heavy Ion Collisions*, Phys. Rev. C88, 044918 (2013) [arXiv:1305.2735 [nucl-th]]

2) M. Luzum and H. Petersen, *Initial State Fluctuations and Final State Correlations in Relativistic Heavy-Ion Collisions*, arXiv:1312.5503 [nucl-th]

Dynamical freeze-out in event-by-event hydrodynamics

Collaborators: Hannu Holopainen[1], Pasi Huovinen[1,2]

[1] Frankfurt Institute for Advanced Studies, [2] Institut für Theoretische Physik, Goethe Universität Frankfurt

Hydrodynamical models are indispensable tools for understanding the behaviour and properties of the strongly interacting matter created in ultrarelativistic heavy ion collisions. Unfortunately, as phenomenological models they have many free parameters and badly controlled approximations. One of these approximations is so-called freeze-out: the stage when the fluid dynamical description breaks down, and the fluid must be converted to particles. The usual assumption is that this happens on a surface of constant temperature or energy density.

A more physical criterion is that freeze-out should happen when the ratio of the expansion rate of the fluid to the scattering rate of the particles forming the fluid, so-called Knudsen number, reaches a certain value (~ 1). We have applied this criterion to event-by-event ideal fluid description of $Au+Au$ and $Pb+Pb$ collisions at $\sqrt{s_{\rm NN}} = 200$ GeV (RHIC) and $\sqrt{s_{\rm NN}} = 2.76$ TeV (LHC) collision energies, respectively, to check whether such a freeze-out criterion affects the final observables.

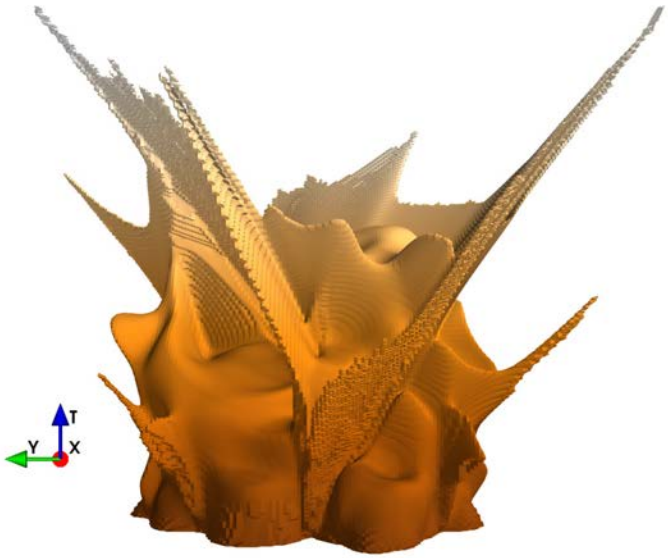


Figure 1: The constant Knudsen number freeze-out surface in a Au+Au collision at $\sqrt{s_{\rm NN}} = 200$ GeV.

In an event-by-event case the dynamical criterion of constant Knudsen number leads to very complicated surface, see Fig. 1. The system also lives longer, its center gets colder, and its edges are hotter. However, the features shown in Fig. 1 are almost entirely averaged out when the particle distributions in many events are evaluated. After the freeze-out temperature and freeze-out Knudsen number are chosen to reproduce the observed p_T-distributions of pions and protons, the azimuthal anisotropies (so called v_2 and v_3 coefficients) are basically identical (see Fig. 2). This result may sound disappointing, but it means that what comes to freeze-out, the studies in the literature, which have allowed us to conclude that the strongly interacting matter has very low viscosity to entropy ratio, are on a solid footing.

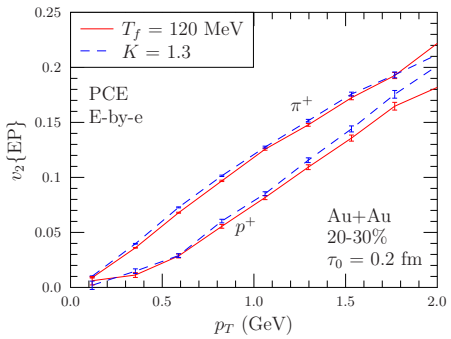


Figure 2: The p_T-differential elliptic flow, $v_2(p_T)$, of pions and protons in event-by-event hydrodynamical calculation of 20-30% central $Au+Au$ collisions at $\sqrt{s_{\rm NN}} =$ 200 GeV. Results are shown for both constant temperature and constant Knudsen number (*i.e.* dynamical) freeze-out criteria.

Related publications in 2012:

1) H. Holopainen, and P. Huovinen, *Dynamical freeze-out criterion in event-by-event hydrodynamics*, arXiv:1310.0347 [nucl-th].

Dynamical formation of droplets at the QCD phase transition in heavy-ion collisions

Collaborators: C. Herold [1,2,3], M. Nahrgang [1,4], I. N. Mishustin [1,5], M. Bleicher [1,2]

[1] Frankfurt Institute for Advanced Studies, [2] Institut für Theoretische Physik, Goethe Universität, Frankfurt, [3] School of Physics, Suranaree University of Technnology, Thailand, [4] Department of Physics, Duke University, Durham, USA, [5] Kurchatov Institute, National Research Center, Moscow, Russia

At large baryon densities, a QCD first-order phase transition is expected from effective models and functional methods. Experimentally, it will be accessible in the upcoming FAIR and NICA facilities. For a profound understanding of the related observables in heavy-ion collisions, it is necessary to study the nonequilibrium dynamics of matter which expands and cools through the phase transition. Here, an enhancement of fluctuations in the spinodal region may induce non-monotonic multiplicity fluctuations.

We investigate this with a chiral fluid dynamics model, simulating the expanding fireball via a locally equilibrated fluid of quarks, coupled to the explicit propagation of the order parameters for chiral symmetry and deconfinement, the sigma field and an effective Polyakov loop.

For an evolution through the first-order phase transition we find that the system dynamically fragments into droplets with high energy and net-baryon density. This happens due to the extended amount of time inside the spinodal region. The large fluctuations are imprinted from fluctuations in the order parameters through the equation of state rather than the explicit energy-momentum exchange. As an experimental signal we propose an enhancement of higher flow harmonics. Fig. 1 shows the Fourier coefficients v_n of the azimuthal baryon number distribution in position space. We find a clear enhancement of all moments for an evolution through the first-order phase transition compared to an evolution through the critical point.

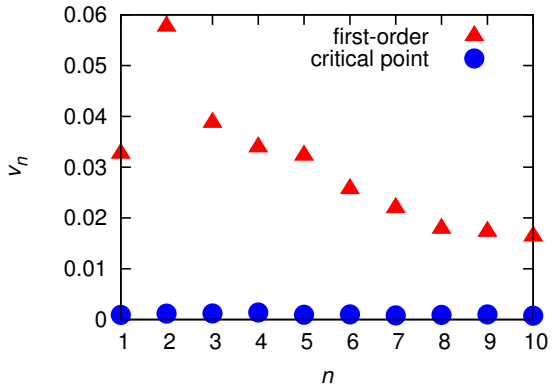


Figure 1: Event-averaged Fourier coefficients of net-baryon distributions in position space for the two scenarios: evolution through the first-order phase transition (triangles) and through the CEP (circles).

Related publications in 2013:

1) C. Herold, M. Nahrgang, I. Mishustin, M. Bleicher, *Chiral fluid dynamics with explicit propagation of the Polyakov loop*, Phys. Rev. C 87, 014907 (2013)

2) M. Nahrgang, C. Herold and M. Bleicher, *Influence of an inhomogeneous and expanding medium on signals of the QCD phase transition*, Nucl. Phys. A 904-905, 899c-902c (2013)

3) C. Herold, M. Nahrgang, I. Mishustin, M. Bleicher, *Dynamic Enhancement of Fluctuation Signals at the QCD Phase Transition*, PoS CPOD2013, 021 (2013)

4) C. Herold, M. Nahrgang, I. Mishustin, M. Bleicher, *Formation of droplets with high baryon density at the QCD phase transition in expanding matter*, Nucl. Phys. A 925, 14-24 (2014), arXiv:1304.5372 [nucl-th]

Initial conditions, hadronization and transport coefficients in heavy-ion collisions

Collaborators: R. Marty[1], E. Bratkovskaya[1], W. Cassing[2], J. Aichelin[3]

[1] Frankfurt Institute for Advanced Studies, [2] Institut für Theoretische Physik, Giessen, [3] Subatech, Nantes, France

The study of the properties of the Quark-Gluon Plasma (QGP) – formed in heavy-ion collisons – requires to understand how the initial quark and gluon distributions affect the final observables through the expansion and hadronization phases.

The issue of initial conditions in relativistic heavy-ion collisions is a subject of intensive debate. Especially the assumption of thermal equilibrium after $\sim$1 fm/c is currently not supported by microscopic transport approaches. In our study we compare the Parton-Hadron-String Dynamics (PHSD) with the novel transport approach RSP (Relativistic quantum molecular dynamics for Strongly interacting matter with Phase transition or crossover) – based on the Nambu–Jona-Lasinio (NJL) model [1] – employing the same initial conditions from PHSD, which have a 'lumpy' energy density profile (see Fig. 1, left picture).

Although we have the same initial energy density profile, the transport properties of bulk partonic matter in RSP and in PHSD are not the same [2]. The main difference between both approaches is that RSP uses light quarks which convert into hadrons using NJL cross sections, and that PHSD uses heavy partons (quarks and gluons) which combine into heavy hadrons with broad spectral functions which then decay into light hadrons.

The comparison of final hadronic observables (right picture of Fig. 1) shows that the initial parton distribution must be out of equilibrium in both approches (PHSD/RSP) in order to reproduce the multiplicity spectra dN/dp_T and $dN/d\eta$ and the elliptic flow v_2 for Au+Au at RHIC energies.

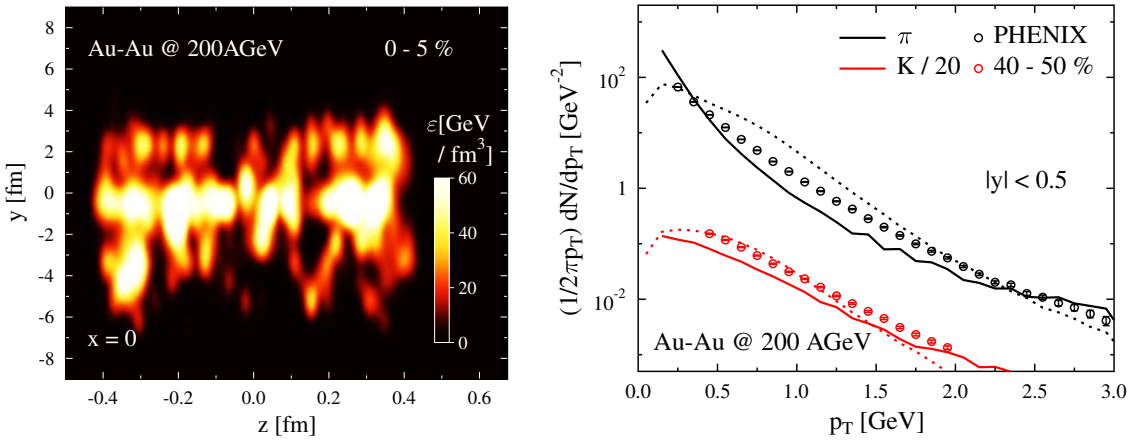


Figure 1: Left: initial energy density for cells in the local rest frame in the $y-z$ plane, Right: transverse momentum distribution dN/dp_T of final charged pions and kaons in RSP (full lines) and PHSD (dashed lines).

The conversion of fluid cells from one model to another – both out of equilibrium – keeps the interesting properties of the initial state: the anisotropy in momentum in p_T/p_z, the chemical mixture of species, and the particle density shift (for a given energy density in a cell, the equation of state gives a particle density which is not the one we really have in this cell in the out of equilibrium calculations).

Related publications in 2012:

[1] Phys. Rev. C 87, 034912 (2013), R. Marty, J. Aichelin.

[2] Phys. Rev. C 88, 045204 (2013), R. Marty, E. Bratkovskaya, W. Cassing, J. Aichelin and H. Berrehrah.

On- and off-shell heavy quark transport properties in the quark-gluon plasma (QGP)

Collaborators: H. Berrehrah[1], E. Bratkovskaya[1], W. Cassing[2], P.B Gossiaux[3], J. Aichelin[3]

[1] Frankfurt Institute for Advanced Studies, [2] Institut für Theoretische Physik, Giessen, [3] Subatech, Nantes, France

Within the aim of a dynamical study of on- and off-shell heavy quarks Q in the quark gluon plasma (QGP) - as produced in relativistic nucleus-nucleus collisions - we study the heavy quark collisional scattering on partons of the QGP and the underlying transport properties.

The collisional scattering cross sections σ^{Q}_{elas} are evaluated for perturbative partons (massless on-shell particles) and for dynamical quasi-particles (massive off-shell particles as described by the dynamical quasi-particles model "DQPM") using the leading order Born diagrams [1]. Figure 1 (left) shows the elastic cross section of charm quark on a "u" quark as a function of $\sqrt{s}$, the energy in the c.m.s. of the collision for different temperatures. Comparing the DpQCD (Dressed pQCD) and IEHTL (Infrared Enhanced HTL) models where the partons have the DQPM pole masses in the first and are off-shell quasi-particles dressed by DQPM spectral functions in the second, we demonstrate that the finite width of the quasi-particles in the DQPM has little influence on σ^{Q}_{elas} except close to thresholds. The size of σ^{Q}_{elas} is dominated by the infrared regulator which in the finite temperature medium is determined by a dynamical gluon mass.

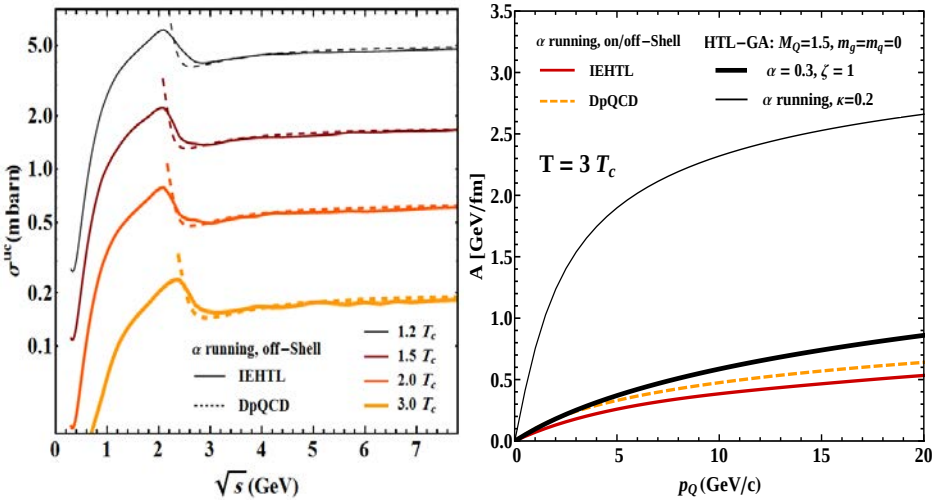


Figure 1: *Left: Elastic cross section of $uc \to uc$ for off-shell (solid lines) and on-shell partons (dashed lines) as a function of $\sqrt{s}$ for different temperatures. Right: c-quark drag coefficient A from non-perturbative approaches DpQCD/IEHTL and the perturbative model HTL-GA as a function of the c-quark momentum.*

Based on σ^{Q}_{elas} in a finite temperature medium [1], the on- and off-shell heavy quark dynamical collisional energy loss and transport coefficients are computed [2,3]. As an example, the charm drag coefficient is shown in figure 1 (right) where both the on- and off-shell partons are employed. The Q momentum dependence of the drag is small in the non-perturbative models DpQCD/IEHTL compared to a pQCD calculations (HTL-GA with α constant or running). Our comprehensive comparison between perturbative and non-perturbative QCD based models shows out significant differences for the different Q transport characteristics. Nevertheless, our conclusion is that an explicit transport calculations in comparison to experimental data are needed to pin down the appropriate scenario, since the microscopic ingredients and the QGP background description are coupled and are specific to each model. The Q scattering cross sections and transport properties [1-3] will form the basis of a consistent study of the heavy quark dynamics in heavy-ion collisions at SPS, RHIC and LHC energies by implementing the partonic processes into the PHSD transport approach.

Related publications in 2013:

[1] H. Berrehrah, P.B. Gossiaux, J. Aichelin, E. Bratkovskaya, W. Cassing and M. Bleicher, *arXiv:1308.5148*
[2] H. Berrehrah, E. Bratkovskaya, W. Cassing, P.B. Gossiaux, J. Aichelin, *arXiv:1311.0736 [hep-ph]*
[3] H. Berrehrah, E. Bratkovskaya, W. Cassing, P.B. Gossiaux, J. Aichelin., *Dynamical collisional energy loss and transport properties of on-shell and off-shell heavy quarks in vacuum and in the Quark-Gluon Plasma*, To be published.

Strange and heavy mesons in hot and dense nuclear matter: hadronic models and transport simulations for a road to FAIR

Collaborators: Daniel Cabrera[1,2], Andrej Ilner[1,2], Juan M. Torres-Rincon[3], Laura Tolos[1,3], Jörg Aichelin[4], Elena Bratkovskaya[1,2], Wolfgang Cassing[5]

[1] Frankfurt Institute for Advanced Studies, [2] Institut für Theoretische Physik, Goethe Universität Frankfurt, [3] Institut de Ciències de l'Espai (IEEC/CSIC), Bellaterra, Spain, [4] Subatech, Université de Nantes, France, [5] Institut für Theoretische Physik, Universität Giessen

We study the properties of strange and heavy-flavoured mesons in a hot and dense nuclear medium within a selfconsistent coupled-channel approach based on the chiral Lagrangian. In the strangeness sector, we have completed a new determination of the in-medium scattering amplitudes and cross sections (such as $\bar{K}N \to \pi\Sigma$) in addition to the (off-shell) K and $\bar{K}$ spectral functions and quasi-particle properties, both at finite nuclear densities and temperatures, mimicking the expected scenario at FAIR experiments (cf. Fig. 1). The former is of particular interest for microscopic transport simulations of strangeness production and propagation in heavy-ion collisions. Our next step in this project is to implement our results in the IQMD and PHSD models, exploiting the successful collaboration between the transport groups of Nantes and FIAS-Frankfurt.

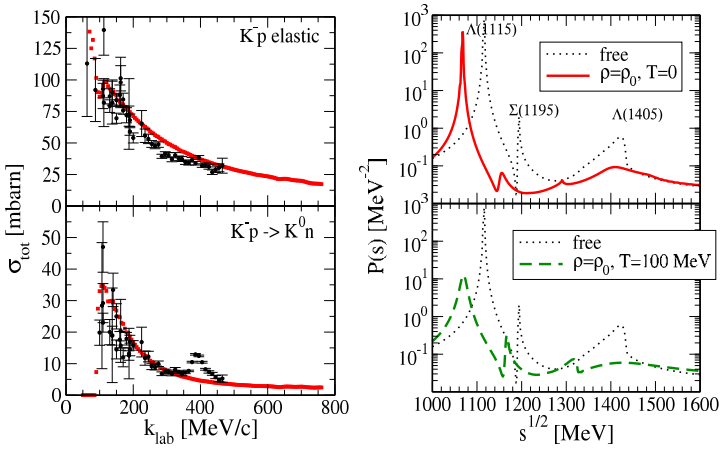


Figure 1: Left: $K^- p$ elastic and $K^- p \to \bar{K}^0 n$ total cross sections (red squares: model). Right: Transition probability ($P \propto |T|^2$) for the $K^- p$ elastic reaction at finite nuclear density (up) and temperature (down).

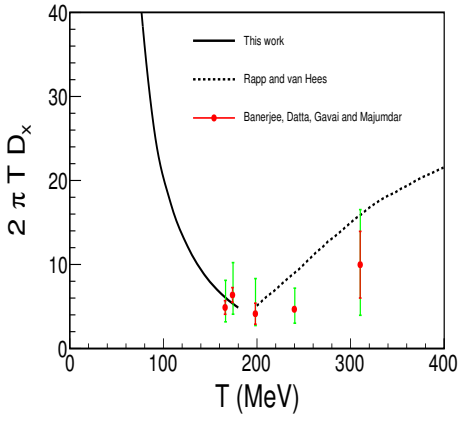


Figure 2: D-meson spacial diffusion coefficient around the crossover at $\mu_B = 0$.

In the heavy-flavour sector, we have applied the unitary extension of heavy-meson chiral perturbation theory to determine the transport coefficients of charmed and bottomed mesons in a hadron gas, both at vanishing and finite baryonic chemical potential. Our approach imposes partial-wave unitarity on the relevant scattering amplitudes (e.g. $D\pi$, $B\pi$), an essential requirement in order to extend the applicability of the low-energy theory to high temperatures ($T \simeq m_\pi$). With a minimal set of parameters the unitarized theory dynamically generates the low lying heavy-light meson s-wave resonances ($D_{0,1}$, $B_{0,1}$) in good agreement with the available experimental data both in the charm and bottom sectors. Since a resonant interaction is bound to produce shorter thermalization times, accounting for this feature is important to produce a realistic estimation of the transport coefficients of heavy mesons in the hadronic phase of a heavy-ion collision (cf. Fig. 2).

Related publications in 2013:

1) L. M. Abreu, D. Cabrera and J. M. Torres-Rincon, Phys. Rev. D **87** (2013) 3, 034019
2) L. Tolos, D. Cabrera, C. Garcia-Recio *et al.*, Nucl. Phys. A **914** (2013) 461
3) D. Cabrera, L. M. Abreu, F. J. Llanes-Estrada and J. M. Torres-Rincon, Nucl. Phys. A **914** (2013) 505
4) J. M. Torres-Rincon, L. M. Abreu, D. Cabrera *et al.*, to be published in JPCS, arXiv:1312.3536 [hep-ph]
5) D. Cabrera, L. M. Abreu, E. Bratkovskaya *et al.*, to be published in JPCS, arXiv:1312.4343 [hep-ph]
6) A. Ilner, D. Cabrera, P. Srisawad and E. Bratkovskaya, sub. to Nucl. Phys. A, arXiv:1312.5215 [hep-ph]

The phase diagram of nuclear and quark matter at high baryon density

Collaborators: Kenji Fukushima[1], Chihiro Sasaki[2]

[1] Department of Physics, Keio University, Japan, [2] Frankfurt Institute for Advanced Studies

In this review we have addressed physical properties of nuclear and quark matter and given pedagogical descriptions on the tools used in theoretical research. On the phase diagram with two environmental parameters, the temperature T and the baryon chemical potential μ_B, only a small portion has been understood; the QCD phase transitions of deconfinement and chiral restoration at (nearly) zero density, and the nuclear liquid-gas phase transition that is inevitable from the saturation property of nuclear matter. For the zero-density crossover, a pile of experimental and lattice-QCD data have been accumulated. Also the hadron resonance gas model works nicely, with which a physical picture has been established. In the nuclear physics territory the correct understanding is guided by experimental data, but the direct application of QCD to nuclear matter is still a big challenge. In practice one cannot avoid modeling the QCD dynamics in a form of the effective description. We reviewed various theoretical approaches to explore the phase diagram of nuclear and quark matter at high baryon density: (1) universality and critical phenomena, (2) relativistic mean field model, (3) chiral perturbation theory, (4) vector mesons from hidden local symmetry approach, (5) large-N_c QCD: Skyrme model and Sakai-Sugimoto model, (6) chiral effective models.

Recent theoretical works suggest that the baryon-rich state of matter may have rich contents than believed. We illustrated two possible scenarios with and without the first-order phase boundary in Fig. 1 and emphasized that the QCD phase diagram can be still non-trivial enough even without the first-order phase transition and the QCD critical point.

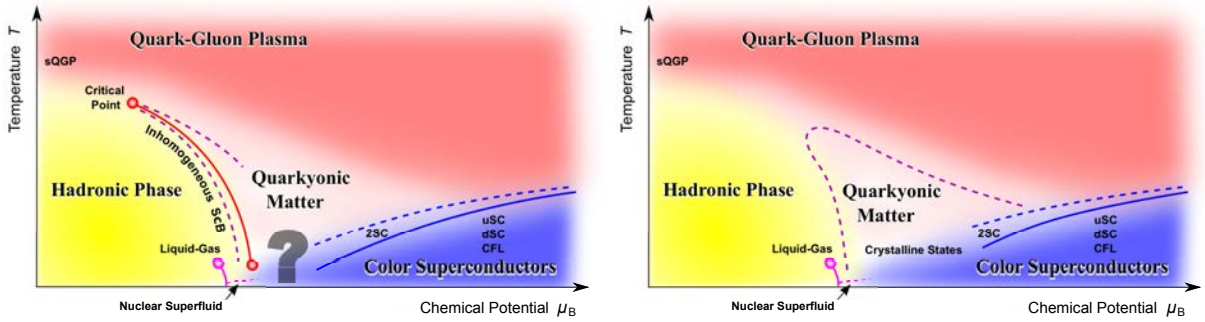


Figure 1: Two representative scenarios for the QCD phase diagram; one with the QCD critical point(s) adapted from Fukushima-Hatsuda (2010) and the other without the first-order phase transition at all.

C. S. acknowledges partial support by the Hessian LOEWE initiative through the Helmholtz International Center for FAIR (HIC for FAIR).

Related publications in 2013:

1) K. Fukushima and C. Sasaki, *The phase diagram of nuclear and quark matter at high baryon density*, Prog. Part. Nucl. Phys. 72, 99 (2013) [arXiv:1301.6377 [hep-ph]]

Probing Deconfinement with Polyakov Loop Susceptibilities

Collaborators: Pok Man Lo[1], Bengt Friman[1], Olaf Kaczmarek[2], Krzysztof Redlich[3,4], Chihiro Sasaki[5]

[1] GSI, Helmholzzentrum für Schwerionenforschung, Darmstadt, [2] Fakultät für Physik, Universität Bielefeld, Bielefeld, [3] Institute of Theoretical Physics, University of Wroclaw, Poland, [4] Extreme Matter Institute EMMI, GSI, Darmstadt, [5] Frankfurt Institute for Advanced Studies

We have calculated the Polyakov loop susceptibilities in the SU(3) lattice gauge theory for different number of quark flavors, $N_f = 0$ and $N_f = (2+1)$. For (2+1)-flavor QCD, the susceptibilities were calculated from the Polyakov loop results where the HISQ action with almost physical strange quark mass and $m_{u,d} = m_s/20$ was used. We have discussed the temperature dependence of the longitudinal χ_L, the transverse χ_T and the absolute value χ_A of the Polyakov loop fluctuations. We have analyzed general properties of the Polyakov loop susceptibilities in relation to the color group structure and motivated their ratios, $R_A = \chi_A/\chi_L$ and $R_T = \chi_T/\chi_L$, as relevant observables to probe deconfinement.

A remarkable feature of different ratios of the Polyakov loop susceptibilities is their strong sensitivity to a phase change in a system. In the SU(3) pure gauge theory the ratios of susceptibilities show discontinuity at the critical point and exhibit a very weak, but different, temperature dependence in the confined and deconfined phase. The explicit breaking of the $\mathscr{Z}_3$ center symmetry in QCD, due to quark fields, modifies this property. The R_A and in particular R_T ratios are substantially smoothened, yet still display interesting features related to the deconfinement, as shown in Fig. 1. The R_A converges to the asymptotic values found in a pure gauge theory, both in the confined and the deconfined phase. Whereas, the R_T converges only to the low temperature limit of a pure gauge theory. At high temperatures and for light quarks, it differs substantially from the results obtained in a pure gauge theory.

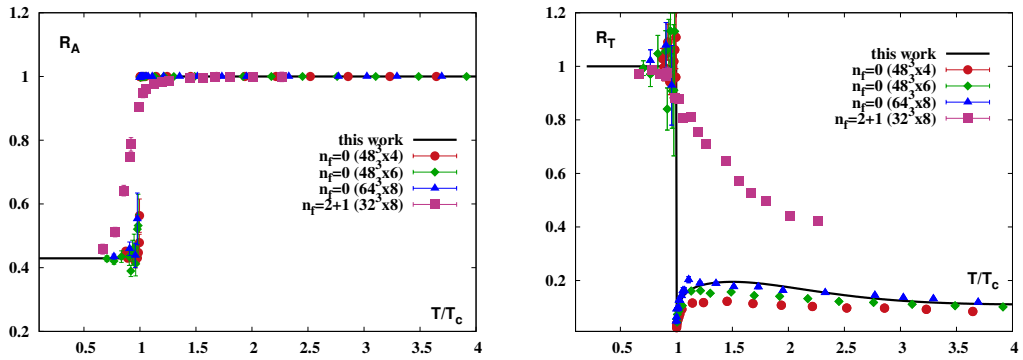


Figure 1: (Left) The ratio of the absolute to longitudinal part of the Polyakov loop susceptibilities calculated within lattice gauge theory for pure gauge system and (2+1)-flavor QCD. The temperature is normalized to its (pseudo) critical value for respective lattice. (Right) The ratio of the transverse to longitudinal susceptibility of the Polyakov loop.

C. S. acknowledges partial support by the Hessian LOEWE initiative through the Helmholtz International Center for FAIR (HIC for FAIR).

Related publications in 2013:

1) P. M. Lo, B. Friman, O. Kaczmarek, K. Redlich and C. Sasaki, *Probing Deconfinement with Polyakov Loop Susceptibilities*, Phys. Rev. D 88, 014506 (2013) [arXiv:1306.5094 [hep-lat]]

2) P. M. Lo, B. Friman, O. Kaczmarek, K. Redlich and C. Sasaki, *Polyakov loop fluctuations in SU(3) lattice gauge theory and an effective gluon potential*, Phys. Rev. D 88, 074502 (2013) [arXiv:1307.5958 [hep-lat]]

Implementation of chromomagnetic gluons in Yang-Mills thermodynamics

Collaborators: Chihiro Sasaki[1], Igor Mishustin[1,2], Krzysztof Redlich[3,4]

[1] Frankfurt Institute for Advanced Studies [2] Kurchatov Institute, Russian Research Center, Moscow, Russia, [3] Institute of Theoretical Physics, University of Wroclaw, Poland, [4] Extreme Matter Institute EMMI, GSI, Darmstadt

We have proposed an effective theory of SU(3) Yang-Milles (YM) theory implementing the major global symmetries, the center and scale symmetries, and their dynamical breaking. This naturally allows a mixing between the Polyakov loop and the dilaton field. Consequently, the magnetic confinement is effectively embedded and results in deviations of the EoS from their Stefan-Boltzmann limit at high temperature. Through a matching to the 3-dimensional YM theory, the gluon condensate increases with temperature in deconfined phase. Contrary, in the conventional treatment of the dilaton condensate, there is a weak thermal behavior of the composite gluon in a wide range of temperature. This suggests, that at some temperature above T_c, the gluon condensate exhibits a distinct behavior on T. In the present theory this temperature is roughly estimated as $\sim 2.4\,T_c$ (see Fig. 1-left), compatible with $\sim 2\,T_c$ extracted from the spatial string tension.

Applying this idea to the interaction measure, the magnetic contribution generates a T^2 dependence and this results in a plateau-like behavior emerging in $I/T^2T_c^2$ at moderate temperature, $T/T_c \sim$ 2-4, as shown in Fig. 1-right. The obtained behavior of $I/T^2T_c^2$ with temperature qualitatively agrees with the latest lattice data. Thus, the role of the magnetic gluon turns out to be alternative to the Hard Thermal Loop (resummed perturbation theory) contribution.

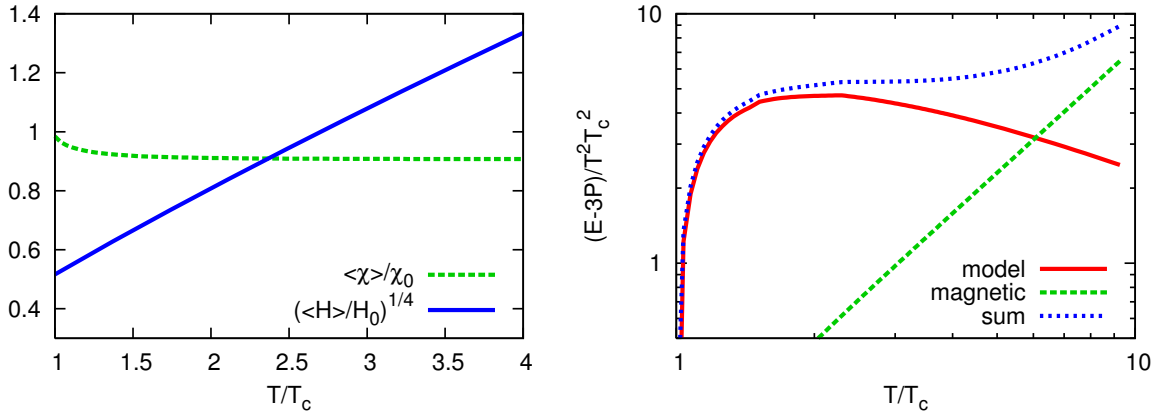


Figure 1: (Left) Thermal expectation value of the dilaton (dashed) and the magnetic condensate (solid). (Right) The interaction measure normalized by $T^2T_c^2$. The dashed curve labeled with "magnetic" corresponds to the contribution from the magnetic gluon $\langle H \rangle$.

C. S. acknowledges partial support by the Hessian LOEWE initiative through the Helmholtz International Center for FAIR (HIC for FAIR).

Related publications in 2013:

1) C. Sasaki, I. Mishustin and K. Redlich, *Implementation of chromomagnetic gluons in Yang-Mills thermodynamics*, arXiv:1308.3635 [hep-ph], to appear in Phys. Rev. D

2) C. Sasaki, *Yang-Mills thermodynamics: an effective theory approach*, arXiv:1312.3818 [hep-ph]

3) C. Sasaki, *Interplay between chromoelectric and chromomagnetic gluons in Yang-Mills thermodynamics*, arXiv:1312.5245 [hep-ph]

Interplay between omega-Nucleon Interaction and Nucleon Mass in Dense Baryonic Matter

Collaborators: Won-Gi. Paeng[1], Hyun Kyu Lee[1], Mannque Rho[1,2], Chihiro Sasaki[3]

[1] Department of Physics, Hanyang University, Korea, [2] Institut de Physique Théorique, CEA Saclay, France, [3] Frankfurt Institute for Advanced Studies

We have considered an effective Lagrangian for the lowest vector mesons $V = (\rho, \omega)$, in addition to pions, and baryons coupled to the mesons. This implements a scalar dilaton field χ reflecting spontaneously broken scale symmetry linked to the QCD trace anomaly. The role of scalar fields in effective Lagrangians is highly problematic in general and it is not at all obvious how to do this also in our case. We will however be guided by phenomenology in low-energy nuclear physics, namely, the EFT Lagrangian be treated at mean field with the parameters of the Lagrangian "sliding" with the density of the background.

The key observation was that the $U(2)$ symmetry, seemingly good in the matter-free vacuum, must break down in medium, and hence the properties of the iso-vector and iso-scalar vector mesons behave markedly differently as density is increased. The essential element is the origin of the bulk of proton mass that appears to have no direct link to chiral symmetry, its renormalization group (RG) flow and its unsuspected association with the property of the ω-NN interaction in dense medium. Our conclusion is that while the ρ and ω masses tend to zero (in the chiral limit), perhaps not in the same way, as density is increased, the effective ω-nuclear coupling "walks" in contrast to the effective ρ-nuclear coupling that "runs". This feature was indicated in the phenomenology of compact-star matter, and we have shown how that feature can be understood in the framework of our effective Lagrangian approach. It turned out that the nucleon mass cannot decrease much as density increases without getting into conflict with nature (see Fig. 1).

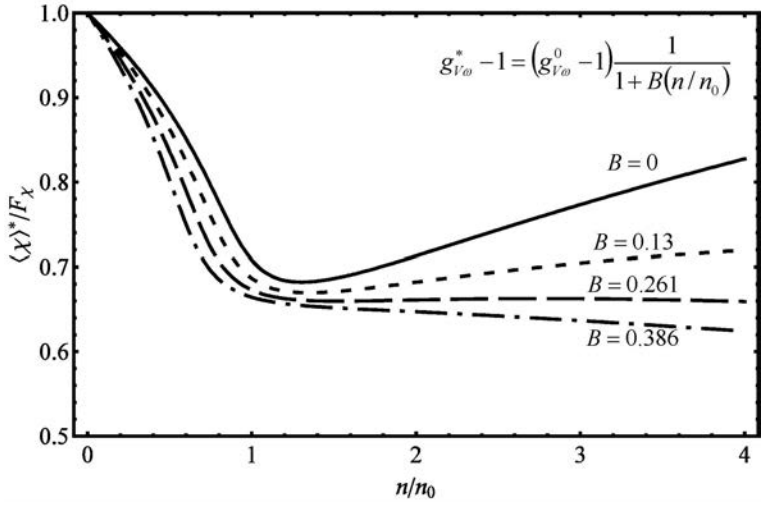


Figure 1: The ratio $m_N^*/m_N \approx \langle\chi\rangle^*/\langle\chi\rangle_0$ as a function of density for varying density dependence of $g^*_{V\omega}$. What is notable is that the nucleon mass stops dropping at a density slightly above nuclear matter density n_0 and stays more or less constant above that density.

C. S. acknowledges partial support by the Hessian LOEWE initiative through the Helmholtz International Center for FAIR (HIC for FAIR).

Related publications in 2013:

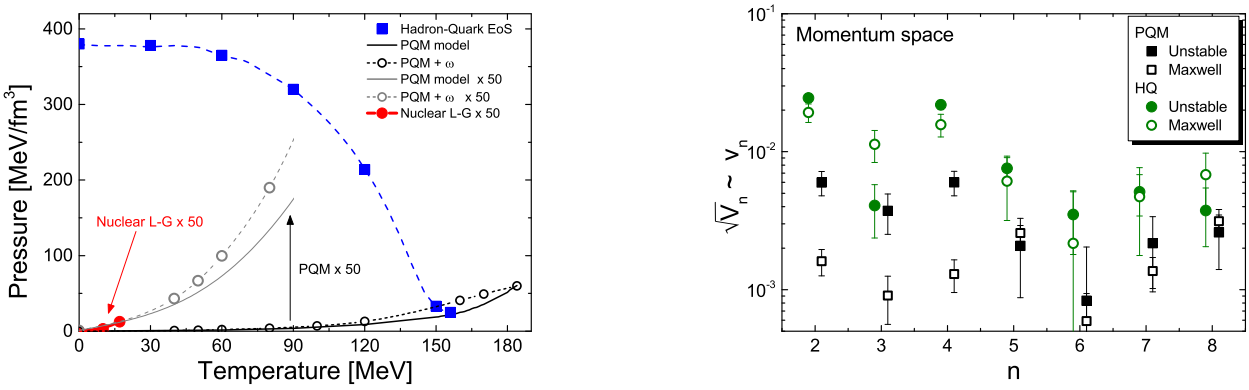
1) W. -G. Paeng, H. K. Lee, M. Rho and C. Sasaki, *Interplay between omega-Nucleon Interaction and Nucleon Mass in Dense Baryonic Matter*, Phys. Rev. D 88, 105019 (2013) [arXiv:1303.2898 [nucl-th]]

Non-equilibrium phase transition in relativistic nuclear collisions: Importance of the equation of state

Collaborators: Jan Steinheimer[1], Jørgen Randrup[2], Volker Koch[2]

[1] Frankfurt Institute for Advanced Studies, [2] Lawrence Berkeley National Laboratory, USA

We have investigated the effect of qualitatively different types of two-phase equation of state on the expansion dynamics and on possible experimental signals of the expected QCD phase transition at large baryon densities. We considered two equations of state representing two qualitatively different EoS classes. On the one hand, as an example for an EoS exhibiting phase coexistence between compressed nuclear matter and the dense quark phase, we considered an EoS that is constructed by interpolating between a hadron gas and a quark-gluon phase (HQ EoS). On the other hand, as a representative for the class of liquid-gas type equations of state, we used the EoS from a Polyakov Quark Meson (PQM)-like model. We find that the PQM model shows a transition that is very similar to that of the liquid-gas transition in nuclear matter and thus this model differs qualitatively from the HQ model with regard to the thermodynamic properties near the phase coexistence line. The qualitative differences between the two equations of state examined in this work lead to significant quantitative differences in the time evolution of fireballs that expand through the respective unstable region of the phase diagram. In the PQM model the lifetime of quark clusters is orders of magnitude longer than what is usually expected for the timescales of heavy-ion collisions and it predicts stable dense quark matter droplets at zero temperature. The instabilities associated with the presence of a first-order phase transition lead to large irregularities in the spatial distribution of the baryon number. However, these irregularities are not translated into significant momentum correlations and the observation of these differences is a challenging task. Thus the key question on how to detect those instabilities, if indeed present, remains unsettled.



(a) (b)

Figure 1: Left: The pseudo-critical pressure as a function of the temperature, $p_{\rm pc}(T)$, for both the HQ (blue dashed curve with squares) and the PQM model (black curves) models. The black dashed line with open circles shows the result of the PQM model with finite quark vector coupling. On a scale magnified by a factor of fifty, the PQM results (grey) are compared with the nuclear liquid-gas transition. Right: The momentum-space two-baryon angular correlation strength $V_n^{\rm mom}$ for various values of n as obtained with the HQ (circles) and PQM (squares) EoS. The results obtained with an unstable EoS (solid) are contrasted with those employing the Maxwell partner (open).

Related publications in 2013:

1) J. Steinheimer, J. Randrup and V. Koch, *Non-equilibrium phase transition in relativistic nuclear collisions: Importance of the equation of state*, arXiv:1311.0999 [nucl-th], to be published in Phys. Rev. C.

2) J. Steinheimer and J. Randrup, *Spinodal density enhancements in simulations of relativistic nuclear collisions*, Phys. Rev. C 87, 054903 (2013)

Hadronization in Relativistic Nucleus-Nucleus Collisions, and the QCD Phase Diagram

Collaborators: R. Stock[1], F. Becattini[2] and J. Steinheimer[1]

[1] FIAS, Frankfurt University, [3] Universita di Firenze and INFN Sezione die Firenze, Italy

Hadron yields in high energy nuclear collisions resemble, closely, a quasi-classical grand canonical Gibbs ensemble. This indicates hadro-chemical equilibrium prevailing right after hadronization. The statistical hadronization model (SM) determines the Gibbs ensemble parameters, temperature T and baryochemical potential μ_B. From top SPS to LHC energy T saturates toward 160 ± 5 MeV, thus coinciding with recent lattice QCD predictions of the parton to hadron phase transformation: hadronization and freeze-out appear to coincide.

Before declaring the semi-experimental determination of the QCD phase diagram, one of the key assumptions in SM application to hadron multiplicities needs to be addressd: are the primordial yields really freezing-in "instantaneously" right after hadronization? Our study of annihilation/regeneration effects during the final cascade expansion with the UrQMD transport model showed essentially no final state influences on mesons, but substantial attenuation of the baryon-antibaryon species, depending both on the species and incident energy. This leads to a downward shift of the temperatures inferred from SM analysis [1]. In a first attempt to account for such effects we quantify the final state attenuations by deducing modification factors for each species from UrQMD, and employ them in the SM analysis. The resulting hadronization temperatures agree well with recent lattice QCD predictions up to $\mu_B = 400$ MeV [2]. In a further, new analysis of ALICE Pb+Pb minimum bias data at 2.7 TeV we demonstrate that standard SM analysis gives temperatures slightly increasing toward peripheral collisions. This is in line with our modification approach because the final state attenuation should diminish here, because of the faster drop-off of density and collision number occuring in the expansion of smaller fireball volumes–and UrQMD shows just this. After inclusion of the centrality dependent modification factors we find, universally, a temperature of 166 ± 5 MeV: the final, universal corrected temperature at $\mu_B = 0$.

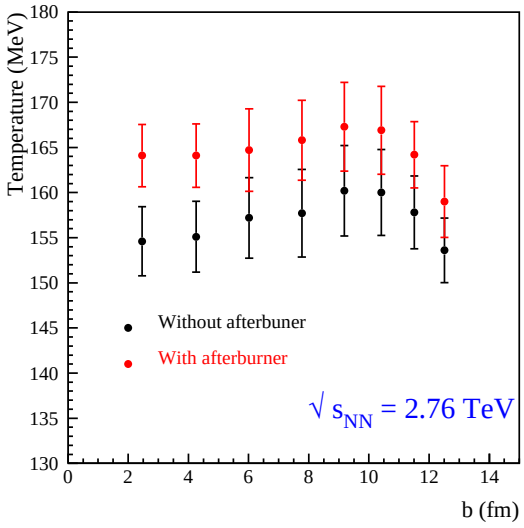


Figure 1: **Hadronization at the LHC: a solved puzzle:** The figure shows hadronization temperatures derived from Statistical Model analysis of ALICE results for hadron production in Pb+Pb collisions at 2.76TeV, as a function of the collision impact parameter b (from central to peripheral collisions). The standard SM method yields the "puzzling" temperature of about 157 MeV. The corrected analysis implements the "afterburner" effects due to baryon annihilation/regeneration during the hadronic phase. It recovers the temperature $T = 164 \pm 5$ MeV that is in agreement with recent predictions of Lattice QCD

Related publications

1) F. Becattini, M. Bleicher, Th. Kollegger, M. Mitrovski, T. Schuster, R. Stock, Phys. Rev. C85, 044921 (2012)

2) F. Becattini, M. Bleicher, Th. Kollegger, T. Schuster, J. Steinheimer, R. Stock, Phys. Rev. Lett. 111, 082302 (2013)

Separate chemical freeze-out of strange hadrons

Collaborators: K.A. Bugaev[1], D.R. Oliinychenko[1,2], J. Cleymans[3], A.I. Ivanytskyi[1], I.N. Mishustin[2,4], E. G. Nikonov[5], V.V. Sagun[1]

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We thoroughly analyzed two approaches to treat the chemical freeze-out of strange particles in hadron resonance gas model with the multicomponent hard-core repulsion. The first approach accounts for their chemical non-equillibribrium via the usual γ_s factor and such a model describes the hadron multiplicities measured in nucleus-nucleus collisions at AGS, SPS and RHIC energies with $\chi^2/\mathrm{dof} = 63.4/55 \simeq 1.15$. In contrast to earlier beliefs established on the low quality fit, we find that within the error bars in heavy ion collisions there is a sizable enhancement of strangeness, i.e. $\gamma_s > 1$, at $\sqrt{s_{NN}} = 2.7, 3.3, 3.8, 4.9, 6.3, 9.2$ GeV (see the left panel of the figure). Also we suggested entirely new concept to treat the strange particle freeze-out separately, but with the full chemical equilibration. This approach is based on the conservation laws which allow us to connect the freeze-outs of strange and non-strange hadrons. Our analysis shows that for the same number of fitting parameters the new approach is working not worse than the γ_s approach with $\chi^2/\mathrm{dof} = 58.5/55 \simeq 1.06$, but for $\sqrt{s_{NN}} = 6.3$, 12 and 17 GeV it tremendously improves the fit quality. For all collision energies we see that $\bar{p}/\pi^-$, $\bar{\Lambda}/\Lambda$, $\bar{\Xi}^-/\Xi^-$ and $\bar{\Omega}/\Omega$ ratios are much better described than within the traditional γ_s approach, since a separation of chemical freeze-outs relaxes the strong connection between the non-strange and strange baryons. The new concept allows us to describe 111 independent hadron ratios measured at 14 different energies with the highest quality ever achieved (see, for example, the right panel of the figure). Also these results allow us to conclude that an apparent strangeness enhancement is due to the separate strangeness chemical freeze-out.

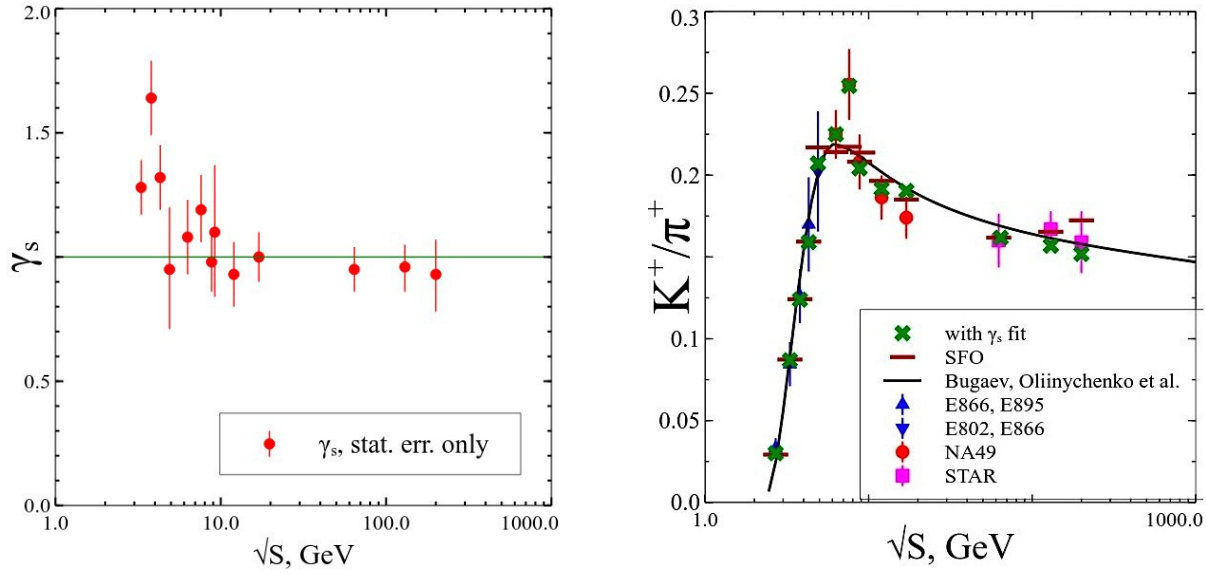


Figure 2: *Left panel:* Center of mass energy dependence of the γ_s factor. *Right panel:* Description of K^+/π^+ ratio. Solid line is the result of the multicomponent model with $\gamma_s = 1$. Crosses stand for the case with γ_s fitted ($\chi^2/\mathrm{dof} = 3.3/14$), while the horizontal bars correspond to separate chemical freeze-out of strange hadrons ($\chi^2/\mathrm{dof} = 6.3/14$).

Related publication in 2013:

1) K. A. Bugaev, D. R. Oliinychenko, J. Cleymans, A. I. Ivanytskyi, I. N. Mishustin, E. G. Nikonov, V. V. Sagun, *Chemical Freeze-out of Strange Particles and Possible Root of Strangeness Suppression*, Europhys. Lett. 104, 22002 (2013)

Exactly solvable model for a nuclear liquid-gas phase transition with a compressible nuclear liquid

Collaborators: K.A. Bugaev[1], A.I. Ivanytskyi[1], V.V. Sagun[1], I.N. Mishustin[2,3]

[1] Bogolyubov Institute for Theoretical Physics of NAS of Ukraine, Kiev, Ukraine, [2] Frankfurt Institute for Advanced Studies, [3] Kurchatov Institute, Russian Research Center, Moscow

We worked out a new formulation of the statistical multifragmentation model (SMM) which describes the compressible nuclear liquid [1]. The previous formulations of this model were dealing with an incompressible nuclear liquid, but this feature contradicts to the existing experimental data and leads to an incorrect value for the critical density. The new SMM is based on the analysis of the virial expansion for a system of the nuclear fragments of all sizes. The developed model not only allows us to account for short-range repulsion, but also to calculate the surface free energy which is induced by the interaction between the fragments. The resulting model is exactly solvable and has no irregular behavior of the isotherms in the mixed phase region which is typical for mean-field models. The general conditions for the 1-st and 2-nd (or higher) order phase transitions are formulated. It is shown that all endpoints of the present model phase diagram are the tricritical points, if the Fisher exponent τ is in the range $\frac{3}{2} \leq \tau \leq 2$. The treatment of nuclear liquid compressibility allows us to reduce the tricritical endpoint density of the SMM to one third of the normal nuclear density (see the left panel of the figure). Also the present model leads to an additional equation for the induced surface tension coefficient. It is shown that at the supercritical temperatures the total surface tension is negative. A specific attention is paid to the fragment size distributions in this region. We have found that the fragment size distributions in the region of negative surface tension coefficient have the typical bimodal shape (see the right panel of the figure).

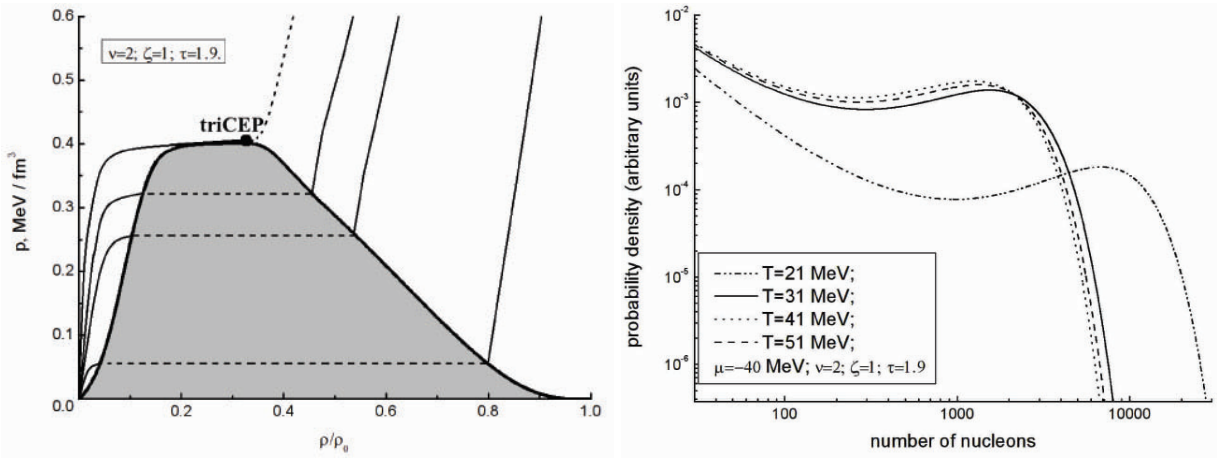


Figure 1: *Left panel:* Model phase diagram is shown in $\rho - p$ plane. The grey area shows the mixed phase of the first order phase transition. The isotherms are shown for $T = 11, 16, 17, 18$ MeV from bottom to top. For the density $\rho/\rho_0 \geq 1/3$ at the isotherm $T = 18$ MeV there exists the 2-nd order phase transition (dashed curve). *Right panel:* Fragment size distributions in the phase with the negative value of the surface tension coefficient are shown for a fixed baryonic chemical potential and different temperatures.

Related publication in 2013:

1) V. V. Sagun, A. I. Ivanytskyi, K. A. Bugaev, I. N. Mishustin: *The statistical multifragmentation model for liquid-gas phase transition with a compressible nuclear liquid*, Nucl. Phys. A924, 24-46 (2014); arXiv:1306.2372 [nucl-th]

Twisted emission geometry in noncentral Pb+Pb collisions measurable via azimuthally sensitive Hanbury-Brown–Twiss correlations

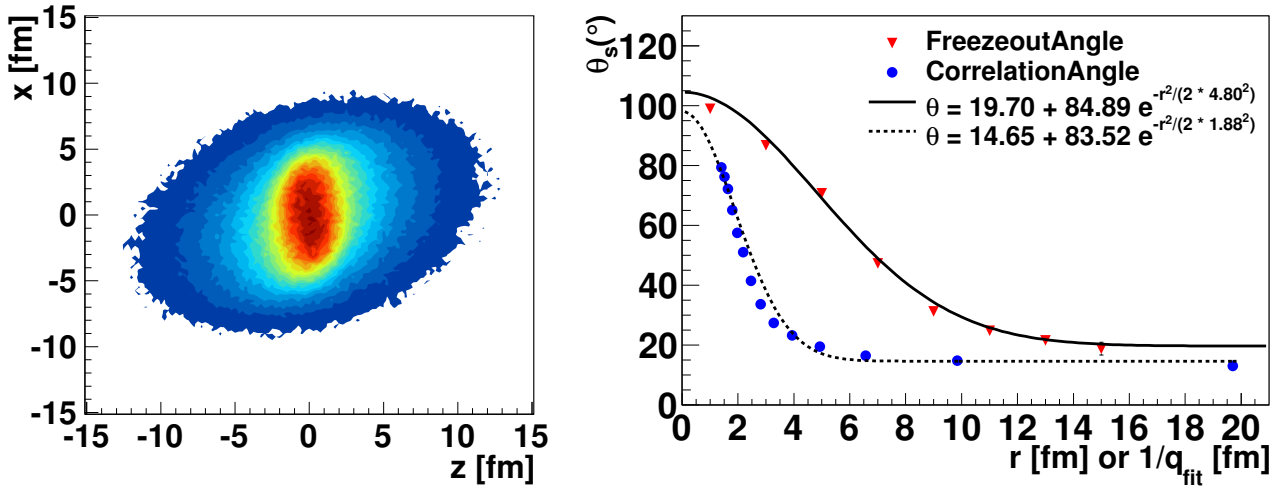
Collaborators: Gunnar Graef[1,2], Mike Lisa[3], Marcus Bleicher[1,2]

[1] Frankfurt Institute for Advanced Studies, [2] Institut für Theoretische Physik, Goethe Universität Frankfurt, [3] Department of Physics, Ohio State University, Columbus,

We use the ultrarelativistic quantum molecular-dynamics (UrQMD) model to simulate Pb+Pb collisions. Figure 1(a) shows the projection of the pion freeze-out distribution into the reaction plane from noncentral Pb+Pb collisions at $E_{lab} = 8$ GeV and $|y| < 0.5$.

In this freeze-out geometry we observe a tilt of the particle emission zone in the collision plane away from the beam axis. We find that the magnitude of this tilt depends on the scale at which the distribution is measured. The distribution is twisted in such a way that the center is tilted perpendicular to the beam direction, while the outer part is within 20 degrees of the beam axis. We quantify this "twisting" behavior with a parametrization and propose a method to measure it experimentally via azimuthally sensitive Hanbury-Brown–Twiss (asHBT) correlations. Figure 1(b) shows the tilt angle θ_S versus the radius as red triangles. These results were obtained by fitting the freeze-out distribution with a tilted three dimensional Gaussian. This technique is not available in experiment. However, we developed a method to measure a scale dependent tilt via asHBT. The blue points show the results of this method for a mock experimental analysis performed with UrQMD results. The x-axis for the asHBT results has to be scaled by a not yet determined factor. Nevertheless, the results of both methods match nicely if the scale factor is taken into account. This shows that the twist is experimentally accessible.

Additionally we show in [1] that the twist arises due to a combination of simple angular momentum conservation, antiflow and shadowing of pion emission at early times and the absence of shadowing at later times.



(a) (b)

Figure 1: a): Projection of the pion freeze-out distribution for Pb + Pb at $E_{lab} = 8$ GeV, $b = 3.4 - 6.8$ fm, $|y| < 0.5$ and $p_\perp < 0.4$ GeV. Z is the direction of the beam and x the direction of the impact parameter. b): θ_S extracted via fits to the freeze-out distribution (red triangles) and via asHBT (blue circles). The x axis shows the radius at which θ_S is extracted and the inverse of the momentum region to which the asHBT analysis was applied. The black lines are Gaussians representing the numerical values of the radius dependence of θ_S in the legend.

Related publications in 2013:

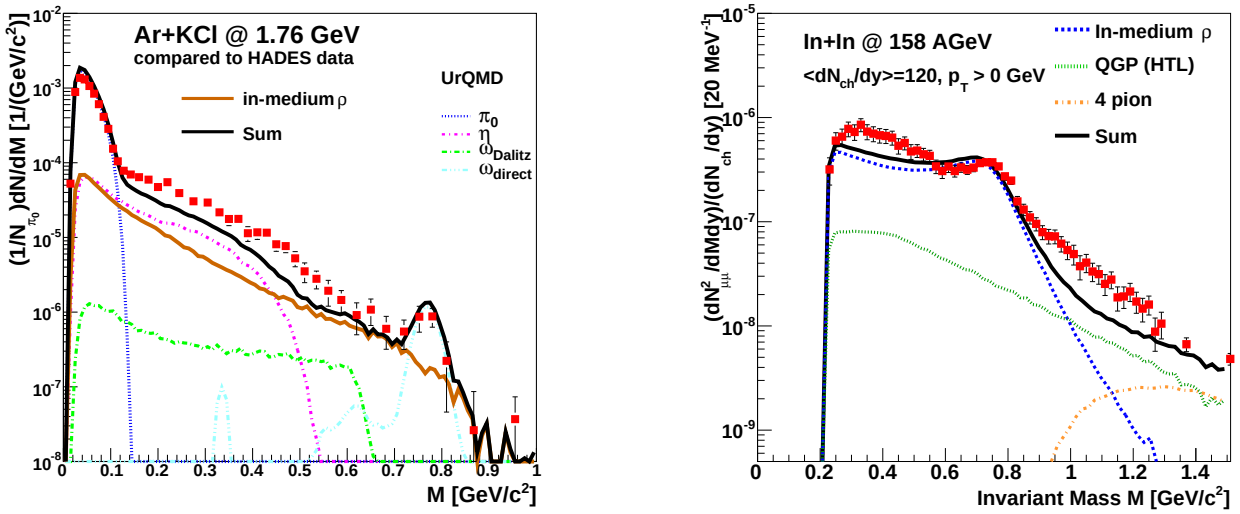
1) G. Graef, M. Lisa, and M. Bleicher, *Twisted emission geometry in noncentral Pb + Pb collisions measurable via azimuthally sensitive Hanbury-Brown–Twiss correlations*, arXiv:1302.3408 [hep-ph], to be published in Phys. Rev. C

Dilepton production in a coarse-grained transport approach

Collaborators: Stephan Endres[1,2], Hendrik van Hees[1,2], Marcus Bleicher[1,2]

[1] Frankfurt Institute for Advanced Studies, [2] Institut für Theoretische Physik, Goethe Universität Frankfurt

Due to their penetrating nature dileptons are a unique tool to study the properties of hadrons (and partons) in the strongly interacting medium created in heavy-ion collisions. They admit the study of the spectral properties and p_T spectra of the light vector mesons (ρ, ω, and ϕ) and provide an assessment of the temperature and flow properties of the medium as well as probably the nature of the chiral phase transition in the QCD phase diagram. Thus it is important to develop realistic models for both the collective motion of the medium over the entire collision history and the in-medium modifications of partons and hadrons. The former can be achieved with transport and/or hydrodynaical simulations of the medium and the latter with relativistic many-body quantum field theory (QFT) in thermal equilibrium. Here we use the UrQMD transport model to simulate the medium. To apply equilibrium evaluations of the vector mesons' in-medium spectral functions based on relativistic many-body QFT, we develop a coarse-graining method to assign a temperature and chemical potential(s) to fluid cells of the transport simulation. To this end the UrQMD output is put on a 3+1 dimensional space-time grid, and the baryon-number and energy density are obtained from averaging over some hundred events. Then using the Eckart definition each cell is transformed to the local restframe to determine the corresponding temperature and baryo-chemical potential, using a chiral equation of state including chiral-symmetry restoration and a deconfinement crossover transition. Using the $T\rho$ approximation by Eletsky and Kapusta to implement medium modifications to the vector-meson self-energies, first successful comparisons of this method to heavy-ion data at GSI SIS energies (HADES) and CERN SPS (NA60) have been done.



(a) (b)

Figure 1: Comparison of the dilepton-invariant mass spectra from a coarse grained transport approach using in-medium ρ-meson spectral functions from the $T\rho$ approximated vector-meson self-energies to data of Ar-KCl collisions from the HADES collaboration at GSI SPS (a) and of In-In collisions from the NA60 collaboration at CERN SPS (b).

Related publications in 2013:

1) S. Endres, M. Bleicher, J. Phys. Conf. Ser. 426, 012033 (2013)
2) S. Endres, H. van Hees, M. Bleicher, PoS CPOD2013, 052 (2013)
3) S. Endres, H. van Hees, J. Weil, M. Bleicher, arXiv:1312.5606 [nucl-th]

3+1 dimensional viscous hydrodynamics at high baryon densities

Collaborators: Iurii Karpenko[1,2], Pasi Huovinen[1,3], Marcus Bleicher[1,3], Hannah Petersen[1,3]

[1] Frankfurt Institute for Advanced Studies, [2] Bogolyubov Institute for Theoretical Physics, NAS of Ukraine, [3] Institut für Theoretische Physik, Goethe Universität Frankfurt

Following the experimental Beam Energy Scan (BES) program at BNL RHIC, we perform a similar "energy scan" using 3+1D viscous hydrodynamics coupled to the UrQMD hadron cascade. The aim of the project is to extend the applicability of a state-of-the-art hydrodynamic model, which is nowadays considered as "heavy ion standard model" for highest RHIC and LHC energies, to lower collision energies. This will allow us to study the possible signals of QCD critical point and softening of the equation of state at large baryon chemical potential, associated with first order phase transition from Quark-Gluon Plasma to hadron gas phase.

To accommodate the model for the lower collision energy regime, 3D initial conditions from UrQMD are used to study a gradual deviation from boost-invariant scaling flow. The starting time of the hydrodynamic stage of evolution is chosen to be $\tau_0 = 2R/\sqrt{(\sqrt{s}/2m_N)^2 - 1}$, where R is a radius of the nucleus and m_N is a nucleon mass. This corresponds to the time when the two nuclei have passed through each other. The equation of state for finite baryon density from a Chiral model coupled to the Polyakov loop is employed for the hydrodynamic stage. To account for viscous effects in the medium, we solve the equations of relativistic viscous hydrodynamics in Israel-Stewart framework. The transition from fluid to particle description (so-called particlization) is made at the constant energy density $\varepsilon_{sw} = 0.5$ GeV/fm^3 when the medium has already hadronized. The scatterings and decays happening after particlization are then treated with UrQMD code.

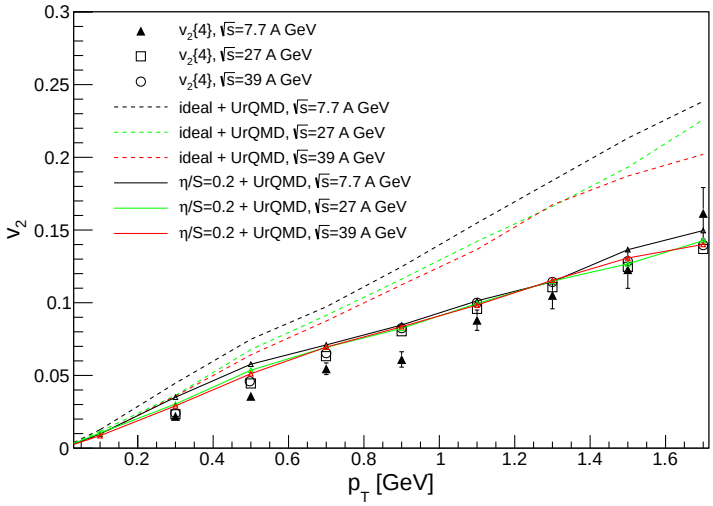


Figure 1: p_T-differential elliptic flow of all charged hadrons for Au-Au collisions at $\sqrt{s_{NN}} = 7.7, 27$ and 39 GeV. The data from STAR collaboration (symbols) are compared to the model calculations with ideal (dashed lines) and viscous ($\eta/s = 0.2$, solid lines) hydrodynamic phase.

We find that the inclusion of shear viscosity in the hydrodynamic stage of evolution consistently improves the description of the data for Pb-Pb collisions at CERN SPS (such as rapidity and p_T distributions of pions and kaons, pion HBT radii), as well as of the elliptic flow measurements for Au-Au collisions in the Beam Energy Scan program at BNL RHIC, see Figure 1. The suggested value of shear viscosity of matter in hydrodynamic phase is $\eta/s \geq 0.2$ for collision energies $\sqrt{s_{NN}} = 6.3 \ldots 39$ GeV.

Related publications in 2013:

1) Iu. Karpenko, M. Bleicher, P. Huovinen, H. Petersen, *Beam energy scan using a viscous hydro+cascade model*, accepted for SQM 2013 proceedings [arXiv:1310.0702]

2) Iu. Karpenko, M. Bleicher, P. Huovinen, H. Petersen, *3+1 dimensional viscous hydrodynamics at high baryon densities*, accepted for FAIRNESS 2013 proceedings [arXiv:1311.0133]

3) Iu. Karpenko, P. Huovinen, M. Bleicher, *A 3+1 dimensional viscous hydrodynamic code for relativistic heavy ion collisions*, submitted for Comput. Phys. Commun. [arXiv:1312:4160]

Mechanisms for production of hypernuclei beyond the neutron and proton drip lines

Collaborators: N. Buyukcizmeci[1,2], A.S. Botvina[1,3,4], J. Pochodzalla[4,5], M. Bleicher[1]

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[2]Department of Physics, Selcuk University, 42079 Kampus, Konya, Turkey,
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We analyze the neutron-rich and proton-rich hypernuclei coming from fragmentation and multifragmentation of spectator residues obtained in relativistic ion collisions. It has been investigated for normal nuclei during the last 10–20 years (see, e.g., the review Th. Aumann, Prog. Part. Nucl. Phys. 59, 3 (2007)). Presently there are extensive experimental projects aimed at this study, for example, the Fragment Separator (FRS) at GSI-Darmstadt, and one is planned for the future FAIR facility too (H. Geissel et al., NIM B204, 71 (2003)). The generalized Statistical Multifragmentation Model SMM (J.P. Bondorf, et al., Phys. Rep. 257, 133 (1995)) applied previously for description of disintegration processes in normal nuclei is also a good candidate to describe the hypernuclear case (A. S. Botvina and J. Pochodzalla, Phys. Rev. C 76, 024909 (2007) and Ref. 1).We show in Figure 1 that the nucleon separation energies in hypernuclei become considerably higher than in normal nuclei, because of coupling hyperons and nucleons inside nuclei. These will have wide mass distributions and isospin and the hyperon contribution to binding such nuclei will make it possible to obtain many nuclei beyond the traditional drip lines. This gives us the opportunity to investigate the properties of exotic hypernuclei, as well as the properties of normal nuclei beyond the drip lines, which can be produced after weak decay of such hypernuclei. Investigation of such hypernuclei will help to answer many fundamental questions of hyperphysics and nuclear physics. It may provide a unique chance to investigate nuclear islands of stability. In this way, we will be able to formulate new experiments at the FAIR and provide valuable information for simulations with our future studies.

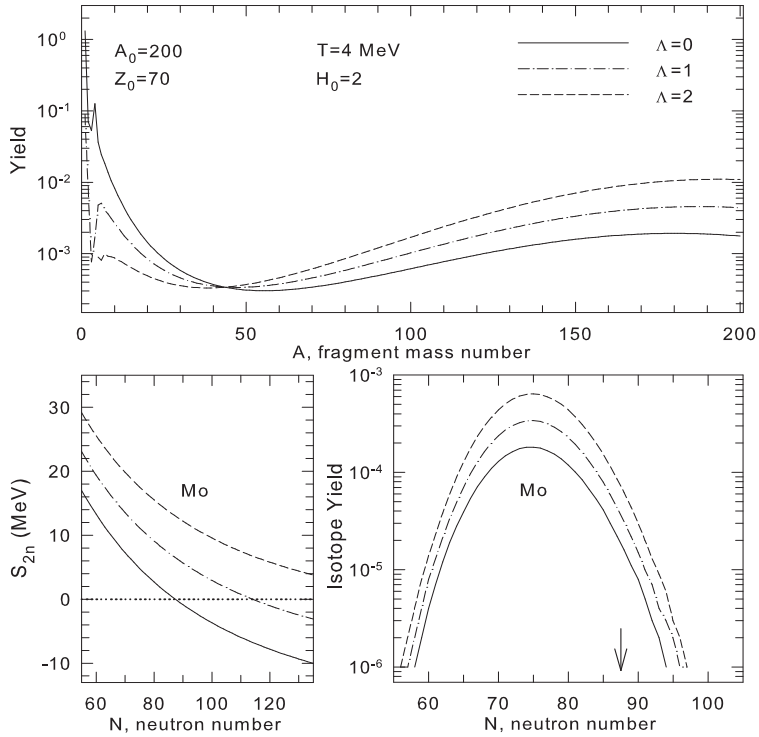


Figure 1: SMM predictions of yields of fragments and hyperfragments versus their mass number, after disintegration of excited systems containing two Λ hyperons. Initial mass numbers A_0, charges Z_0, and temperatures T of the systems are shown. Lines are calculations for fragments with a certain number of Λ hyperons. Yields are given per one disintegration event (top panel). Isotope yield and separation energy of two neutrons in hypernuclei of molybdenum versus neutron number (bottom panels). Arrow shows the neutron drip line.

Related publications in 2013

1) N. Buyukcizmeci, A.S. Botvina, J. Pochodzalla, M. Bleicher, Phys. Rev. C 88, 014611 (2013)

MHD Shocks characteristics

Collaborators: Ritam Mallick, Stefan Schramm

Frankfurt Institute for Advanced Studies

Shock waves occur when disturbances in a medium propagate faster than the local speed of sound. Shocks are characterized by nearly discontinuous changes in the characteristics of the medium, like pressure, temperature, energy, etc. Shock waves are usually created under rapid compression of matter. However, a similar discontinuity in matter can also be generated if the system suddenly expands and there is a phase transition (PT), usually known as shocks or space-like (SL) shocks. In some situations there may be a fast PT (first order) where the normal vector to the surface of the discontinuity can be time-like. If the thickness of the time-like surface is sufficiently thin, we can assume that the PT happens along an approximate structureless time-like surface (called time-like (TL) shocks). In the present work we studied the characteristics of TL and SP shocks in a background magnetic field (magnetohydrodynamics (MHD)).

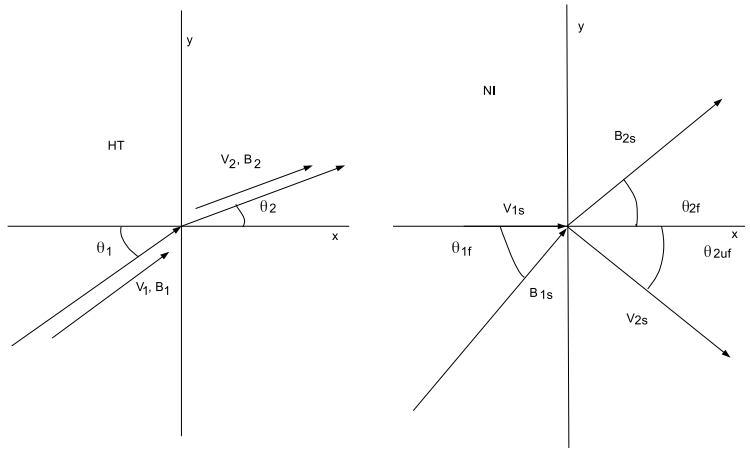


Figure 1: Pictorial description of the upstream and downstream parameters for the HT and NI frame, respectively.

First one derives the equations for the subluminal shock in the Hoffmann-Teller (HT) frame (a frame where the matter velocities and magnetic fields are parallel, Fig. 1(a)) and from there we have derived a more general shock (sub and superluminal shock) in the normal incidence (NI) frame (incident matter velocity is perpendicular to the shock front Fig 1 (b)). This is very useful as it removes all the imaginary and unphysical quantities present in the superluminal shock.

In the HT frame the four matter conservation equations and two electromagnetic conservation equations (Maxwell equations) are derived. Along with these equations a set of standard EOS in the upstream and downstream phases is needed to describe the matter phases and solve for the velocities. The shock wave brings about a PT from hadronic to quark matter. The magnetic effects are relevant once the field strength is greater than 10^{17}G. This is a phenomenon that might take place inside a neutron stars (NS), where the star is ultimately converted to a quark star (QS). The SL and TL MHD shock waves are quite different from one another. For the SL shocks all the downstream components depend strongly on the magnetic field and its angle with respect to the shock normal. In contrast, TL shocks are unaffected by magnetic field. The difference in the downstream behaviour of matter variables for SL and TL shocks could have some observational consequences for NS. Therefore, if the PT is brought about by a shock wave, its signature may differ for SL and TL shocks and could be strongly dependent on the magnetic field involved.

Related publications in 2013:

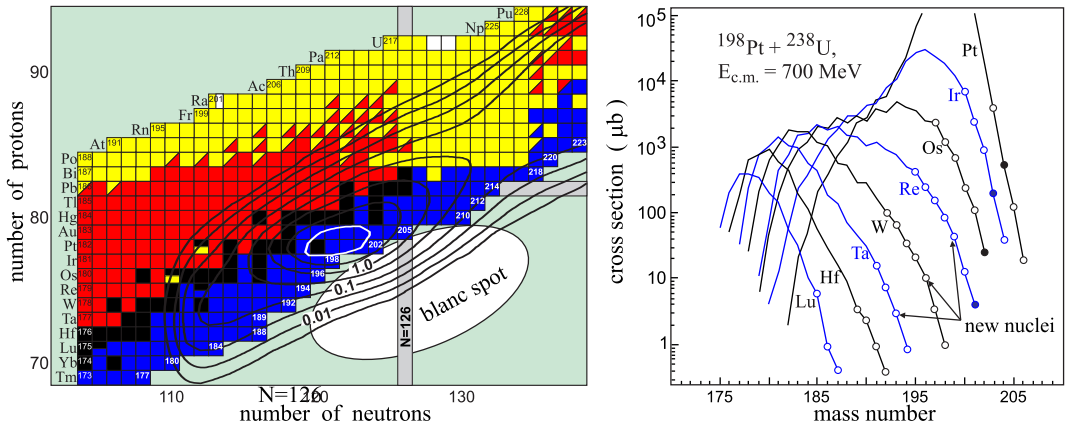
1) R. Mallick and S. Schramm, *Oblique magnetohydrodynamic shocks: space-like and time-like characteristics*, arXiv:1309.0397 [astro-ph] (to be published in PRC)

Production of heavy trans-target nuclei in multinucleon transfer reactions

Collaborators: V.I. Zagrebaev[1,2], W. Greiner[1]

[1] Frankfurt Institute for Advances Studies, [2] Flerov Laboratory of Nuclear Reactions, Dubna, Russia

The problems of production and study of new neutron rich heavy nuclei are discussed intensively by nuclear society. Low-energy multinucleon transfer reactions look quite appropriate for the production of new neutron-enriched heavy nuclei. Reactions with actinide beams and targets are of special interest for synthesis of new neutron-enriched transfermium nuclei and not-yet-known nuclei with the closed neutron shell $N = 126$ having the largest impact on the astrophysical r-process. However, it is rather difficult to perform these experiments because of the low beam intensities of the massive projectiles and problems with separating and detecting the heavy reaction products. In this connection, realistic predictions of the corresponding cross sections for different projectile-target combinations are definitely required. In our analysis we used a model based on the Langevin-type dynamical equations of motion. This model was proposed recently for simultaneous description of strongly coupled multinucleon transfer, quasi-fission, and fusion-fission reaction channels (which are difficult to distinguish experimentally in many cases). The estimated cross sections for the production of new neutron-enriched heavy nuclei in low-energy multinucleon transfer reactions are found to be very promising. For example in low energy damped collisions of ^{198}Pt with ^{238}U several tens of new neutron rich heavy isotopes can be produced with cross sections higher than 1 microbarn (see the figure). Thus, such experiments might be performed at currently available accelerators.



(left panel): Contour plot of the cross sections (on a logarithmic scale) for the formation of primary reaction fragments in collisions of ^{198}Pt with ^{238}U at $E_{\text{c.m.}} = 700$ MeV. Contour lines are drawn over half an order of magnitude and the units of measurement are shown in millibarns.. (right panel): Isotopic yields of elements below lead (from Lu to Pt) in collisions of ^{198}Pt with ^{238}U at $E_{\text{c.m.}} = 700$ MeV. Circles denote not-yet-known isotopes (with solid circles showing isotopes with the closed neutron shell N = 126).

Unfortunately, some uncertainty remains in the values of several parameters used in the calculations. This uncertainty does not allow one to perform very accurate predictions for the productions of new (especially trans-target) nuclei in multinucleon transfer reactions. Most of these model parameters (nucleon transfer rate, nuclear viscosity, and fission barriers) are fundamental characteristics of low-energy nuclear dynamics. Determination of the values of these parameters (as well as their temperature dependence) is of significance in its own right. The available experimental data on the production of heavy nuclei in low-energy multinucleon transfer reactions are still insufficient and fragmentary. Urgently needed are new experiments, including those in which the role of shell effects in reaction dynamics can be clarified. Careful experimental study of the mass distributions in damped collisions of ^{160}Gd with ^{186}W or ^{192}Os with ^{197}Au (a kind of surrogate reaction) could be quite useful.

Related publications in 2013:

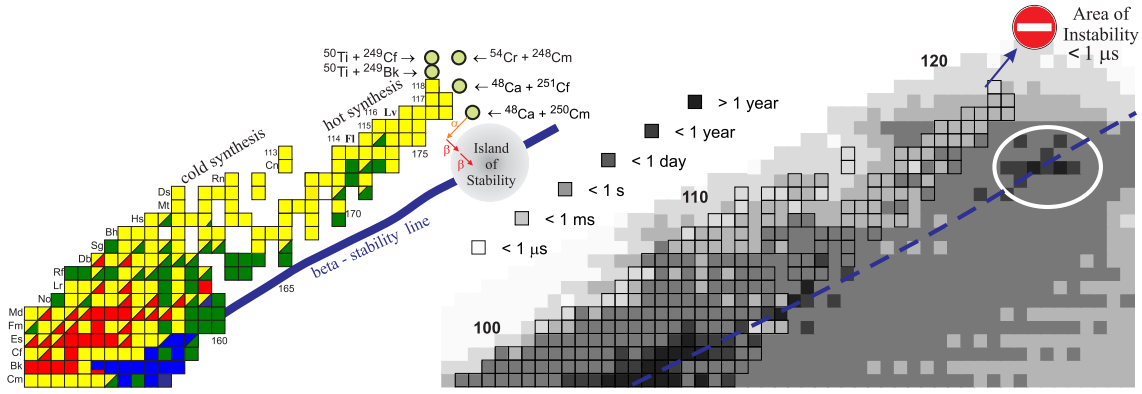
1) V.I. Zagrebaev, and Walter Greiner, *Production of heavy trans-target nuclei in multinucleon transfer reactions*, Phys. Rev. C87, 034608 (2013)

Future of superheavy element research: Which nuclei could be synthesized within the next few years?

Collaborators: V.I. Zagrebaev[1,2], A.V. Karpov[1,2], W. Greiner[1]

[1] Frankfurt Institute for Advances Studies, [2] Flerov Laboratory of Nuclear Reactions, Dubna, Russia

Due to the bending of the stability line toward the neutron axis, in fusion reactions of stable nuclei one may produce only proton rich isotopes of heavy elements. That is the main reason for the impossibility to reach the center of the "island of stability" ($Z \sim 110 \div 120$ and $N \sim 184$) in fusion reactions with stable projectiles. Note that for elements with $Z > 100$ only neutron deficient isotopes (located to the left of the stability line) have been synthesized so far (see the figure). Further progress in the synthesis of new elements with $Z > 118$ is not quite evident. Cross sections of the "cold" fusion reactions decrease very fast with increasing charge of the projectile. For the more asymmetric ^{48}Ca induced fusion reactions rather constant values (of a few picobarns) of the cross sections for the production of SH elements with $Z = 112 \div 118$ have been predicted owing to increasing values of the fission barriers of the produced isotopes. These predictions have been fully confirmed by the experiments performed in Dubna and later in Berkeley and at GSI. For the moment $^{249}_{98}$Cf ($T_{1/2}$ = 351 yr) is the heaviest available target that can be used in experiments. Thus, to get SH elements with $Z > 118$ in fusion reactions, one should proceed to heavier than ^{48}Ca projectiles. However low values of the fusion cross sections and very short half-lives of nuclei with $Z > 120$ (see the figure) put obstacles in synthesis of new elements.



(left panel): Upper part of the nuclear map. Current and possible experiments on synthesis of SH elements are shown. (right panel): Predicted half-lives of SH nuclei and the Şarea of instabilityŤ. Known nuclei are shown by the outlined rectangles.

Different nuclear reactions (fusion of stable and radioactive nuclei, multi-nucleon transfers and neutron capture), which could be used for the production of new isotopes of SH elements, have been analyzed in the paper [1]. The gap of unknown SH nuclei, located between the isotopes which were produced earlier in the cold and hot fusion reactions, can be filled in fusion reactions of ^{48}Ca with available lighter isotopes of Pu, Am, and Cm. Cross sections for the production of these nuclei are predicted to be rather large, and the corresponding experiments can be easily performed at existing facilities. For the first time, a narrow pathway is found to the middle of the island of stability owing to possible β^+-decay of SH isotopes which can be formed in ordinary fusion reactions of stable nuclei. Multi-nucleon transfer processes at near barrier collisions of heavy (and very heavy, U-like) ions are shown to be quite realistic reaction mechanism allowing us to produce new neutron enriched heavy nuclei located in the unexplored upper part of the nuclear map. Neutron capture reactions can be also used for the production of the long-living neutron rich SH nuclei. Strong neutron fluxes might be provided by pulsed nuclear reactors and by nuclear explosions in laboratory conditions and by supernova explosions in nature. All these possibilities have been discussed in the paper.

Related publications in 2013:

1) V.I. Zagrebaev, A.V. Karpov, and Walter Greiner, *Future of superheavy element research: Which nuclei could be synthesized within the next few years?*, J. Phys.: Conference Series 420, 012001 (2013)

Three decay modes of superheavy nuclei

Collaborators: D. N. Poenaru[1,2], R. A. Gherghescu[2], W. Greiner[1]

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Superheavy (SH) nuclei with Z=104-118 are decaying by alpha emission (AE) and spontaneous fission (SF). Our calculations of half-lives for heavier SHs show an unexpected result: cluster decay (CD) may dominate over AE or SF. Whenever partial half-life for a leading (shortest partial half life) decay mode is shorter than one microsecond, it is not possible to observe experimentally the event. The result is important for theory and future experiments producing heavier SHs with a substantial amount of funding. In our paper [1] we study how these three decay modes compete for even-even nuclei with $Z = 118 - 124$. We found a trend toward shorter half-lives and larger branching ratios for heaviest SHs up to $Z = 124$.

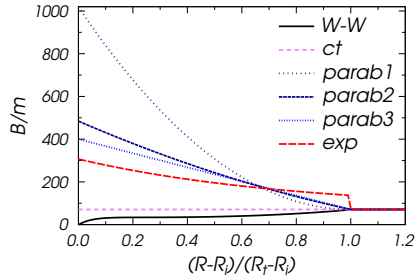


Figure 1: Nuclear inertia variations for the spontaneous fission of ^{284}Cn with light fragment ^{138}Ba. W-W (Werner-Wheeler) and $B/m = A_\mu = A_1 \cdot A_2/A$ are not large enough to fit the data.

AE is studied within our ASAF (analytical superasymmetric fission), UNIV (universal curve), and semFIS (semiempirical) models; for CD we use ASAF and UNIV. Q-values are calculated from the latest (2012) experimental mass table AME12, or from theoretical WS-10 (2010) and WS3-11 (2011). Measurements for 580 AE and 27 CD are reproduced with deviations under one or two orders of magnitude. Our SF calculations are performed using macroscopic-microscopic method. Shell and BCS pairing corrections are based on the two center shell model. Example: ^{284}Cn. As shown in figure 1, several kinds of nuclear inertia are employed: Werner-Wheeler approximation and simple laws of variation allowing to get agreement with experiment. There are very large differences which can reach ten orders of magnitude, from model to model of SF reported in the literature (see fig. 2). For even-even neutrondeficient isotopes of the elements 118 and 120 AE is the dominant decay mode. For few isotopes of the elements 118, 120, and 122 SF may compete with AE. CD is the most important decay mode of the element 124. It could also be important for several neutron-rich isotopes of 118, 120, and 122. We plan to improve the accuracy of SF by using cranking inertia. Observation of some superheavy nuclei with atomic number over 121 may not be possible due to cluster decay.

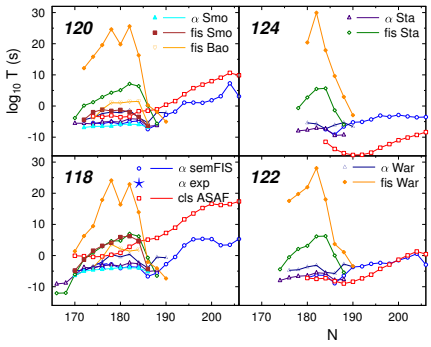


Figure 2: Comparison of theoretical half-lives for α decay, cluster decay and spontaneous fission of even-even SHs with $Z = 118 - 124$. Smo (Smolanczuk 1995), Bao (Bao 2013), Sta (Staszczak 2013), War (Warda 2012)

Related publications in 2013:

1) D. N. Poenaru, R. A. Gherghescu, W. Greiner, *Nuclear inertia and the decay modes of superheavy nuclei*, J. Phys. G: Nucl. Part. Phys. 40, 105105 (2013)

2) D. N. Poenaru, R. A. Gherghescu, W. Greiner, *Heavy-particle radioactivity*, J. Phys. Conf. Ser. 436, 012056 (2013)

3) D. N. Poenaru, R. A. Gherghescu, W. Greiner, *Alpha- cluster- and fission decay of superheavy nuclei*, Rom. J. Phys. 58, 1157 (2013)

α-matter in Relativistic Mean-Field Model

Collaborators : Ş. Mişicu[1], I.N. Mishustin[2,3] and W. Greiner[2]

[1] National Institute of Physics and Nuclear Engineering-HH, Bucharest-Magurele, Romania, [2] Frankfurt Institute for Advanced Studies, [3] Kurchatov Institute, National Research Center, Moscow, Russia

Nuclear systems formed of α-clusters are a steady challenge both for theorists and experimentalists. Whereas for light nuclei α clustering is best illustrated by the famous Hoyle 0_2^+ state in ^{12}C at 7.65 MeV, in superheavy elements a fullerene-like structure, formed of α-clusters, was speculated on account of the central density depletion for charges around $Z = 120$, according to RMF predictions [1]. To the date the equation of state and Bose-Einstein Condensation (BEC) of infinite systems of α clusters were investigated from non-relativistic point of view (see [2] and references therein). Consequently we extended the relativistic mean-field (RMF) approach for symmetric nuclear matter, which includes along with the Fermi baryons (relativistic protons and neutrons) and their interactions with scalar and vector meson fields, also a complex scalar Bose self-interacting field describing α particles. We disregarded from our considerations other types of baryon species (e.g., hyperons and their antiparticles) or clusterized baryon matter (e.g., deuterons, tritons) and instead we foccused on the properties of infinite systems composed of Dirac baryonic matter (nucleons) and various degrees of α-particle admixtures (first part of the paper). In this approach the α clusters are described by a scalar complex Lagrangean, which includes cuartic and sextic self-interactions, and interacts with scalar σ and ω meson fields. The role of the self-interaction was proved to be paramount in predicting a weakly bound Bose-Einstein condensate.

The properties of so-called Q-balls formed of large lumps of α matter were also investigated and we derived energy per particle (Fig.1), radii and stability conditions for these exotic objects.

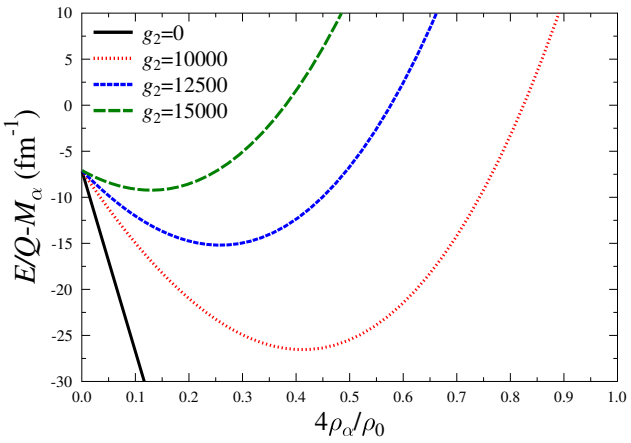


Figure 1: Energy per particle of the Q-ball various non-vanishing values of the quadratic self-interaction coupling constant.

References

1) W. Greiner, *Fusion Dynamics at the Extremes*, eds. Yu.Ts. Oganessian, V. I. Zagrebaev, pp. 1-20, World Scientific, Singapore (2001)
2) F. Carstoiu and Ş. Mişicu, Phys. Lett. B 682, 33 (2009)

Possible production of neutron-rich transuranic elements in spallation targets of Accelerator Driven Systems

Collaborators: I. Mishustin[1,2], I. Pshenichnov[1,3], Yu. Malyshkin[1], W. Greiner[1]

[1] Frankfurt Institute for Advanced Studies, [2] National Research Center "Kurchatov Institute", Russia, [3] Institute for Nuclear Research, Russian Academy of Sciences, Russia

As demonstrated in our previous calculations [1-3], very high neutron fluxes can be achieved in spallation targets irradiated by an intensive proton beam. They can be used not only for burning of minor actinides from spent nuclear fuel, but also for production of neutron-rich (super)heavy elements. However, for higher efficiency of neutron capture the addition of moderator material is required. Long-time irradiation of such a target by an intensive beam may lead to multiple neutron capture by tarhet nuclei and formation of new neutron-rich elements.

A new software NuCoD (Nuclide Composition Dynamics) was created by our group for modeling time evolution of the elemental composition in spallation targets. NuCoD is coupled to Geant4-based code MCADS for simulation of nuclear reactions and particle transport in targets with quasi-constant nuclide composition. Apart from other transport codes, MCADS allows to work with elements heavier than uranium. Radioactive decay chains are generated by recursive solving of nuclide rate equations.

Production of neutron-rich transuranic elements was modeled for a small spallation target made of $Am(OH)_3$ and surrounded by Be reflector, see the left figure below. The right figutre shows the map of nuclides produced in this target after 6 months of irradiation ny 1 GeV deutron beam. As calculations show, significant amounts of trans-Am nuclei can be produced in the target, e.g. 32 mg of ^{249}Bk, about 1 mg of ^{249}Cf and ^{251}Cf. This is comparable with amounts of these elements produced in high-flux U reactors. Even heavier nuclides like ^{254}Es can be produced in amounts sufficient for extraction and investigation.

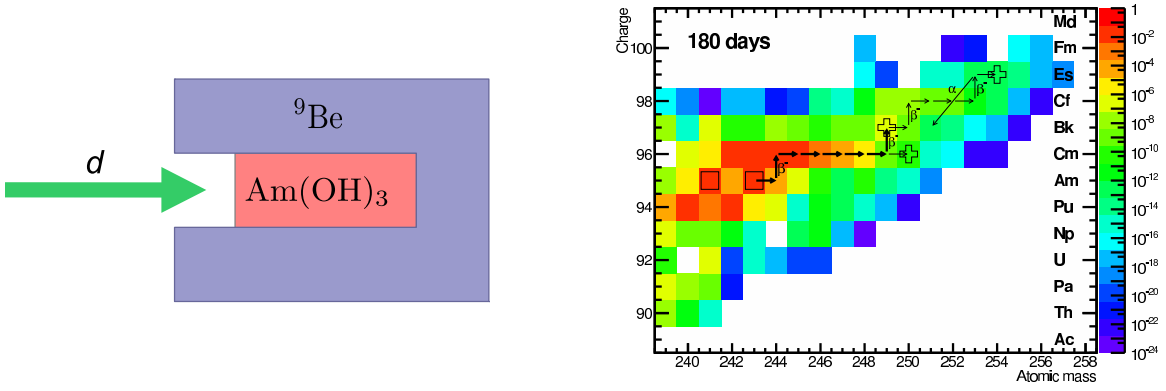


Figure: (left) The target of cylindrical shape with dimensions $r = 6$ cm and $l = 36$ cm, covered by a 12 cm thick Be layer. (right) Relative abundences of predicted isotope in the target after 180 days of irradiation by 1 GeV deuteron beam at 20 mA current. The arrows show the most probable path of new-isotope production.

Related publications in 2013:

1) Yu. Malyshkin, I. Pshenichnov, I. Mishustin, W. Greiner, *Interaction of fast neutrons with actinide nuclei studied with Geant4*, in Proceedings of the International Conference on Nuclear Data for Science and Technology, New-York (March 2013)

2) Yu. Malyshkin, I. Pshenichnov, I. Mishustin, W. Greiner, *Monte Carlo modeling of spallation targets containing uranium and americium*, submitted to Nuclear Instruments and Methods B; arXiv:1311.6620 [physics.ins-det]

3) Yu. Malyshkin, I. Pshenichnov, I. Mishustin, W. Greiner, *Burning of Am isotopes from nuclear waste studied with Geant4 toolkit* in Proceedings of Joint International Conference on Supercomputing in Nuclear Applications + Monte Carlo, Paris (October 2013)

Microscopic Monte Carlo modeling of energy deposition by ions

Collaborators: Lucas N. Burigo[1,2], Igor A. Pshenichnov[1,3], Igor N. Mishustin[1,4], Marcus Bleicher[1,2]

[1] Frankfurt Institute for Advanced Studies [2] Institut für Theoretische Physik, Johann Wolfgang Goethe University, Frankfurt am Main, Germany [3] Institute for Nuclear Research, Russian Academy of Sciences, Moscow, Russia [4] Kurchatov Institute, Russian Research Center, Moscow, Russia

The Geant4-based Monte Carlo model for Heavy-Ion Therapy (MCHIT) created in FIAS has been further developed for investigation of energy deposition at the nanometer scale. The aim of the project is to study the stochastic impact of radiation at the level of individual cells. MCHIT was extended to include physical models of the Geant4-DNA package which allows microscopic Monte Carlo simulation of the transport of ions and secondary electrons. This is a necessary step towards the investigation of energy deposition in the nanometre scale because the condensed history approach (macroscopic Monte Carlo) fails to give detailed stochastic information of the energy deposition in single events.

Figure 1 shows a validation of MCHIT for simulation of radial dose distributions around the ion tracks for protons, helium, carbon and oxygen ions. MCHIT reproduces well the experimental data from 100 nm down to subnanometer radius. However, such radial dose profiles are obtained over an average of many ion tracks and do not give information about the fluctuations per ion track. The stochastic property of ionisation events which account for $\sim$90% of the energy deposition can be investigated with nanodosimetry. This technique measures the size of ionisation clusters in a sensitive volume of few nanometers. Figure 2 shows results for MCHIT simulations of ionisation cluster-size distributions in the core of ion tracks for a 20 nm wide sensitive volume. Simulation results agree well with experimental data for 96 and 240 MeV carbon ions. This shows that microscopic electromagnetic models used in MCHIT can reproduce well the pattern of ionisations in nanometer volumes crossed by carbon ions. Similar calculations show that MCHIT can also be applied for simulation of ionisation cluster-size distributions for protons, deuterons, helium, ^{6}Li and ^{7}Li.

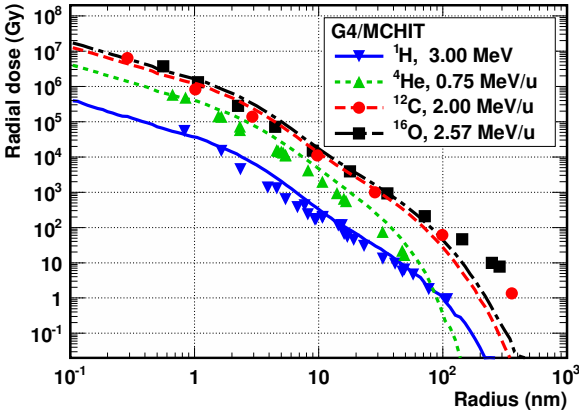


Figure 1: Radial dose distributions simulated by MCHIT. Experimental data from Wingate and Baum 1976 and Varma *et. al.* 1977.

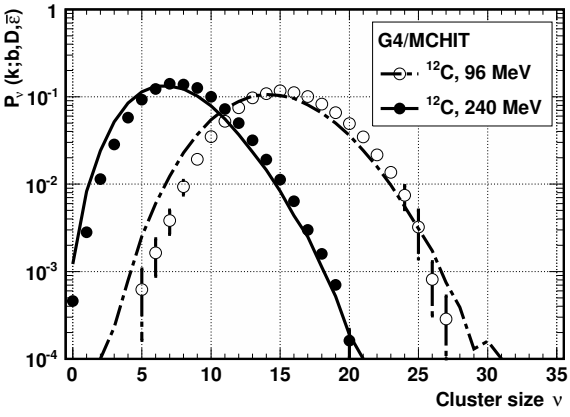


Figure 2: Ionisation cluster-size distributions in the core of 96 and 240 MeV ^{12}C tracks simulated by MCHIT. Experimental data from Conte et. al. (2013).

Related publications in 2013:

1) L. Burigo, I. Pshenichnov, I. Mishustin, and M. Bleicher, *Ionization cluster-size distributions in the core region of ion tracks calculated with Geant4*, paper in preparation

Monte Carlo modeling of therapeutic ion-beams

Collaborators: Lucas N. Burigo[1,2], Igor A. Pshenichnov[1,3], Igor N. Mishustin[1,4], Marcus Bleicher[1,2]

[1] Frankfurt Institute for Advanced Studies [2] Institut für Theoretische Physik, Johann Wolfgang Goethe University, Frankfurt am Main, Germany [3] Institute for Nuclear Research, Russian Academy of Sciences, Moscow, Russia [4] Kurchatov Institute, Russian Research Center, Moscow, Russia

The Monte Carlo method is a powerful tool to describe the interactions of beam nuclei and all secondary particles with an extended medium. The Monte Carlo model for Heavy-Ion Therapy (MCHIT) based on the Geant4 toolkit was created in FIAS for simulation of complex radiation fields in ion-beam cancer therapy.

MCHIT has been validated for simulation of microdosimetry spectra measured with neutron, proton and nuclear beams [1-2]. Microdosimetry spectra characterize the energy deposition to objects of cellular size, i.e., a few micrometers. Such information can be applied for investigation of radiation effects using radiobiological models. In our recent studies, MCHIT was coupled with the Microdosimetric Kinetic (MK) model for estimation of relative biological effectiveness (RBE) of therapeutic ion fields [2]. Figure 1 shows the estimated RBE for 10% survival fraction of human salivary gland cells when irradiated by proton, helium, lithium and carbon ions. The RBE profile can be folded to the physical energy deposition curve to yield the biological dose profile as presented in Fig. 2. As demonstrated by MCHIT+MK calculations, helium and lithium nuclei present similar biological dose profiles as carbon nuclei due to the enhancement of RBE in the vicinity of the Bragg peak. In addition, helium and lithium ions have smaller nuclear cross sections which lead to lower yield of projectile fragments and less dose in the tail region. Therefore, helium and lithium beams should be regarded as promising options for ion-beam cancer therapy.

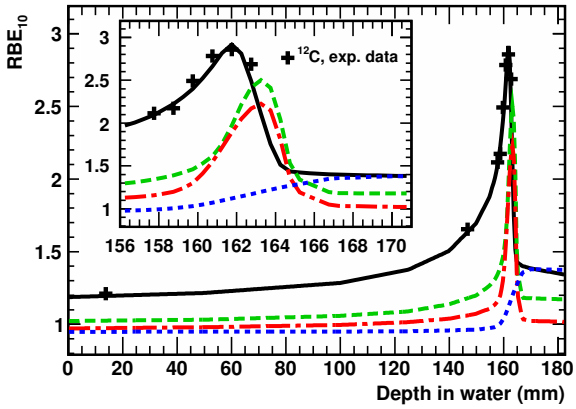


Figure 1: RBE for 10% survival fraction of human salivary gland cells when irradiated by proton, helium, lithium and carbon ions estimated by MCHIT+MK model [2]. Experimental data from Kase *et. al.* 2006.

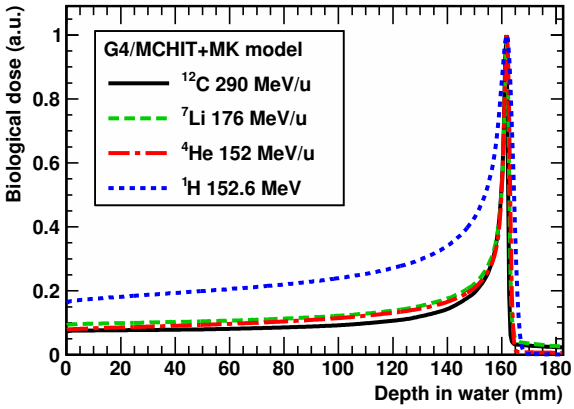


Figure 2: Biological dose profile for protons, helium, lithium and carbon ions with same range in water calculated by MCHIT+MK model [2].

Related publications in 2013:

1) L. Burigo, I. Pshenichnov, I. Mishustin, and M. Bleicher, *Microdosimetry of radiation fields from a therapeutic C-12 beam in water: A study with Geant4 toolkit,* Nucl. Inst. Meth. B310, 37–53 (2013); arXiv:1211.3648 [physics.med-ph]

2) L. Burigo, I. Pshenichnov, I. Mishustin, and M. Bleicher, *Microdosimetry spectra and RBE of H-1, He-4, Li-7 and C-12 nuclei in water studied with Geant4,* (2013) arXiv:1307.2174 [physics.med-ph]

Study of low density nuclear matter by Molecular Dynamics Simulation

Collaborators: Rana Nandi, Stefan Schramm

Frankfurt Institute for Advanced Studies.

We have developed a molecular dynamics simulation code to study the low density nuclear matter relevant for neutron star crusts as well as collapsing stages of supernova. To describe interaction between nucleons we used relativistic mean field model after reducing it to corresponding semi-classical and semi-relativistic equations of motion. Fermionic nature of nucleons are described by a phenomenological potential which has a Gaussian form and prohibits nucleons having same spin and isospin from coming close to each other in phase space. The parameters of this potential are obtained by fitting the kinetic energy of free Fermi gas at zero temperature and at various densities. For the Coulomb interaction we used a screened Coulomb potential, to avoid the finite size effects. To check the performance of our code we calculated the binding energy per nucleon of symmetric nuclear matter. We obtained right behaviour for the binding energy as shown in Figure 1.

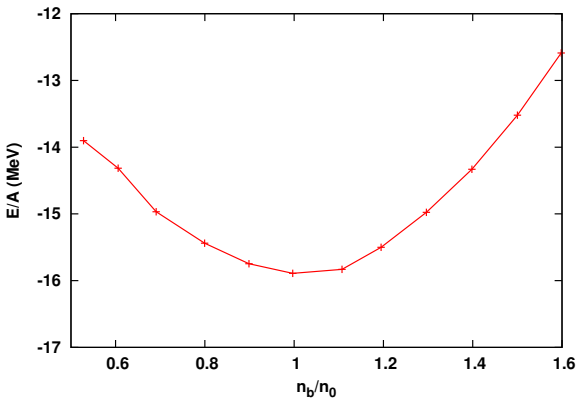


Figure 1: Energy per nucleon of symmetric nuclear matter at zero temperature as a function of baryon densities.

In order to resolve the various large-scale geometric structures involved at such densities, big systems and large time scales are needed, which require extensive computing resources. For speeding up the simulation to practical wall-times we have ported the molecular dynamics code to a GPU version, modifying an existing GPU implementation for molecular dynamics that was developed in FIAS. Our next step is to integrate the molecular dynamics engine in the UrQMD simulation for a better, and much faster, implementation of hadronic potentials in this simulation package. This version might also be used for medical simulations studying tumour therapy with heavy ions.

Applications of a chiral SU(3) model in nuclear and astrophysics

Collaborators: Torsten Schürhoff[1,2], Stefan Schramm[1,2,3]

[1] Frankfurt Institute for Advanced Studies, [2] Institut für Theoretische Physik, Goethe Universität Frankfurt, [3] Center for Scientific Computing (CSC), Frankfurt

We use an effective chiral SU(3) model to study both nuclear and astrophysical topics. In the last year, a new parameter set for the model was developed using the binding energy of nuclei. Various consistency checks were performed on the model to make sure that the new parametrization gives reasonable results in many different areas of both nuclear and astrophysics. Within the new parameter set, we can reproduce neutron star masses of 2 solar masses and slightly above, which is in agreement with recent observations of 2 solar mass neutron stars.

We also performed an analysis of the resulting equation of state of the parameter set and 8 different subsets that have been developed. We find a first order phase transition if quarks are included in the model. We also checked for reasonable results for the compressibility (275 MeV), symmetry energy, charge radii and hyperon potentials.

Additionally, the driplines of nuclei and hypernuclei (including a Λ hyperon in the nucleus) were studied within the model.

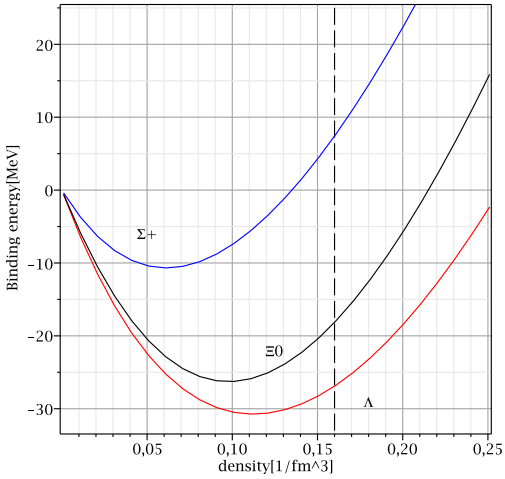


Figure 1: Hyperon potential at saturation density for the Σ^+, Ξ^0 and Λ hyperon. The model parameters had been fitted to describe nuclear binding energies. Other results like the hyperon potentials come out naturally in this approach without any further adjustments.

Related publications in 2013:

1) S. Schramm, V. Dexheimer, R. Negreiros, T. Schürhoff, and J. Steinheimer, *Structure and Cooling of Neutron and Hybrid Stars*, in International Symposium on Exciting Physics, Makutsi, South Africa, 13 - 20 Nov. 2011, FIAS Interdisciplinary Science Series, pp. 323 - 332. Springer, 2013

2) S. Schramm, V. Dexheimer, R. Negreiros, J. Steinheimer, and T. Schürhoff, *Compact Stars - How Exotic Can They Be?*, in Nuclear Physics: Present and Future, Boppard, Germany, 29 May - 5 June 2013. 2013. arXiv:1310.5804 [astro-ph]

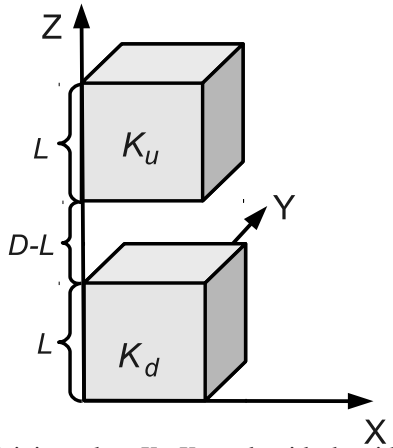
3) S. Schramm, V. Dexheimer, R. Negreiros, T. Schürhoff, and J. Steinheimer, *Modeling Hybrid Stars in Quark-Hadron Approaches*, in Compact Stars in the QCD Phase Diagram III (CSQCD III), Guarujt'a, Brazil, 12 - 15 Dec. 2012. 2013. arXiv:1306.0989 [astro-ph]

Nuclear interactions with modern three-body forces lead to the instability of neutron matter and neutron stars

Collaborators: D. K. Gridnev[1], S. Schramm[1], K. A. Gridnev[1,2] and Walter Greiner[1]

[1] Frankfurt Institute for Advanced Studies, [2] Saint Petersburg State University, Russia

It is a common place that two liters of water contain twice as much energy as one liter. Thermodynamically speaking, this is the result of the energy being an extensive quantity. From the quantum mechanical point of view this extensivity of the energy can be stated as the following result: let $E(N)$ denote the ground state energy of N atoms. Then the limit $\lim_{N\to\infty} E(N)/N$ is supposed to exist, that is the energy per atom (molecule) approaches a limit in the many-body problem. A formidable task is to prove that the energy can be linearly bounded from up and from below $cN \leq E(N) \leq CN$. This type of inequality proves the stability of matter and was first obtained by J. F. Dyson and A. Lennard. If the electrons were bosons then the energy would not grow linearly in N, thus the Pauli principle is absolutely essential for the stability of the world around us. Nuclear matter is also stable. For finite nuclei this is best manifested in the Bethe-Weizsäcker formula; large numbers of of neutrons (with the aid of the gravitational forces) can form neutron stars, which form a dense neutron matter. The basic model of a nuclear system assumes that the Hamiltonian $H = T + \sum_{i<j} v_{ij} + \sum_{i<j<k} v_{ijk}$ provides a good description for *any* number of nucleons. Here T is the kinetic energy operator, v_{ij} and v_{ijk} are two and three-body interactions respectively. Contrary to stability of normal matter, the proof that nuclear matter is stable if one uses the Hamiltonian with modern nuclear forces did not exist. It is a striking fact, but modern nuclear forces predict unstable nuclear matter. The problem lies in the form of the repulsive core of nuclear 3-body forces. Recently it was mathematically shown that modern nuclear interactions like Argonne 18 pair potential plus Illinois 7 three-body forces lead to the collapse of neutron matter! The reason for that is the weak repulsive part of the three-body force. The energy of N neutrons behaves like $E(N) \simeq cN^3$, which means that the energy per particle diverges with large N. Bound multineutrons exist within this model as well, one only needs a large number of neutrons to make them bound. The proof by variational principle uses the trial function, where neutrons are stuffed into two separate cubes, so that the contribution from 3-body interactions dominates for large neutron numbers. The obtained results partly change the paradigm, in which the stability of neutron stars is attained through the Pauli principle; the strong repulsive core in the nucleon interactions is by no means less important.



The neutrons are placed into two disjoint cubes K_u, K_d each with the side length L (subscripts u,d stand for "up" and "down" respectively). The upper cube is shifted by a distance D along the Z-axis with respect to the lower cube. L, D enter as parameters into the trial function.

Related publications in 2013:

D.K. Gridnev, S. Schramm, W. Greiner, K. Gridnev: *Argonne V18 Pair Interaction Plus Modern Versions of Urbana or Illinois Three-Body Forces Make Neutron Matter Unstable*, arXiv:1306.5573 [nucl-th] (2013), under consideration in J. Phys. G.

Tabulated equation of state for supernova matter

Collaborators: N. Buyukcizmeci[1,2], A. S. Botvina[1,3], I.N. Mishustin[1,4]

[1] Frankfurt Institute for Advanced Studies, Frankfurt, Germany, [2] Selcuk University, Konya, Turkey, [3] INR, Moscow, Russia, [4] National Research Center "Kurchatov Institute", Moscow, Russia

We have performed detailed calculations of the Equation of State (EoS) of stellar matter at subnuclear densities, moderate temperatures (0.5-10 MeV) and different charge-to-baryon number ratios. Such conditions are expected to occur during the collapse of massive stars and subsequent supernova explosions. The calculations are done within the Statistical Model for Supernova Matter (SMSM), which was first introduced in Ref. [1] as a generalization of the Statistical Multifragmentation Model [2]. The latter was successfully used earlier for the description of nuclear multifragmentation reactions. Recently, we compared three sets of EOSs, namely, those by Botvina and Mishustin (SMSM) [1], by Hempel and Schaffner-Bielich (HS) [3] and by Furusawa et al. (FYSS) [4] for stellar matter in Ref. [5]. Later on, we have constructed tables for SMSM EOS of the supernova matter for a wide range of the densities $\rho = (10^{-8} - 0.32)\rho_0$ ($\rho_0 \approx 0.15$ fm^{-3}), and of the-temperatures $T = 0.2 - 25$ MeV for different electron fractions $Y_e = 0.02 - 0.56$ [6]. The different T (35 points), ρ/ρ_0 (31 points) and Y_e (28 points) values sum up to 30380 EOS grid points are presented in the tables. *"SMSM-EOS-Tables.txt"* (20 different thermodynamic quantities), *"SMSM-EOS-Mass-Distribution-Tables.txt"* (1003 columns) and *SMSM-Massdist-Figs-Density-1(or 2,3 and 4).zip* (3920 figures) files are available online at `http://fias.uni-frankfurt.de/physics/mishus/research/smsm/`.

The SMSM EOS can be used for hydrodynamical simulations of massive stars collapse and supernova explosion processes. We describe the whole ensemble of nuclei, without any artificial limitation of their masses and charges, and general characteristics of matter, like temperature and chemical potentials. The nuclear mass and isotope distributions are needed for realistic calculations of electron capture and neutrino induced reactions. In addition, the β-equilibrium can be a useful physical limit for theoretical estimate of the nuclear composition without full knowledge of weak reactions. The SMSM allows β-equilibrium calculations as shown in Fig. 1, and the corresponding Tables are still under construction. These results can be used modeling of the outer layers of proto-neutron stars and crusts of neutron stars. We believe that using EOS developed by different groups of authors is crucially important for evaluating real behavior of stellar matter. This work is directly related to the planned studies of the phase diagram of strongly interacting matter at the FAIR. We will be able to formulate new experiments at the FAIR and provide up-to-date equation of state for simulations with our future studies.

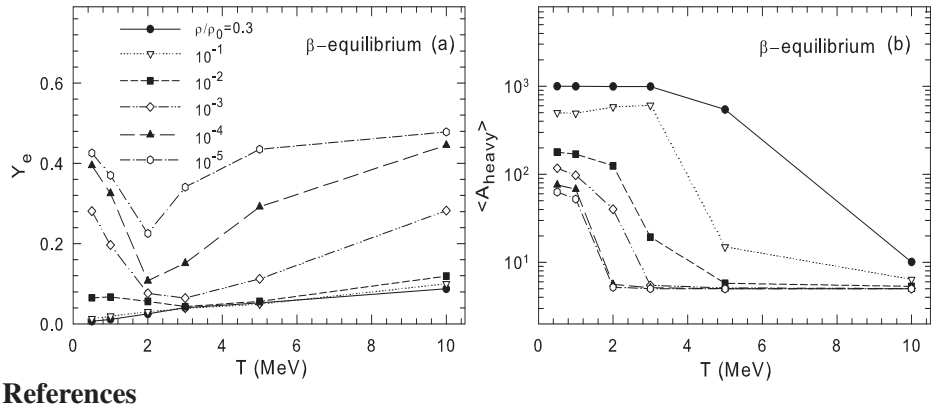


Figure 1: Electron fractions and the average value of heavy fragments $\langle A_{\rm heavy}\rangle$ in β-equilibrium case versus temperature at densities $\rho/\rho_0 = 0.3 - 10^{-5}$.

References

1) A.S. Botvina, I.N. Mishustin, Phys. Lett. B 584, 233 (2004); Nucl. Phys. A 843, 98 (2010)
2) J.P. Bondorf et al., Phys. Rep. 257, 133 (1995)
3) M. Hempel and J. Schaffner-Bielich, Nucl. Phys. A 837, 210 (2010)
4) S. Furusawa, S. Yamada, K. Sumiyoshi, H. Suzuki, Astrophys. Journal 738, 178 (2011)
5) N. Buyukcizmeci et al., Nucl. Phys. A 907, 13 (2013)
6) N. Buyukcizmeci, A.S. Botvina,I.N. Mishustin, submitted to Astrophys. Jour., (2013)

Radial oscillations of neutral and charged hybrid stars

Collaborators: Alessandro Brillante[1,2], Igor Mishustin[1,3]

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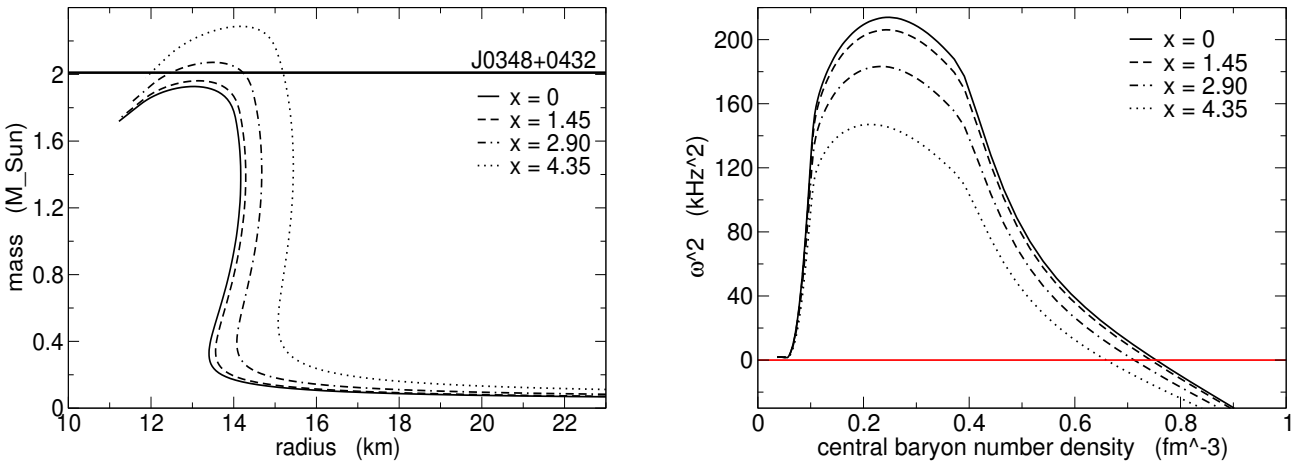
We have constructed models of neutral and charged hybrid stars in hydrostatic equilibrium. Using the MIT bag model for the deconfined phase and the RMF model for the hadronic phase, sequences of hybrid stars with the Gibbs construction were obtained. It is assumed that the electrostatic energy is small compared to the gravitational energy. The net charge is negligible on the miscroscopic scale, but changes the bulk stellar properties. The ensuing configurations are in agreement with the observational constraints for masses and radii of compact stars. We have generalized the GR equation for the radial eigenmodes of stars to incorporate electromagnetic effects. The resulting Sturm-Liouville equation for perturbations around equilibrium is given by:

$$\begin{aligned}\omega^2 e^{2\Lambda_0-2\Phi_0}(\rho_0+P_0)\,\xi &= -e^{-\Lambda_0-2\Phi_0}\left[e^{\Lambda_0+3\Phi_0}\frac{\gamma P_0}{r^2}\left(r^2 e^{-\Phi_0}\xi\right)'\right]' - (\rho_0+P_0)\,{\Phi_0'}^2\xi + 4r^{-1}\xi P_0' \\ &\quad +8\pi(\rho_0+P_0)\,\xi e^{2\Lambda_0}P_0 + (\rho_0+P_0)\,r^{-4}\xi e^{2\Lambda_0}{Q_0}^2\,.\end{aligned}$$

We find the dependence of the eigenfuctions on the internal charge distribution very weak, once the net charge is fixed. Both the softening of the EoS due to the appearance of a deconfined phase and the Coulomb interaction lead to smaller frequencies at given central density. The onset of dynamical instability is shifted toward lower densities. Calculated masses and allow to reconcile our soft EoS with the Demorest constraint. For large values of x we have found a new class of massive stars, which correspond to hollow spheres, and have no neutral counterparts with the same baryon number.



(b)

Figure 1: a): Mass-radius diagram of hybrid stars with the Gibbs construction for different values of the charge parameter $x = 10^{19}N_c/N_B$. N_c and N_B denote the total charge number and baryon number, respectively. b): Frequency of the fundamental oscillation mode as function of central baryon density for different values of the charge parameter x.

Related publication:

A. Brillante and I. Mishustin, *Radial oscillations of neutral and charged hybrid stars*, Europhys. Lett. 105, 39001 (2014); arXiv:1401.7915 [astro-ph.SR]

Deformed Magnetars

Collaborators: Ritam Mallick, Stefan Schramm

Frankfurt Institute for Advanced Studies

Some new classes of pulsars, namely the anomalous X-ray pulsars (AXPs) and soft-gamma repeaters (SGR), have been identified to have much higher surface magnetic field ($\sim 10^{14} - 10^{15}$G). The properties of neutron stars, i.e., mass, radius, spin, etc., depend very sensitively on the equation of state (EoS) of matter describing the neutron star. However, in magnetars they also depend sensitively on the magnetic field. Although the magnetic pressure is anisotropic, in order to make the calculation more tractable, usually the magnetic pressure was isotropically added or subtracted to the total pressure.

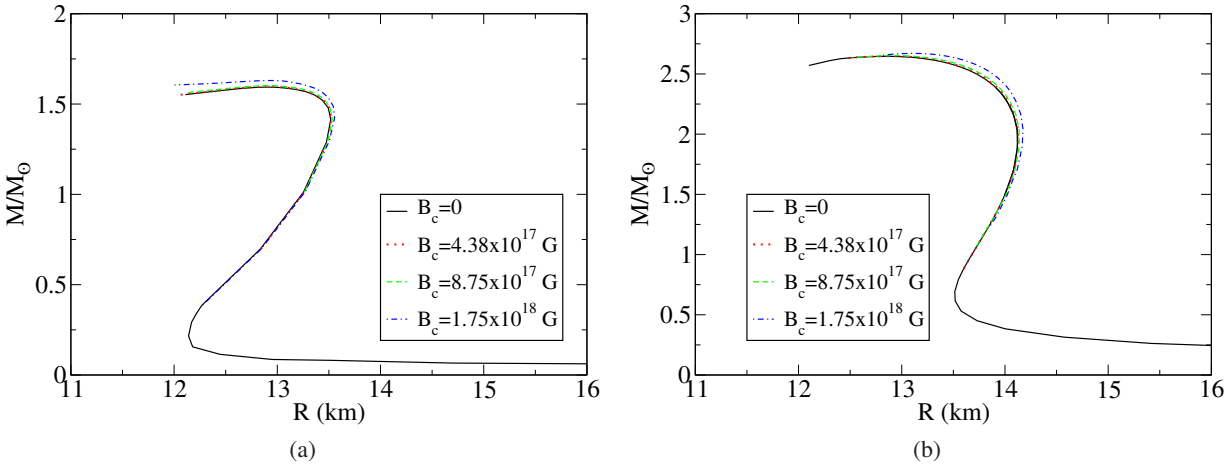


Figure 1: Mass-radius curve for TM1 and NL3 parameter set for nuclear EoS, showing the change in mass and radius due to magnetic field.

A better 2D treatment of the problem is done, by semi-analytically calculating the deformation of a neutron star assuming non-uniform magnetic pressure along different directions (equatorial and polar). The magnetic pressure was treated as a perturbation to the total pressure. Assuming a non-uniform magnetic field distribution, varying with density, we have expanded both the pressure and energy density in spherical harmonics up to the quadrupole term. Analogously, the space-time metric describing the geometry of the star is also expanded. Subsequently, the Einstein equations are solved and one obtains all the metric corrections as functions of known magnetic pressure. The monopole correction term (m_0) yields the excess mass and the quadrupole correction term (k_2) along with the surface magnetic field determines the deformation of the star. The excess mass of the star due to the magnetic field adds to about $3-4\%$ (Fig. 1(a) and 1(b)) of the original mass and the change in the equatorial radius of the star is also about the same amount (which is quite different from previous $1D$ calculations which predicts $(10-15\%)$ mass change). We have obtained a central bound on the magnetic field within this approach from the mass-radius diagram, beyond which the star fails to produce a maximum mass. As a practical limit of this approach we have assumed that the central field is always such that the magnetic energy to gravitational energy of the star is < 0.1. With the given EoS, this yields a central magnetic field close to 1.75×10^{18} G.

Related publications in 2013:

1) R. Mallick and S. Schramm, *Deformation of a magnetized neutron star*, arXiv:1307.5185 [astro-ph]

Study of neutron stars within Pseudo-complex General Relativity

Collaborators: I. Rodríguez[1], P. O. Hess[2], S. Schramm[1], W. Greiner[1]

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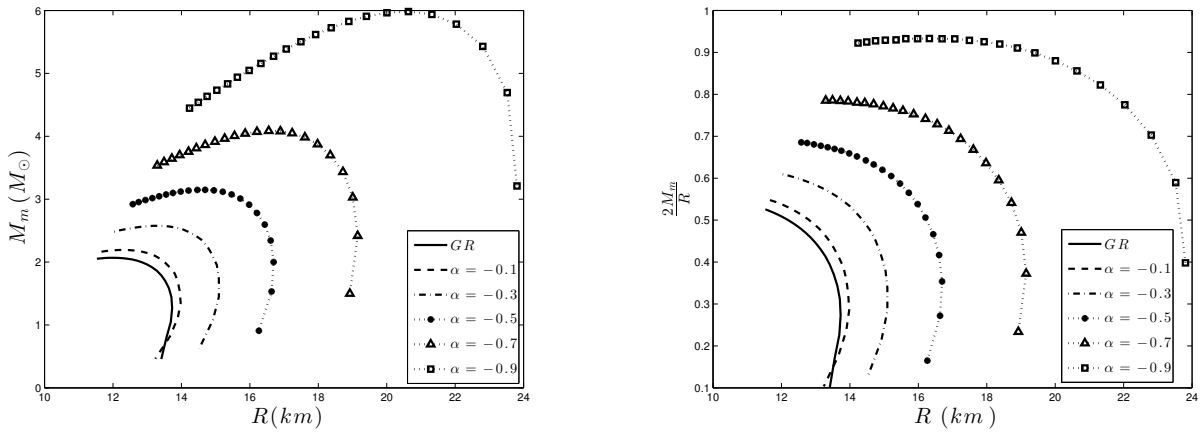
The theory of General Relativity (GR) has been extensively corroborated by experiment since its formulation almost a century ago. An adequate analysis of compact objects such as neutron stars must be done within the frame of this theory of gravitation. Despite of the great elegance and accuracy of GR the presence of singularities has bugged many physicists over the last decades. According to it something very peculiar is predicted: Space-time regions become causally disconnected from us, black holes are formed surrounded by a separation surface called event horizon. In terms of gravitational collapse this means that there are some cases depending on the mass of the progenitor where the effect of gravity cannot be counteracted, no form of matter whatsoever can support the star above certain mass limit. It is believed under such extreme conditions the vacuum quantum fluctuations become non-negligible becoming able to halt the collapse and avoiding the creation of the event horizon. The theory of Pseudo-complex General Relativity contains itself an extra term (Λ-term) whose physical meaning may be the overall effect of these fluctuations.
Within its frame a study of neutron stars has been conducted. The model specifically link both the baryonic and the Λ-term interior energy densities through a linear relation $\varepsilon_\Lambda = \alpha\varepsilon_m$. The star is then surrounded by an exterior shell which presents strong fall-off properties with distance.
Remarkably high masses configurations are obtained (cf. Fig. 1(a)) which exceed the mass limit predicted by GR. The baryonic compactness (cf. Fig. 1(b)) approaches the corresponding one to black holes with increasing $|\alpha|$, i.e the Schwarzschild radii of these compact objects are located just under their surface. They will resemble the properties of black holes to some extent presenting high redshifts but without having an event horizon.



(a) (b)

Figure 1: Baryonic total mass (a) and baryonic compactness (b) vs. total radius for different values of the coefficient α. The central Λ-term pressure has been fixed to $1\varepsilon_0$

Related publications in 2013:

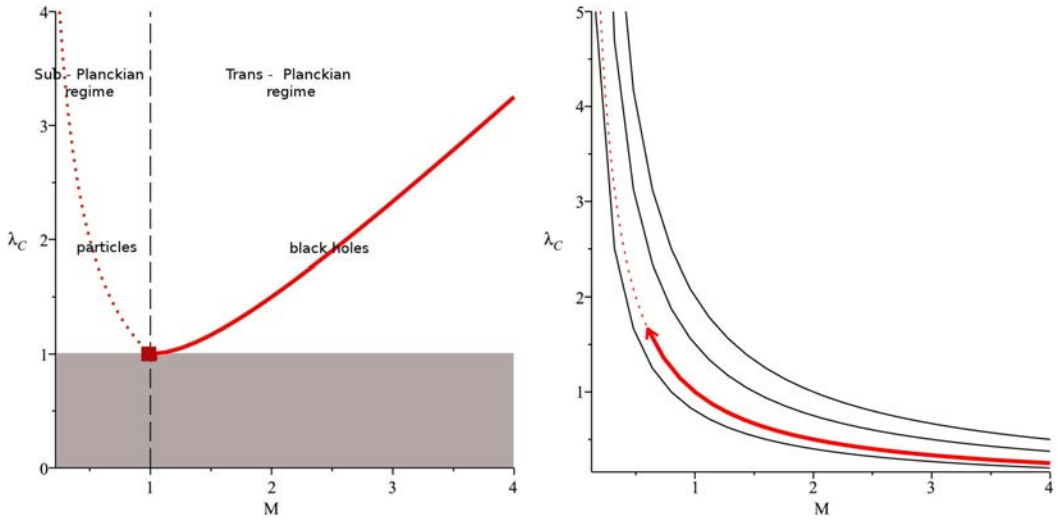
1) I. Rodríguez, P. O. Hess, S. Schramm, and W. Greiner, *Baryonic properties of neutron stars within Pseudo-complex General Relativity*, Submitted to Astronomical Notes.
2) P. O. Hess, I. Rodríguez, and W. Greiner, *Pseudo-complex General Relativity and Neutron Stars*, Submitted to Astronomical Notes.

Black holes in ultraviolet self-complete quantum gravity

Collaborators: P. Nicolini[1], M. Bleicher[1,2], M. Isi[3], J.R. Mureika[3], E. Spallucci[4], E. Winstanley[5]

[1]Frankfurt Institute for Advanced Studies, [2]Institut für Theoretische Physik, Johann Wolfgang Goethe-Universität, [3]Loyola Marymount University, Los Angeles, USA, [4]University of Trieste, Italy, [5]University of Sheffield, UK

The compression of matter in particle accelerators follows the widely accepted "thumb rule" of the Compton wavelength λ_C, i.e., the higher the energy, the smaller the size. Such contention, however, is not always valid, but correctly describes a collision only when energies involved in the process are far below the Planck energy, $M_P \sim 10^{19}$ GeV. Even if particle physics experiments occur at scales not exceeding 10^{13} GeV, one should consider, at least in principle, the possibility that, at extreme energies $\sim M_P$, even particles can exert gravitational interaction. Therefore one discovers that there exists a maximum compression configuration for matter, at which colliding particles collapse to a black hole. A further increase of energy would not allow to probe shorter lengths but would lead to the formation of bigger black holes, whose radius grows proportionally with the mass. As a result black holes are re-discovered as a new phase of matter and prevent the access to scales smaller than the Planck length, $\ell_P = M_P^{-1} \sim 10^{-35}$ m, during particle collisions (see left figure). This paradigm, known as gravity ultraviolet self-completeness, has, however, some weak points. First, neutral, non-rotating black holes can decay and accordingly probe shorter scales than the Planck length itself. Second, the gravity self-completeness is not compatible with other predicted quantum gravity effects, like the t'Hooft's spontaneous dimensional reduction. In a two-dimensional spacetime, the gravitational coupling becomes dimensionless and there is no longer any scale to distinguish small and large black holes (see right figure). A first attempt to overcome these problems has consisted in including generalized uncertainty principle effects in the gravity sector to improve the Schwarzschild metric. The procedure has allowed the description of a Planck scale extremal, zero temperature, black hole configuration. The later, by virtually stopping the Hawing evaporation, consistently separates matter phases and protects scales shorter than the Planck length.



Left: Phase diagram of matter in Planck units. The grey area is actually excluded.
Right: Phase diagram of matter in a 2D spacetime (Planck units). No clear separation of phases occurs.

Related publications in 2013:

1) J. R. Mureika and P. Nicolini, *Self-completeness and spontaneous dimensional reduction*, European Physics Journal Plus 128, 78 (2013)

2) M. Isi, J. R. Mureika and P. Nicolini, *Self-Completeness and the Generalized Uncertainty Principle*, Journal of High Energy Physics 1311, 139 (2013)

3) P. Nicolini, J. Mureika, E. Spallucci, E. Winstanley and M. Bleicher, *Production and evaporation of Planck scale black holes at the LHC*, arXiv:1302.2640 [hep-th]

Applications of nonlocal theories to inflatonless bouncing cosmology and unparticle physics

Collaborators: P. Nicolini[1], G. Calcagni[2], A.M. Frassino[1], L. Modesto[3], O. Panella[4]

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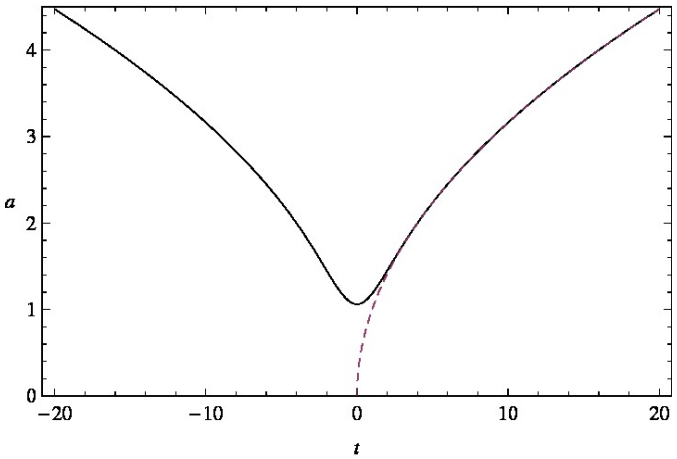
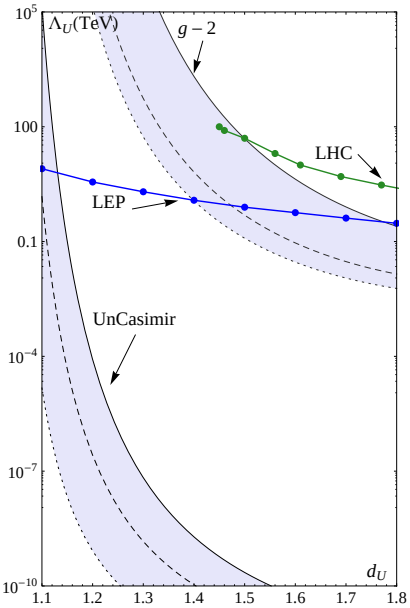
Nonlocal theories belong to the larger family of theoretical proposals aiming to improve Einstein gravity both in the ultraviolet and the infrared limit. Technically nonlocal gravity is formulated by replacing the usual Einstein-Hilbert action with a gravitational action containing an infinite series of derivative terms of the Ricci scalar. Along this line of reasoning, and by exploiting the largely predicted asymptotically safe character of gravity, we derived a model of universe which provides a big bang scenario in terms of a super-accelerating bouncing phase. As a special result, nonlocal effects drive the inflation without the introduction of an artificial inflaton scalar field as in conventional cosmological models.

Nonlocality plays a decisive role also in the context of unparticle physics. Unparticles are a hypothetical, yet unobserved particle sector, exhibiting special properties of conformal invariance. The latter is enjoyed despite the fact that unparticles are massive objects. In order to achive this, unparticles actually do not have an integer particle number but a continuous one. This property is obtained by means of a dimensional transmutation of a sector of scale invariant fields at a scale $\Lambda_U > 10$ TeV. As a result one ends up with an unparticle Lagrangian having a nonlocal free term and an interaction term depending on a small dimensionless coupling constant $\lambda < 1$ with the standard model fields. On these grounds, we consider the case of the Casimir effect due to the simultaneous presence of a conventional vector field and a scalar unparticle sector (*i.e.* Un-Casimir effect). The importance of this calculation lies in the fact that, contrarily to all previous unparticle scenarios, it is possible to set limits on the scale Λ_U irrespective of the value of the unknown parameter λ. Despite the current experimental observations do not lead to stringent bounds, the Un-Casimir effect can shed light on unpartcle physics by overcoming the conventional ambiguity associated to λ.



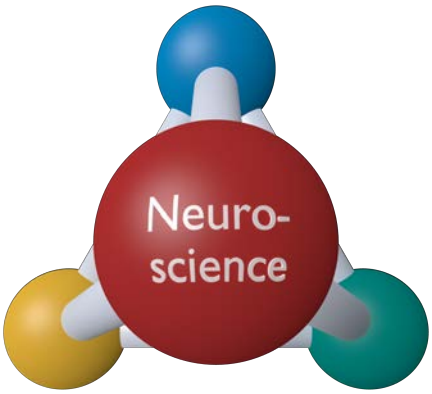


Left: Bouncing super accelerating profile of the nonlocal inflationary universe.
Right: Unparticle scale limits set by the Un-Casimir effect vs other limits affected by the ambiguity of λ.

Related publications in 2013:

1) G. Calcagni, L. Modesto and P. Nicolini, *Super-accelerating bouncing cosmology in asymptotically-free non-local gravity*, arXiv:1306.5332 [gr-qc].
2) A. M. Frassino, P. Nicolini and O. Panella, *Un-Casimir effect*, arXiv:1311.7173 [hep-ph].

4.2 Neuroscience



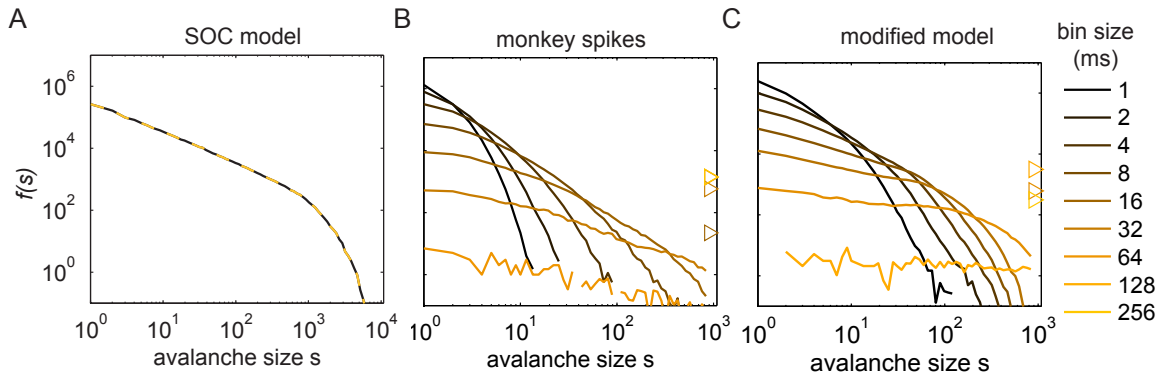
Self-Organized Criticality and Neural Activity *in vivo*

Collaborators: Viola Priesemann[1,2], Matthias Munk[3], Danko Nikolić[1], Michael Wibral[4], Jochen Triesch[1]

[1] Frankfurt Institute for Advanced Studies, [2] Max Planck Institute for Dynamics and Self–Organization, Göttingen, [3] Max Planck Institute for Biol. Cybernetics, Tübingen [4] Brain Imaging Center, Goethe University, Frankfurt

In vitro, neural networks show spontaneous bursts, called neural avalanches. The size distribution of these avalanches follows a power-law. Therefore, it was proposed that neural activity is self-organized critical (SOC). Moreover, criticality provides a basis for optimal information processing. Past evidence for SOC was based on recordings from brain slices or anesthetized animals. We therefore tested, whether also human brain activity is SOC – from wakefulness to deep sleep. Across all vigilance states, the avalanche distributions were similar, but reflected a slightly sub-critical regime. A sub-critical regime allows the brain to keep a safety margin from super-criticality, which has been linked to epilepsy, while maintaining almost optimal information processing capacity. realistic networks (Lazar and Triesch) showed optimal performance in the sub-critical regime, which supports the hypothesis that the brain, too, should be sub-critical.

Our SOC analysis in humans was based on local field potentials, which are a coarse measure for neural activity compared to spikes. In fact, all previous evidence for SOC *in vivo* was based on such coarse measures. SOC analysis on spikes proper is hampered by subsampling, i.e., only a small fraction of all neurons can be sampled. Taking this into account, our analysis of spikes *in viv*o (rats, cats, monkeys) confirmed that neural activity is slightly sub-critical (cf. Fig. 1). Furthermore, we showed a second difference to SOC: Neural activity lacks a separation of time scales (STS). The STS is fundamental to SOC, and assures that subsequent avalanches are separated in time. In contrast, neural avalanches overlap in time, i.e., they form a melange. In sum, we showed that neural activity *in vivo* is slightly sub-critical, and "driven" (no STS). A driven, sub-critical regime arguably allows for faster and more robust information processing compared to SOC.



a): SOC avalanches are characterized by a power-law distribution for their avalanche size s – with a cutoff which reflects the finite size of the model. b): Spike avalanche distributions in vivo do not show a power-law and change with an analysis parameter – the temporal bin size. c): The modified SOC neural model – incorporating subsampling, drive (no STS), and tuning to sub-criticality – matched the in vivo avalanches (b).

Related publications in 2013:

1) Viola Priesemann, Mario Valderrama, Michael Wibral, Michel Le Van Quyen, *Neuronal Avalanches Differ from Wakefulness to Deep Sleep – Evidence from Intracranial Depth Recordings in Humans*, PLoS Comput. Biol. 9, e1002985 (2013)

2) Viola Priesemann, Michael Wibral, Jochen Triesch, *Learning more by sampling less: subsampling effects are model specific*, BMC Neurosci. 14, P414 (2013)

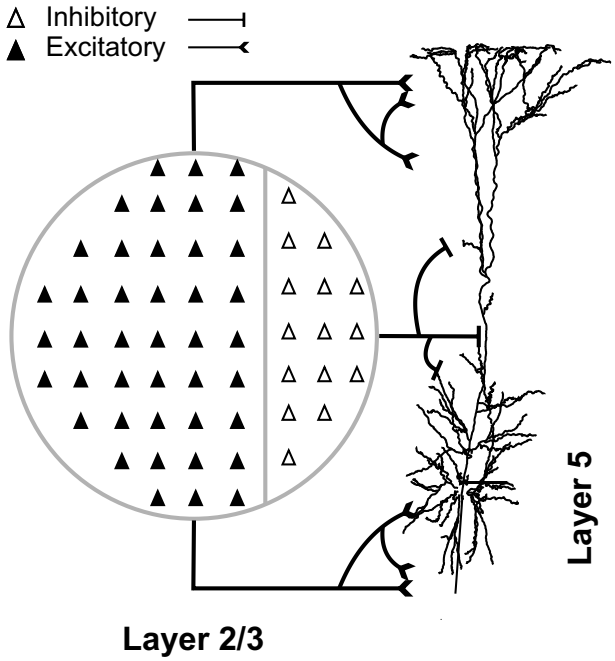
3) Viola Priesemann, Michael Wibral, Mario Valderrama, Robert Propper, Michel Le Van Quyen, Theo Geisel, Matthias HJ Munk, Jochen Triesch, Danko Nikolić, Matthias HJ Munk, *Neural activity in vivo is slightly subcritical – and driven*, submitted

Modeling the Effect of Transcranial Magnetic Stimulation on Cortical Circuits

Collaborators: M. Murakami[1], C. Rusu[1,2], J. Triesch[1], U. Ziemann[3]

[1] Frankfurt Institute for Advanced Studies, [2] Romanian Institute of Science and Technology, Cluj-Napoca, Romania,
[3] Department of Neurology, Universität Tübingen

Transcranial magnetic stimulation (TMS) allows to manipulate neural activity non-invasively. Much research is currently trying to exploit this ability in clinical and basic research settings. However, the details of how TMS induces neural activity patterns in cortical circuits remain poorly understood, which hampers targeted clinical application. In a standard TMS paradigm, single-pulse stimulation over motor cortex produces high-frequency repetitive responses of around 600 Hz in descending motor pathways called I-waves. We have used computational modeling to shed light on the mechanism underlying I-wave generation. Our model consists of a detailed layer 5 (L5) pyramidal cell and a population of layer 2 and 3 (L2/3) neurons projecting onto it with synapses exhibiting short-term depression. Our model successfully explains all basic characteristics of I-waves observed in epidural responses during *in vivo* recordings of conscious humans. In addition, it shows how the complex anatomical structure of L5 neurons plays an important role in the generation of I-waves. We find that later I-waves are formed due to inputs to distal synapses, while earlier ones are driven by synapses closer to the soma. Finally, the model explains, inhibition and facilitation effects in paired-pulse stimulation protocols. In contrast to previous models which required either neural oscillators or chains of inhibitory interneurons acting upon L5 cells our model is fully feed-forward, without lateral connections or loops. It parsimoniously explains findings from a range of experiments and brings us one step closer to designing optimized stimulation protocols for specific clinical purposes.



The model we have developed includes a reconstructed dendritic tree of a L5 pyramidal cell. A total of 300 excitatory and inhibitory L2/3 cells (ratio 4:1) project synapses on to the L5 cell. Our model predicts that short-term synaptic depression of these synapses plays an important role in certain effects oberved in paired-pulse stimulation protocols.

Related publications in 2013:

1) C. Rusu, M. Murakami, U. Ziemann, J. Triesch, *A Model of TMS-induced I-waves in Motor Cortex*, accepted at Brain Stimulation

Learning and self-organization in neural network models of brain function

Collaborators: C. Dimitrakakis[1], J. Eser[2], C. Hartmann[2], D. Krieg[2], A. Lazar[3], D. Miner[2], M. Murakami[2], V. Priesemann[2], J. Triesch[2], P. Zheng[2]

[1] Chalmers Univ. of Technology, Sweden, [2] Frankfurt Institute for Advanced Studies, [3] Max-Planck-Institute for Brain Research, Frankfurt

Understanding the learning and self-organization processes in the brain is of fundamental importance for understanding its function. A major activity of the Triesch lab is to study these issues with neural network models.

In a major line of research we have considered the self-organization of neural circuits through the interaction of different forms of neuronal plasticity. This has allowed us to parsimoniously explain recent findings on the statistics and fluctuations of synaptic connection strengths. The distribution of synaptic strengths of local excitatory connections in the cortex is long-tailed (approximately lognormal), but individual synapses can undergo strong fluctuations from day to day. This raises the question how the brain can maintain stable long-term memories at all. Recent evidence has shown that very strong synapses are relatively more stable than weak ones and could thus be the physiological basis of long-lasting memories. We have shown that the distribution of synaptic strengths and their pattern of fluctuations can be explained by self-organization in a recurrent spiking network model combining spike-timing-dependent plasticity (STDP), synaptic scaling, structural plasticity, and intrinsic plasticity. In this network, STDP induces a rich-get-richer mechanism for excitatory synapses, while synaptic scaling induces competition between them. The resulting dynamics produces lognormal-like weight distributions (see Figure) and patterns of synapse fluctuations closely matching experimental data. This process is robust to parameter changes in the network but critically depends on the presence of the different homeostatic plasticity mechanisms. We have also characterized the dynamic properties of these networks and discovered a phenomenon we call "deferred chaos," which is caused by the mixing of discrete and quasi-continuous state variables in these networks. More recently, we have extended these networks to more realistic leaky-integrate-and-fire model neurons arranged on a two-dimensional sheet to explain certain aspects of the distance-dependence of cortical wiring strength. Current work is also investigating the patterned spontaneous activity of such networks.

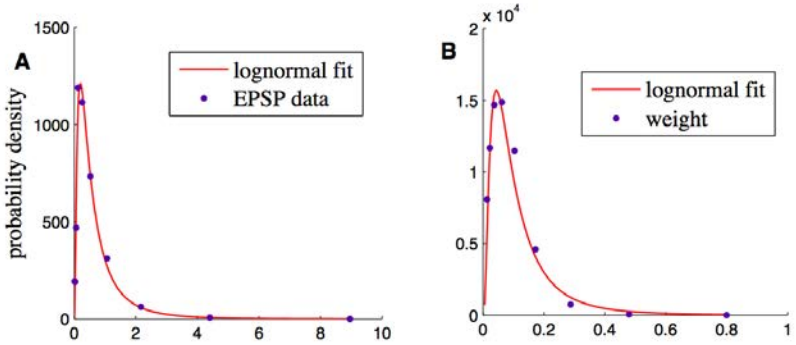


Figure: Distribution of synaptic weights in our model matches lognormal distribution of EPSPs in cortex. A: distribution of EPSP sizes from Song et al. (2005) and lognormal fit. B: distribution of weight strengths in our model and lognormal fit.

Related publications:

1) P. Zheng, C. Dimitrakakis, J. Triesch, *Network Self-organization Explains the Statistics and Dynamics of Synaptic Connection Strengths in Cortex*, PLoS Computational Biology 9(1): e1002848 (2013)

2) J. Eser, P. Zheng, J. Triesch, *Nonlinear Dynamics Analysis of a Self-Organizing Recurrent Neural Network: Chaos Waning*, PLoS One 9(1): e86962. doi:10.1371/journal.pone.0086962, 2014

3) D. Miner, J. Triesch, *Relating synaptic efficacies and neuronal separation in a simulated layer 2/3 cortical network*, accepted at COSYNE, Salt Lake City, USA, 2014

4) D. Krieg, J. Triesch, *A unifying theory of synaptic long-term plasticity based on a sparse synaptic strength*, submitted

Studying infant cognitive development using gaze-contingency and microbehavioral analysis

Collaborators: G. Deák[1], M. Knopf[2], T. Kolling[2], A. Romberg[3], J. Triesch[4], Q. Wang[4], C. Yu[3]

[1] Cognitive Science Dept., UC San Diego, USA, [2] Department of Psychology, Goethe University Frankfurt, [3] Department of Psychological and Brain Sciences, Indiana University, USA, [4] Frankfurt Institute for Advanced Studies

Studying infant cognitive development is notoriously difficult due to infants' poorly developed motor abilities. Eye movements are an exception, which is why many paradigms for studying infant cognition rely on their eye movements. With recent advances in remote eye tracking technology, the eye movements of infants can now be measured accurately and non-invasively.

In a first line of research, we have developed gaze-contingent paradigms where infants can control some aspect of their environment through their eye movements. Specifically, we have previously shown that infants as young as 6–8 months can learn that their eye movements produce the appearance of novel images on a computer screen. Now we have extended this research in two directions. With our collaborator Prof. Knopf and her group from Frankfurt, we have applied the paradigm (and small variations of it) to adult and elderly subjects. These experiments have shown that the paradigm can be used from 6-month-old infants to senior citizens, making it suitable for studying this cognitive development across the life span with one and the same paradigm. With Prof. Chen Yu at Indiana University we have been exploring the potential use of gaze-contingent paradigms for the studying early word learning abilities in infants.

In a second line of research, we have continued to investigate the development of gaze following in infants, i.e., their ability to look where someone else is looking. With my former colleague Prof. Deák in San Diego, we have finished an extensive study involving home observations of mother-infant interactions during naturalistic play situations. Through micro-behavioral analysis of the video records we collected data on gaze shifts, body movements, object manipulations, and utterances. Analysis of these data revealed that infants pay close attention to their caregiver's hands as they manipulate objects. At the same time, analysis of sequential mother-infant behaviors revealed that the caregivers' looking behavior could allow an infant to learn gaze following by establishing associations between where the caregiver is looking and where there is something the infant likes to watch, lending support to a theory we had proposed previously.

Home observation of mother infant interactions during naturalistic play. Shown are two still images from synchronized video cameras focusing on infant and mother, respectively.

Related publications:

1) G.O. Deák, A. Krasno, J. Triesch, J. Lewis, L. Sepeta, (2014), *Watch the hands: infants can learn to follow gaze by seeing adults manipulate objects*, Developmental Science doi: 10.1111/desc.12122

2) G.O. Deák, J. Triesch, A. Krasno, K. de Barbaro, M. Robledo, (2013), *Learning to share: The emergence of joint attention in human infancy*, in: B. Kar (Ed.), Cognition and Brain Development: Converging Evidence from Various Methodologies (pp. 173-210). Washington, DC: American Psychological Association

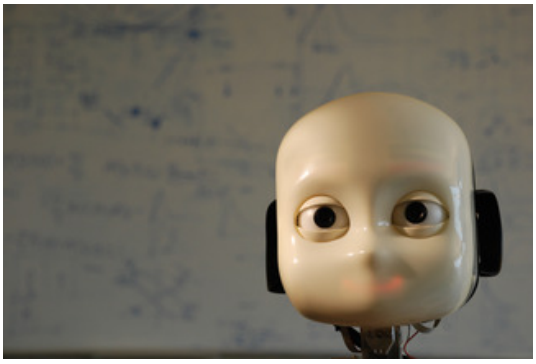
Autonomous Learning of Active Visual Perception in a Humanoid Robot

Collaborators: P. Chandrashekhariah[1], S. Forestier[1], L. Lonini[1], C.A. Rothkopf[1], B.E. Shi[2], G. Spina[1], C. Teulière[1], J. Triesch[1]

[1] Frankfurt Institute for Advanced Studies, [2] Hong Kong University of Science and Technology, Hong Kong, China

We aim to better understand the principles of learning and development that allow biological vision systems to autonomously learn to perceive their environments. At the same time, we try to apply these principles to build autonomously learning vision systems for robots. A fundamental question is how effective representations of visual input can be learned in an autonomous fashion and how intelligent behavior can be acquired on the basis of the learned representations. We have developed a "curious" active vision system that autonomously explores its environment and learns object representations without any human assistance. Similar to an infant, who is intrinsically motivated to seek out new information, our system is endowed with an attention and learning mechanism designed to search for new information that has not been learned yet. Our method can deal with dynamic changes of object appearance which are incorporated into the object models.

In a second line of research in collaboration with Prof. Shi and his team at the Hong Kong University of Science and Technology we are working on methods for efficient coding of sensory information in active perception. In 2012 we had proposed a new way to combine unsupervised learning of generative models with reinforcement learning. The central idea is a reward signal reinforcing sensor movements contributing to an efficient encoding of the sensory inputs. We applied the idea to the autonomous learning of binocular vision. The result was the first model to explain the joint development and self-calibration of disparity representations and vergence eye movements. Since then we have validated the approach on our humanoid robot and tested its robustness. In addition, we have generalized the approach to the autonomous learning and self-calibration of motion perception and smooth pursuit eye movements. Finally, and somewhat surprisingly, we have also proposed a connection between efficient coding ideas and imitation learning.



The iCub robot head used in our studies. Its degrees of freedom and appearance are modeled after a 2-year-old child. Development and testing of new algorithms is often performed in simulation before results are validated on the actual hardware.

Related publications in 2013:

1) L. Lonini, Y. Zhao, P. Chandrashekhariah, B.E. Shi, J. Triesch, *Autonomous learning of active multi-scale binocular vision*, IEEE Int. Conf. on Development and Learning and Epigenetic Robotics (ICDL), 2013

2) L. Lonini, S. Forestier, C. Teulière, Y. Zhao, B.E. Shi, J. Triesch, *Robust active binocular vision through intrinsically motivated learning*, Frontiers in Neurorobotics 7:20, doi: 10.3389/fnbot.2013.00020, 2013

3) J. Triesch, *Imitation Learning Based on an Intrinsic Motivation Mechanism for Efficient Coding*, Frontiers in Psychology 4:800, doi: 10.3389/fpsyg.2013.00800 (2013)

4) P. Chandrashekhariah, G. Spina, J. Triesch, *Let it Learn: A Curious Vision System for Autonomous Object Learning*, 8th Int. Conf. on Computer Vision Theory and Applications (VISAPP), 2013

5) P. Chandrashekhariah, J. Triesch, *Hide and Seek: an active binocular tracking system*, 9th Int. Conf. on Computer Vision Theory and Applications (VISAPP), 2014

Neural maps versus salt-and-pepper organization in visual cortex

M Kaschube[1,2]

[1] Frankfurt Institute for Advanced Studies, [2] Faculty of Computer Science and Mathematics, Goethe University, Frankfurt

Neural maps have traditionally raised significant attention among theoreticians. A prominent example is the orientation preference map found in cat, ferret, tree shrew and several primates, describing the layout of neurons in the visual cortex selective for the orientation of visual edges. The orientation preference map is almost continuous at the cellular scale (Figure, upper scheme). Over the past years, it has become evident that in at least three rodent species – mouse, rat and gray squirrel – cells in the visual cortex are orientation selective, but their spatial layout shows little order, termed interspersed or 'salt-and-pepper' organization (Figure, lower scheme). It appears plausible that such marked differences are accompanied by different processing strategies, which may become more apparent on the circuit level than on the neuronal level.

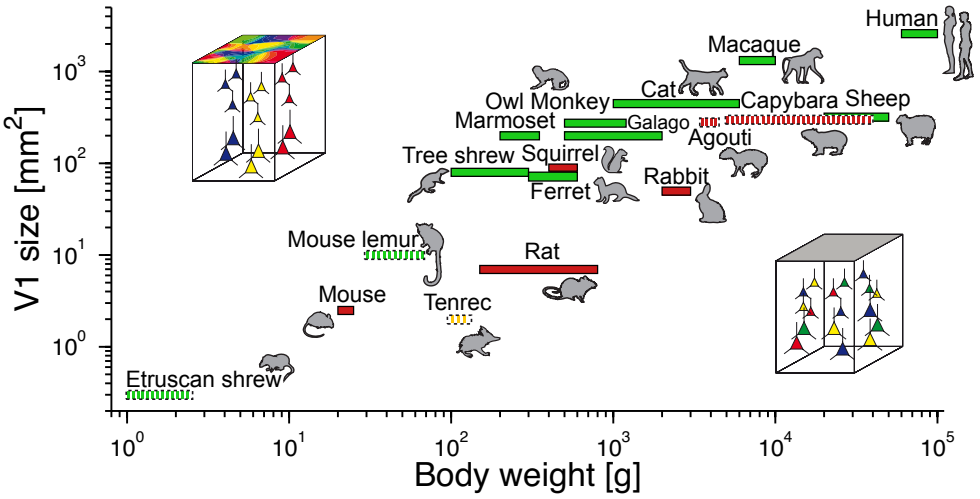


Figure: Both orientation preference maps (OPMs) and salt-and-pepper layouts of orientation preference appear over wide and overlapping ranges of primary visual cortex (V1) surface area and body weight. The two types of cortical organization are indicated by schemes: upper scheme, OPM; lower scheme, salt-and-pepper. Green color indicates species of the Laurasiatheria clade, which includes carnivores, and of the Euarchonta clade, which primates belong to. Red color indicates Glires, which consist of rodent and lagomorph species. Yellow color indicates Afrotheria. Filled/hatched bars indicate known/unknown spatial organization of orientation preference. Green filled bars indicate OPM; red filled bars indicate salt-and-pepper organization. For body weight, the extent of each bar marks the observed range (for V1 size the range is suppressed for clarity).

The two described types of layouts may just be the tip of the iceberg, perhaps pointing towards two fundamentally distinct types of cortical organization derived through the process of natural selection in mammalian evolution. Converging evidence suggest that the salt-and-pepper organization is not just a shuffled version of the OPM, but that its microcircuits develop according to different network interactions, affect neuronal selectivities via different mechanisms and express different patterns of functional connectivity. It has yet to be determined which cortical processing strategies are associated with each type of organization. Contrasting them in theoretical and experimental work could provide us with a unique opportunity for shedding new light on the functional benefit of neural maps.

Related publication:

M. Kaschube, *Neural maps versus salt-and-pepper organization in visual cortex*, Curr. Opin. Neurobiol. 24, 95-102 (2014)

Inhibition facilitates direction selectivity in a noisy cortical environment

Collaborators: Audrey Sederberg[1] and Matthias Kaschube[2,3]

[1]University of Chicago, Chicago IL, USA, [2]Faculty of Computer Science and Mathematics, Goethe University, Frankfurt, [3]Frankfurt Institute for Advanced Studies

In a broad class of models, direction selectivity in primary visual cortical neurons arises from the linear summation of spatially offset and temporally lagged inputs combined with a spike threshold. In this work, we characterize the robustness of this class of models to input noise and background activity that is uncorrelated with the visual stimulus. We show that inhibition is required to produce a strongly direction-selective neuron in this model, even in the absence of noise. Inhibitory inputs that mirror excitatory inputs, but lag by a fixed delay, promote a highly direction-selective response by suppressing all activity in the null direction while minimally affecting activity in the preferred direction. This mechanism can be accurately reproduced in a simple conceptual model. Further, we show in both firing-rate and spiking models that direction selectivity is higher at low levels of contrast, confirming observations. The interplay of excitation and inhibition illustrates how cortical circuits could reliably extract information from feed-forward inputs in a noisy, high-background context.

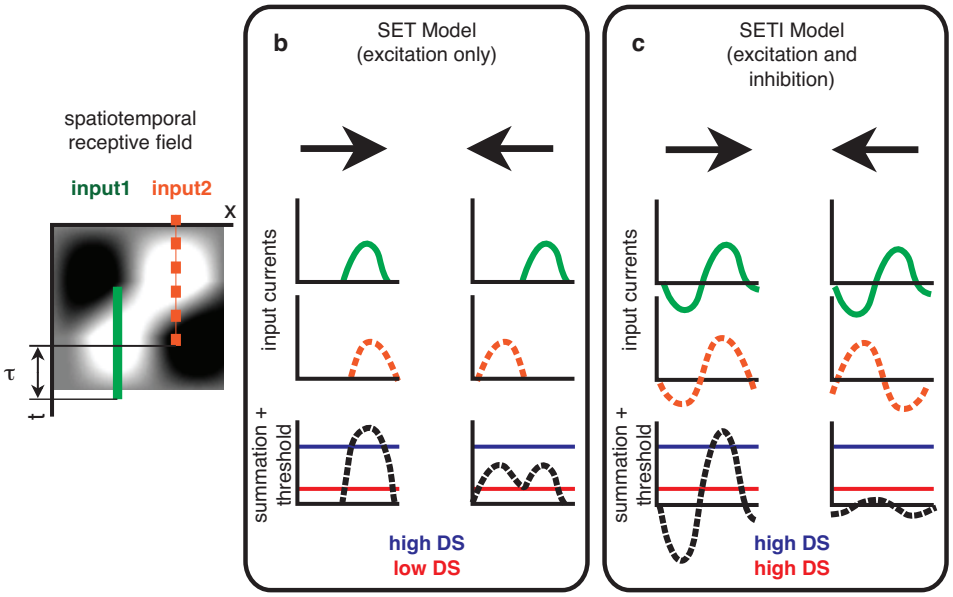


Figure: Overview of model showing a single period of the model response to a grating stimulus moving left or right. a: The spatiotemporal receptive field of a putative direction selective (DS) neuron, formed by the linear sum of two non-DS inputs, illustrated by thick lines (solid/green and dashed/orange) overlaid on their contribution to the spatiotemporal receptive field. There is a delay of τ between inputs. b: Response of Spatiotemporal Excitation plus Threshold (SET) model neuron to motion in each direction. Left-to-right motion drives the delayed input (1) first, then the non-delayed input (2), resulting in coincident arrival. Right-to-left motion drives the non-delayed input first (2), then the delayed input (1). Depending on the threshold placement, the neuron could be completely DS (higher threshold, blue) or weakly DS (lower threshold, red). c: Response of Spatiotemporal Excitation plus Threshold plus Inhibition (SETI) model neuron to motion in each direction. The addition of lagged inhibitory inputs reduces activity levels for right-to-left motion, but not for left-to-right motion. DS is high for both thresholds.

Related publication:

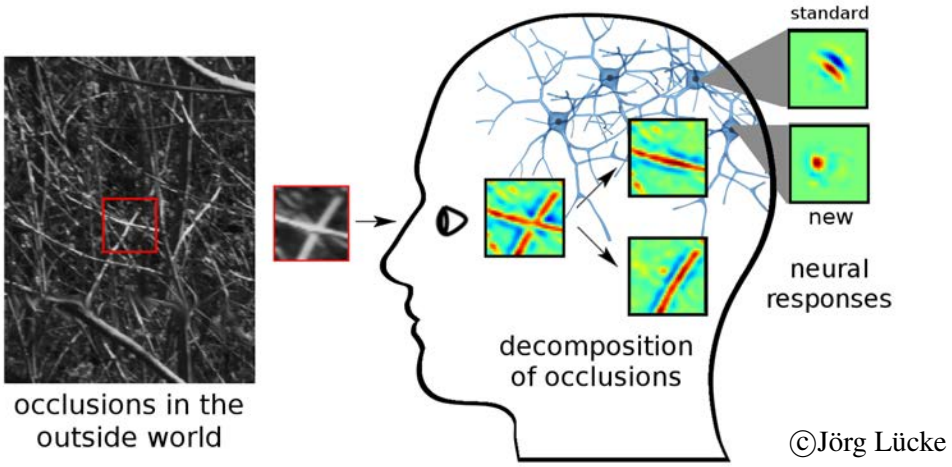
A. Sederberg, M. Kaschube, *Inhibition facilitates direction selectivity in a noisy cortical environment*, J. Comput. Neurosci. (in revision)

Occlusions and Neural Responses in Primary Visual Cortex

Collaborators: J. Bornschein[1,2], Z. Dai[1,3], G. Exarchakis[4], M. Henniges[1], J. Lücke[1,5], A.-S. Sheikh[1,5], J. Shelton[1,5], P. Sterne[1]

[1] 1 Frankfurt Institute for Advanced Studies, [2] University of Montreal (current address), [3] University of Sheffield (current address), [4] UC Berkeley, [5] TU Berlin (current address)

The statistics of our visual world is dominated by occlusions. Almost every image processed by our brain consists of mutually occluding objects, animals and plants. Our visual cortex is optimized through evolution and throughout our lifespan for such stimuli. Yet, the standard computational models of primary visual processing do not consider occlusions.



Occlusions in the visual world have to be considered to appropriately interpret images. New statistical learning models that take occlusions into account can explain neural responses in the primary visual cortex.

In the DFG project "Non-linear Generative Models for Representational Recognition and Unsupervised Learning in Vision", the Bernstein Focus Neurotechnology, and in collaboration with the Honda Research Institute we develop new learning technology that allows for an application of new occlusive models to visual data. Using these models we ask what effects visual occlusions may have on predicted response properties of simple cells which are the first cortical processing units for images. Our results suggest that recently observed differences between experiments and predictions of the standard simple cell models can be attributed to occlusions. The most significant consequence of occlusions is the prediction of many cells sensitive to center-surround stimuli. Experimentally, large quantities of such cells are observed since new techniques (reverse correlation) are used. Without occlusions, they are only obtained for specific settings and none of the seminal studies (sparse coding, ICA) predicted such fields. In contrast, the new type of response naturally emerges as soon as occlusions are considered. In comparison with recent *in vivo* experiments we find that occlusive models are consistent with the high percentages of center-surround simple cells observed in macaque monkeys, ferrets and mice.

Related publications in 2013:

1. J. Bornschein, M. Henniges, and Lücke, *Are V1 Simple Cells Optimized for Visual Occlusions? A Comparative Study*, PLOS Computational Biology 9(6): e1003062 (2013)
2. Z. Dai, G. Exarchakis, and J. Lücke, *What are the invariant occlusive components of image patches? A probabilistic generative approach*, Advances in Neural Information Processing Systems, 243–251 (2013)
3. J. Lücke, J. Shelton, P. Sterne, P. Berkes, J. Bornschein, A.-S. Sheikh, *Combining Feed-Forward Processing and Sampling For Neurally Plausible Encoding Models*, International Conference on Computational and Systems Neuroscience, poster III-28 (2013)

Quantifying human behavioral goals with inverse reinforcement learning

Collaborators: C. A. Rothkopf[1], C. Dimitrakakis[2], D. H. Ballard[3]

[1] Frankfurt Institute for Advanced Studies, [2] Ecole Polytechnique Federale de Lausanne, Lausanne, Switzerland, [3] Department of Computer Science, University of Texas at Austin, Austin, Texas, USA

In a large variety of situations one would like to have an expressive and accurate model of observed animal or human behavior. While general-purpose mathematical models may capture successfully properties of observed behavior, it is desirable to root models in biological facts. Because of ample empirical evidence for rewardbased learning in visuomotor tasks we use a computational model based on the assumption that the observed agent is balancing the costs and benefits of its behavior to meet its goals. This leads to using the framework of Reinforcement Learning, which additionally provides well-established algorithms for learning of visuomotor task solutions.

To quantify the agent's goals as rewards implicit in the observed behavior we propose to use inverse reinforcement learning, which quantifies the agentŠs goals as rewards implicit in the observed behavior. Based on the assumption of a modular cognitive architecture, we introduce a modular inverse reinforcement learning algorithm that estimates the relative reward contributions of the component tasks in navigation, consisting of following a path while avoiding obstacles and approaching targets. It is shown how to recover the component reward weights for individual tasks and that variability in observed trajectories can be explained succinctly through behavioral goals. It is demonstrated through simulations that good estimates can be obtained already with modest amounts of observation data, which in turn allows the prediction of behavior in novel configurations.

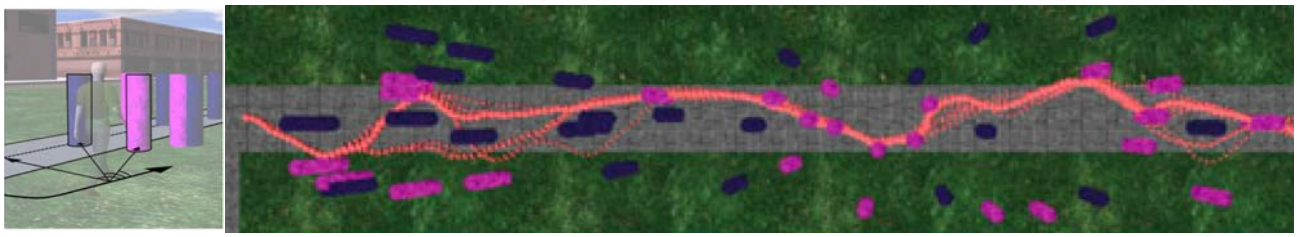


Figure: *Left:* Overview of ego-centric polar coordinate reference frame of navigation problem formulation. *Right:* Simulated trajectories using relative costs inferred from human subject data.

Related publications in 2013:

1) C. A. Rothkopf, D. H. Ballard, *Modular inverse reinforcement learning for visuomotor behavior,* Biological Cybernetics, 107, 477-490 (2013)

2) C. A. Rothkopf, *Inferring intrinsic costs in human navigation with inverse reinforcement learning*, Bernstein Conference, September 25-27, Tübingen, Germany, (2013)

Computational models of visuomotor heuristics

Collaborators: C. A. Rothkopf[1], P. Schrater[2]

[1] Frankfurt Institute for Advanced Studies, [2] Department of Computer Science & Department of Psychology, University of Minnesota, Minneapolis, USA

Animals ranging from dragonflies through teleost fish to humans all intercept moving targets using the same strategy of adjusting their speed so as to hold the angle pointing towards their target constant over time. This constant-bearing-angle strategy has been suggested as a fundamental visuomotor heuristic and as an instance of Darwininan intelligence that overcomes the need for complex and expensive computations involving multiple sources of uncertainty.

We consider the task of intercepting a moving ball for which many previous studies have shown that humans use this constant bearing angle strategy. Here we manipulated the observation function in a virtual reality setup so as to change the uncertainty of the ball's position parametrically. Specifically, the contrast of the ball changes as a function of the heading angle towards the ball along the subject's momentary trajectory. Subjects adjusted their interception strategy within an average of 26 trials and were consistently able to catch these balls.

To gain insight into the adopted new interception strategy, we setup an approximate optimal control models, which is provided observation function governing the uncertainty in state variables given visual observations. Parameters of this model are based on previous literature. The approach utilizes a Monte Carlo sampling of smooth trajectories of increasing complexity in a low dimensional parameter space. This analyses shows that the ideal actor modifies its trajectories by executing controls that increase information gain, and that these changes mirror human behavior.

Thus, we provide evidence that humans quickly abandon the constant bearing angle strategy in favor of more informative action sequences, if this allows catching moving targets more reliably. The constant-bearing-anglestrategy is not an invariant heuristic of Darwinian intelligence as humans employ near-optimal information seeking actions that violate the constant bearing angle strategy, but produce less uncertainty in the interception.

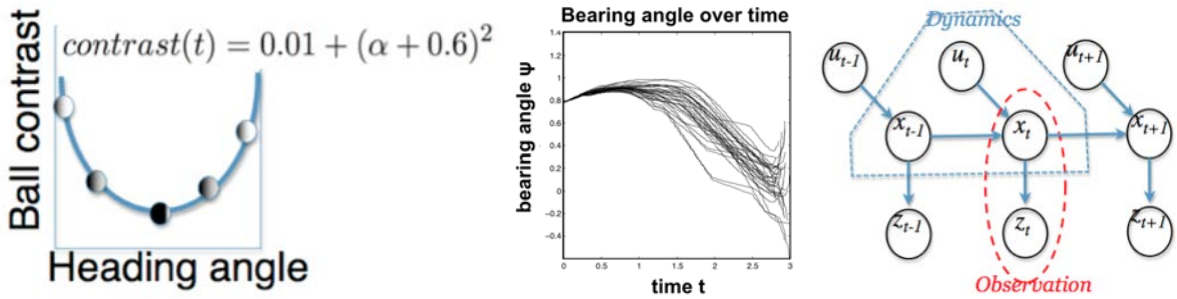


Figure: *Left:* Functional relationship between heading angle of interceptor and contrast of target. *Center:* Bearing angle over time for interception movements of 10 subjects, showing a significant departure from the constant bearing angle strategy. *Right:* Modeling framework for representing uncertainties about object properties and their temporal dynamics.

Related publications in 2013:

1) C. A. Rothkopf, P. Schrater, *Optimally adapting heuristics: humans quickly abandon the constant bearing angle strategy*, Bernstein Conference, September 25-27, Tübingen, Germany, (2013)

Predicting retinal ganglion cells' properties from the statistics of the natural input to the visual system

Collaborators: D. Pamplona1[1], J. Triesch[1], C. A. Rothkopf[1]

[1] Frankfurt Institute for Advanced Studies

The efficient coding hypothesis posits that sensory systems are adapted to the regularities of their signal input so as to reduce redundancy in the resulting representations. It is therefore important to characterize the regularities of natural signals to gain insight into the processing of natural stimuli. While measurements of statistical regularity in vision have focused on photographic images of natural environments it has been much less investigated, how the specific imaging process embodied by the organismŠs eye induces statistical dependencies on the natural input to the visual system. This has allowed using the convenient assumption that natural image data are homogeneous across the visual field. Extensive previous resealch of the autocorrelation function and the power spectrum of natural images has shown that for large image ensembles the average power spectrum falls off with radial frequency as $1/f_r^{\alpha}$ where the value for a is empirically estimated to be close to 2.

Our previous work gave up on this assumption and showed how the imaging process in a human model eye influences the local statistics of the natural input to the visual system across the entire visual field. Artificial scenes with three-dimensional edge elements were generated and the influence of the imaging projection onto the back of a spherical model eye were quantified. These distributions show a strong radial influence of the imaging process on the resulting edge statistics with increasing eccentricity from the model fovea. This influence is further quantified through computation of the second-order intensity statistics as a function of eccentricity from the center of projection using samples from the dead leaves image model. The current work derived the optimal linear filters that can remove these local redundancies in the visual input both under the assumption of only external noise, leading to variants of the classical Wiener filter, and with external and internal noise, leading to more recent models of retinal processing. We show, that a variety of physiologically observed properties of retinal ganglion cells, including the increase in size with eccentricity and their radial bias in shape across the visual field, can be predicted on the basis of this approach.

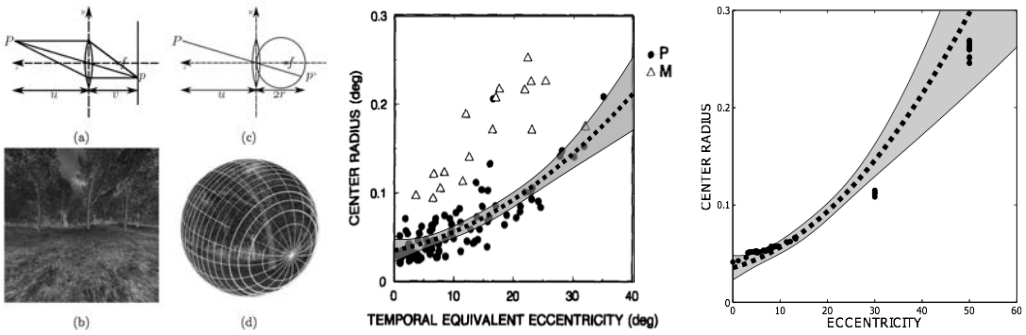


Figure: *Left:* Differences of the image formation process between photographic images and images projected into a model eye. *Center:* Receptive field center size of P and M retinal ganglion cells of the macaque as a function of the retinal eccentricity. Image reused from Croner and Kaplan (1995). *Right:* Corresponding receptive field sizes according to the proposed model. Note that the fitting function and the confidence bounds are take from the neurophysiological data from Croner and Kaplan (1995).

Related publications in 2013:

1) D. Pamplona, J. Triesch, C. A. Rothkopf, *Power spectra of the natural input to the visual system*, Vision research, 83, 66-75 (2013)

2) D. Pamplona, J. Triesch, C. A. Rothkopf, *Constrained efficient coding of the natural input explains ganglion cells anisotropies*, (in preparation)

Gamma oscillations: Temporal coordination without a metronome

Collaborators: W. Singer[1,2], P. Fries[3], D. Nikolić[1,2,3]

[1] Max Planck Institute for Brain Research, Frankfurt, [2] Frankfurt Institute for Advanced Studies, [3] Ernst Strüngmann Institutefor Neuroscience, Frankfurt

We clarified a common confusion in the literature: Gamma oscillations in the brain should not be conceptualized as a sine wave with constant oscillation frequency. Rather, these oscillations serve to concentrate neuronal discharges to particular phases of the oscillation cycle and thereby provide the substrate for various, functionally relevant synchronization phenomena.

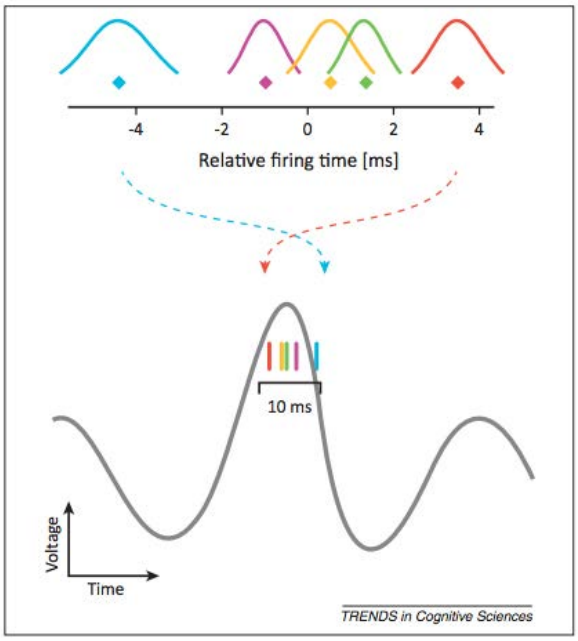


Figure: The relationships between the timing of neuronal spiking activity and the phase of oscillation cycle. Top: a sequence in which five neurons preferentially fire for a given stimulus.Bottom:the relationship to the underlying oscillation cycle, as indicated by local field potentials. These relative neuronal firing times are not constant, but change dynamically as a function of stimulus properties (not shown).

Related publication:

D. Nikolić, R.C. Mureşan, W. Feng, W. Singer, *Scaled correlation analysis: A better way to compute a cross-correlogram*, European Journal of Neuroscience 35, 742–762 (2012), doi: 10.1111/j.1460-9568.2011.07987.x

D. Nikolić D., P. Fries, W. Singer, *Gamma oscillations: precise temporal coordination without a metronome*, Trends in Cognitive Sciences, 17: 54-55 (2013); doi:10.1016/j.tics.2012.12.003

Synchronization hubs and rhythmic inhibition

Collaborators: S.E. Folias[1,2], S. Yu[3], A. Snyder[2], D. Nikolić[3,4,5], J.E. Rubin[2,6]

[1] University of Alaska, Anchorage,USA, [2] University of Pittsburgh, Pittsburgh, PA, USA, [3] Max Planck Institute for Brain Research, Frankfurt, [4] Frankfurt Institute for Advanced Studies, [5] Ernst Strüngmann Institute for Neuroscience, Frankfurt [6] Center for the Neural Basis of Cognition, Pittsburgh, PA, USA

Neurons in the visual cortex exhibit heterogeneity in feature selectivity and the tendency to generate action potentials synchronously with other nearby neurons. By examining visual responses from cat area 17 we found that, during gamma oscillations, there was a positive correlation between each unit's sharpness of orientation tuning, strength of oscillations, and propensity towards synchronisation with other units. Using a computational model, we demonstrated that heterogeneity in the strength of rhythmic inhibitory inputs can account for the correlations between these three properties. Neurons subject to strong inhibition tend to oscillate strongly in response to both optimal and suboptimal stimuli, and to synchronise promiscuously with other neurons, even if they have different orientation preferences. Moreover, these strongly inhibited neurons can exhibit sharp orientation selectivity provided that the inhibition they receive is broadly tuned relative to their excitatory inputs. These results predict that the strength and orientation tuning of synaptic inhibition are heterogeneous across area 17 neurons, which could have important implications for these neurons' sensory processing capabilities. Furthermore, although our experimental recordings were conducted in the visual cortex, our model and simulation results can apply more generally to any brain region with analogous neuron types in which heterogeneity in the strength of rhythmic inhibition can arise during gamma oscillations.

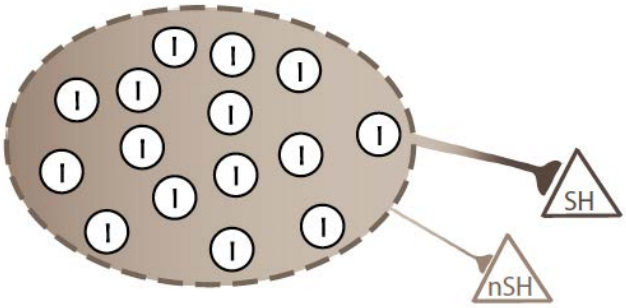


Figure: Schematic illustration of how a pool of inhibitory interneurons engaging in synchronous oscillations delivers approximately synchronous (i.e. narrowly distributed) pulses of synaptic inhibition to excitatory neurons. In our model, syncrhonization hubs (SH) receive stronger levels of rhythmic inhibition from the inhibitory pool compared with neurons that are not SHs (nSH), as represented here by connection thicknesses.

Related publication in 2013:

S.E. Folias, S. Yu, A. Snyder, D. Nikolić, J.E. Rubin, *Synchronisation hubs in the visual cortex may arise from strong rhythmic inhibition during gamma oscillations*, European Journal of Neuroscience, 38, 2864 (2013)

Regression tree for encoding through patterns

Collaborators: R. Haslinger[1,2], G. Pipa[3], L. Lewis[2], D. Nikolić[4,5,6], Z. Williams[1], E. Brown[1,2]

[1] Massachusetts General Hospital, Charlestown, USA, [2] MIT, Department of Brain and Cognitive Sciences, Cambridge, MA, USA, [3] Department of Neuroinformatics, University of Osnabrück, Germany, [4] Max Planck Institute for Brain Research, Frankfurt, [5] Frankfurt Institute for Advanced Studies, [6] Ernst Strüngmann Institute for Neuroscience, Frankfurt

When computing a cross-correlation histogram, slower signal components can hinder the detection of faster components, which are often in the research focus. For example, precise neuronal synchronization often co-occurs with slow co-variation in neuronal rate responses. We developed a method - dubbed scaled correlation analysis - that enables the isolation of the cross-correlation histogram of fast signal components. The method computes correlations only on small temporal scales (i.e. on short segments of signals such as 25 ms), resulting in the removal of correlation components slower than those defined by the scale. Scaled correlation analysis has several advantages over traditional filtering approaches based on computations in the frequency domain. Among its other applications, the method can assist the studies of precise neuronal synchronization.

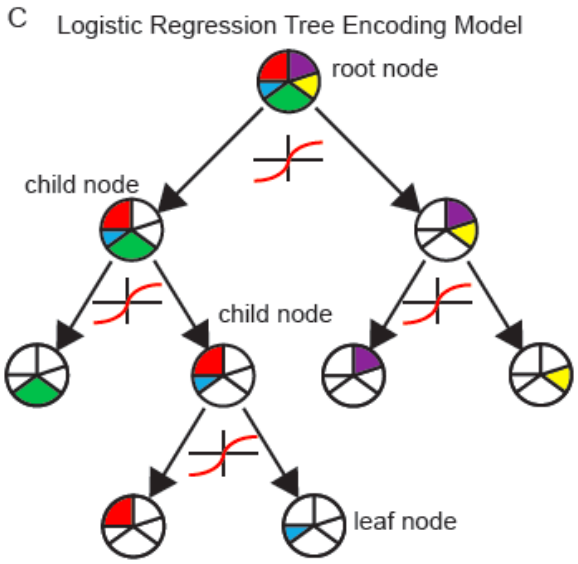


Figure: Schematic of the tree based pattern-encoding model. Partitioning of patterns is accomplished using a regression tree that constitutes a probability model for each pattern. The root node contains all patterns (colors denote patterns with similar encoding properties) and is split into two child nodes. The probability of each child node is described by a stimulus-dependent logistic regression model. The child nodes are themselves split, until the Bayesian information criterion is minimized. The leafs on the tree are the final clusters, comprised of patterns with the same probabilistic dependence upon the stimuli.

Related publication in 2013:

R. Haslinger, G. Pipa, L. Lewis, D. Nikolić, Z. Williams, E. Brown, *Encoding through patterns: regression tree based neuronal population models*, Neural Computation 25, 1953 (2013)

Evidence that swimming-style synaesthesia is genuine

Collaborators: N. Rothen[1], D. Nikolić[2,3], U.M. Jürgens[2,4], A. Mroczko-Wasowicz[5], J. Cock[1], B. Meier[1]

[1] Department of Psychology and Center for Cognition, Learning and Memory, University of Bern, Bern, Switzerland, [2] Max Planck Institute for Brain Research, Frankfurt, [3] Frankfurt Institute for Advanced Studies, [4] Department of Psychology, University of Zagreb, Zagreb, Croatia, [5] National Yang-Ming University, Institute of Philosophy of Mind and Cognition, Taipei, Taiwan

Recently, swimming-style colour synaesthesia was introduced as a new form of synaesthesia, and has been shown to be a form of ideasthesia (Nikolić et al., 2011). A synaesthetic Stroop test was used to establish its genuineness. Since Stroop interference can occur for any type of overlearned association, in the present study we used a modified Stroop test and psychophysiological synaesthetic conditioning to further establish the genuineness of this form of synaesthesia. We compared the performance of a swimming-style colour synaesthete and a control who was trained on swimming-style colour associations. Our results showed that behavioural aspects of swimming-style colour synaesthesia can be mimicked in a trained control. Importantly, however, our results showed a psychophysiological conditioning effect for the synaesthete only. We discuss the theoretical relevance of swimming-style colour synaesthesia according to different models of synaesthesia. We conclude that swimming-style colour synaesthesia is a genuine form of synaesthesia, can be mimicked behaviourally in non-synaesthetes, and is best explained by a re-entrant feedback model.

Figure: Left: Illustration of swimming-style synesthesia as presented on the cover page of Cerebral Cortex reporting our previous study (Nikolić et al., Cortex, 47, 874 (2011))). Right: Stimuli used in the most recent study.

Related publication in 2013:

1) N. Rothen, D. Nikolić, U.M. Jürgens, A. Mroczko-Wasowicz, J. Cock, B. Meier, *Psychophysiological evidence for the genuineness of swimming-style colour synaesthesia*. Consciousness and Cognition, 22, 35 (2013)

2) U.M. Jürgens, D. Nikolić, *Synaesthesia as an Ideasthesia – cognitive implications*, in: Synesthesia - Learning and Creativity. Edited by J. Sinha. Proceedings from the conference Synesthesia and Children. Learning and Creativity, Ulm, May 2012. Synaisthesis, Luxembourg (in press)

3) A. Mroczko-Wasowicz, D. Nikolić, *Coloured alphabets in bi-lingual synaesthetes*, in: The Oxford Handbook of Synaesthesia: 165 (2013)

Attentional Gating of Information Flow: Modelling the Role of Oscillations

Collaborators: Thomas Burwick and Sebastian Blaes

Frankfurt Institute for Advanced Studies, Goethe University, Frankfurt am Main, Germany

This work deals with modeling attention-controlled neural information processing through oscillatory neural networks. Recent years have revealed the involvement of cortical oscillatory processes in attentional selection of perceived objects, based on attention that focusses on locations or features. Here, we aim at understanding the functional role of these oscillations from a mathematical and computational point of view in a manner that respects the essentials of neurophysiological findings, in particular, with respect to alpha ($\sim$ 10Hz), beta ($\sim$ 20Hz), and gamma frequency range (30-90 Hz) oscillations. Our models link the observed neurophysiological mechanisms with functional relevance in the context of computational intelligence.

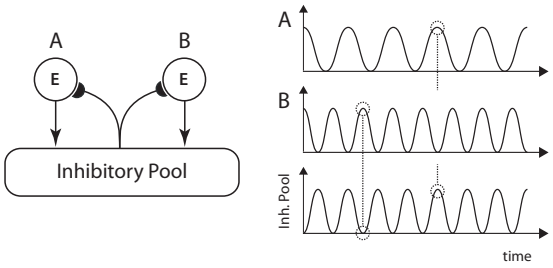


Figure 1: Illustration of selective inhibition through couplings between excitatory units (E) and pool of inhibitory units. Relative phase and/or frequency differences lead to inhibition of unit A, while unit B escapes inhibition.

Perceiving an object requires the selection of sensed features and grouping of the features into an object representation, a process known as binding. The resulting selection of the object is controlled by attentional choices. When studying visual areas V4 and IT of the macaque monkey's brain, Moran & Desimone (1985) observed that attention to a stimulus blocks the processing of unattended stimuli. In 2001, Fries et al. found that related brain processes involve cortical oscillations in the gamma range. Further considerations led to the Communication-through-Coherence Hypothesis (Fries, 2005) and corresponding experimental confirmations by Womelsdorf et al. (2007) and Bosman et al. (2012).

In order to model and thereby understand possible functional roles of oscillations in the context of attentional selection, we build on recent progress made in realizing pattern recognition mechanisms based on oscillatory neural networks (Burwick, 2008, 2011). An essential aspect underlying cortical gamma range oscillations is the oscillating pool of inhibitory units and the resulting synchronized inhibitory effect. Due to the synchronization, time windows arise, where the inhibitory effect sufficiently decayed so that excitatory activity is possible. Information processing, for example, pattern recognition arises if different populations of excitatory units imply different drives of the inhibitory pool, introducing a competition among the excitatory units that is won by the dominating population of excitatory units that finally generates the rhythm of the inhibitory pool, see Figure 1 and (Burwick, 2011) for additional explanations. In accordance with neurophysiological observations, we let the focus of attention be realized through making the corresponding excitatory units the generating ones, that is, the ones that imprint their rhythm on the inhibitory pool. We demonstrate the selection process for attended targets among distracters in the context of the model through examples, see Figure 2 (the input was constructed from the image dataset described in G. Griffin, A. Holub, P. Perona, "The Caltech 256", Caltech Technical Report).

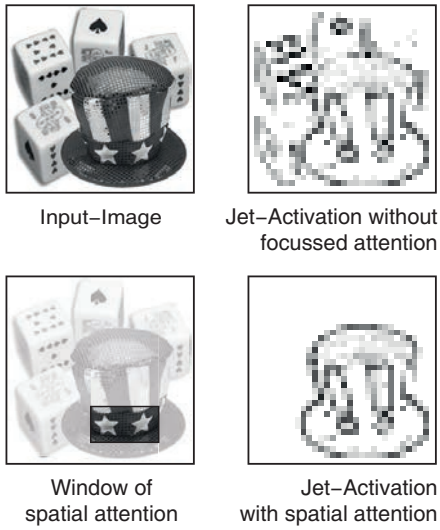
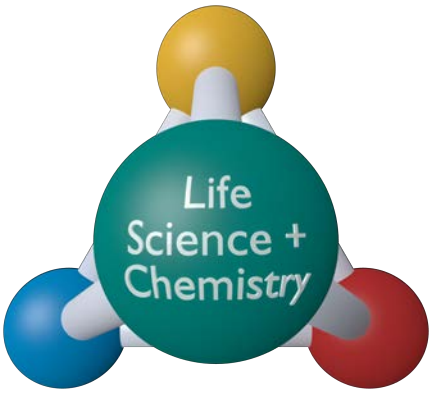


Figure 2: Ocillation-based selective inhibition controlled by an attentional window. (From a forthcoming publication.)

Related publication:

T. Burwick, *The Binding Problem*, WIREs Cogn Sci 2014. doi: 10.1002/wcs.1279

4.3 Biology, Chemistry, Molecules, Nanosystems



Quantitative 4D analyses of epithelial folding during Drosophila gastrulation

Collaborators: Zia Khan[1], Yu-Chiun Wang[2], Eric F. Wischaus[3,4], and Matthias Kaschube[5,6]

[1]Center for Bioinformatics and Computational Biology, University of Maryland, College Park, MD, USA, [2]RIKEN Center for Developmental Biology, 2-2-3 Minatojima-minamimachi, Chuo-ku, Kobe-shi, Hyogo-ken 650-0047, Japan, [3]Department of Molecular Biology, Princeton University, Princeton, NJ, USA, [4]The Howard Hughes Medical Institute, Moffett Laboratory 435, Princeton University, Princeton, NJ, USA, [5]Faculty of Computer Science and Mathematics, Goethe University, [6]Frankfurt Institute for Advanced Studies, Frankfurt, Germany

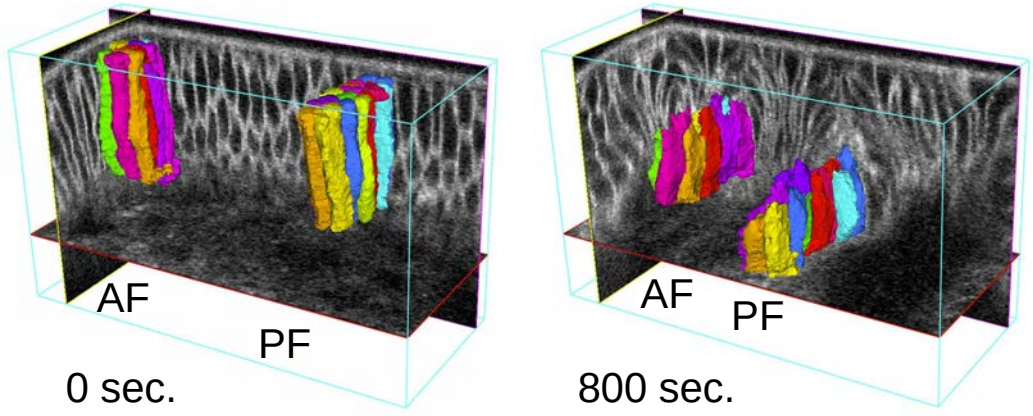


Figure: Quantitative 4D analyses of cells in the dorsal folds in *Drosophila* using EDGE4D. Basal-most initiating cells tracked into the anterior (AF) and posterior folds (PF) between 0 sec. and 800 sec. past the onset of gastrulation. Colors designate the same cell between these two time points.

Understanding the cellular and mechanical processes underlying the shape changes of individual cells and their collective behaviors in a tissue during dynamic and complex morphogenetic events is currently one of the major frontiers in developmental biology. The advent of high speed, time-lapse microscopy and its use in monitoring the cellular events in fluorescently labeled developing organisms demonstrate tremendous promise in establishing detailed descriptions of these events and could potentially provide a foundation for subsequent hypothesis-driven research strategies. However, obtaining quantitative measurements of dynamic shapes and behaviors of cells and tissues in a rapidly developing metazoan embryo using time-lapse 3D microscopy remains technically challenging with the main hurdle being the shortage of robust imaging processing and analysis tools. Therefore, we developed EDGE4D, a software tool for segmenting and tracking membrane labeled cells using multi-photon microscopy data. Our results demonstrate that EDGE4D enables quantification of the dynamics of cell shape changes, cell interfaces, and neighbor relations, at single-cell resolution during a complex epithelial folding event in the early Drosophila embryo. We expect that this tool to be broadly useful for the analysis of epithelial cell geometries and movements in a wide variety of developmental contexts.

Implementation and Availability:

Source code for EDGE4D can be downloaded from (https://sites.google.com/site/edge4dsupplement).

Related publication:

Z. Khan, Y.-C. Wang, E.F. Wischaus, M. Kaschube, *Quantitative 4D analyses of epithelial folding during Drosophila gastrulation*, Development (in revision)

Z. Khan, Y.-C. Wang, E.F. Wischaus, M. Kaschube, *EDGE4D a tool for quantitative 4D analyses of epithelial folding during Drosophila gastrulation*, EMBO|EMBL Symposium: Seeing is Believing – Imaging the Processes of Life. Oral presentation (2013)

Free atomic and molecular clusters, nanoparticles

Collaborators: A.V. Verkhovtsev[1], G.B. Sushko[1], A.V. Yakubovich[1], A.V. Solov'yov[1]

[1] MBN@FIAS

Short description:
Investigation of electronic structure and dynamical properties of atomic and molecular clusters.

Main results:

• In Refs. [1,2] the investigation of geometrical, electronic and magnetic properties of small transition metal clusters was carried out. The optimized structures and geometrical properties of Ti_N and $Ti_{N-1}Ni$ clusters consisting of up to 15 atoms were studied using both the ab initio and classical approaches. It was shown that the geometrical properties, obtained within the classical simulations, are in good agreement with those obtained within the more sophisticated ab initio framework (Fig. 1).

• We analyzed the influence of the Ni-doping on the stability and properties of the bimetallic Ni-Ti compounds. Ab initio analysis [1] of electronic and magnetic properties of the clusters showed that the doping of titanium clusters by Ni atoms causes a significant charge transfer in a system (Fig. 2) and change of the magnetic properties (Fig. 3).

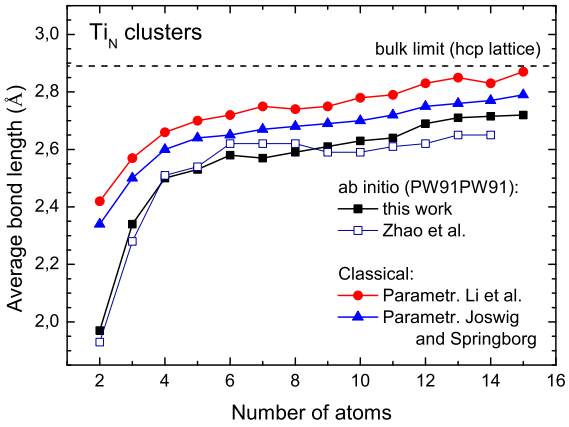


Fig. 1: Average bond length as a function of cluster size for Ti_N clusters calculated within the ab initio (black line) and classical frameworks (red and blue lines). The classical force fields were obtained using the Finnis-Sinclair potential. Two different parameterizations of the potential, proposed by Li et al. and Joswig et al., were used in the calculations.

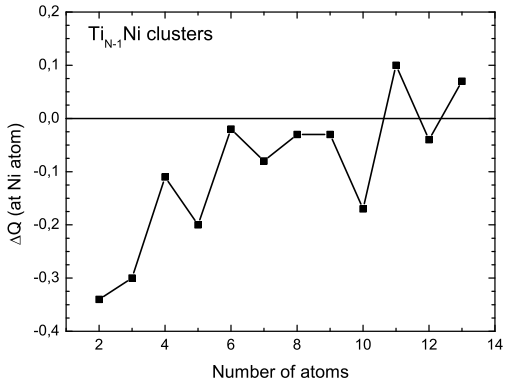


Fig. 2: The Mulliken charge (ΔQ) of the Ni atom in the $Ti_{N-1}Ni$ clusters.

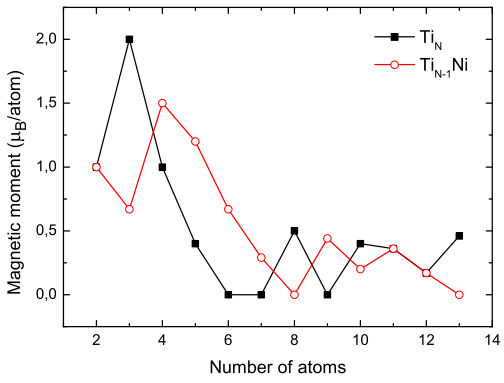


Fig. 3: Magnetic moments per atom of pure and Ni-doped titanium clusters as a function of cluster size.

Related publications in 2013:

1. A.V. Verkhovtsev, M. Hanauske, A.V. Yakubovich, A.V. Solov'yov, *Characterization of small pure and Ni-doped titanium clusters: Ab initio versus classical approaches*, Comput. Mater. Sci. 76, 80-88 (2013)

2. A.V. Verkhovtsev, G.B. Sushko, A.V. Yakubovich, A.V. Solov'yov, *Benchmarking of classical force fields by ab initio calculations of atomic clusters: Ti and Ni-Ti case*, Comput. Theor. Chem. 1021, 101-108 (2013)

3. A.V. Korol and A.V. Solov'yov, *Atomic cluster collisions. Editorial*, Eur. Phys. J. D 67, 1-(1-6) (2013)

Nanocarbon systems (Fullerenes, nanotubes, nanowires etc.)

Collaborators: A.V. Verkhovtsev[1], A.V. Korol[1], A.V. Solov'yov[1], R.G. Polozkov[2], V.K. Ivanov[2]

[1] MBN@FIAS, [2] St. Petersburg State Polytechnic University, Russia

Short description:
Investigation of electronic structure and dynamical properties of various nanocarbon systems, such as fullerenes, nanotubes etc.

Main results:

We carried out investigation of electron excitations in various carbon-based nanoscale systems in the process of photoionization [1,2]. As a case study, we considered a number of highly symmetric fullerenes, namely C_{20}, C_{60} and C_{80}, as well as aromatic hydrocarbons – benzene (C_6H_6) and coronene ($C_{24}H_{12}$). The calculations were performed within the ab initio TDDFT framework and model approach, based on the plasmon resonance approximation. Results of the model-based calculations are in close agreement with those of the more accurate quantum-chemical calculations and correspond also to the existing experimental data (Fig. 1).

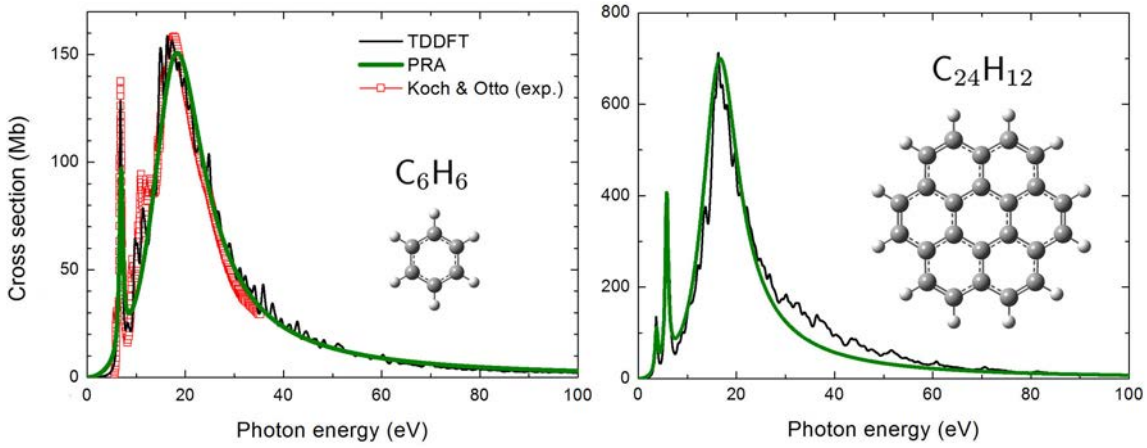


Fig. 1: The photoionization cross section of benzene (left) and coronene (right) calculated within the TDDFT method (thin black line) and the plasmon resonance approximation (thick green line). In case of benzene theoretical curves are compared to the experimental data of Koch et al. (Chem. Phys. Lett. 12, 476 (1972)).

Related publications in 2013:

1. A.V. Verkhovtsev, A.V. Korol and A.V. Solov'yov, *Theoretical investigation of electron excitations in photoionization of nanoscale carbon-based systems*, St. Petersburg State Polytechnical University Journal: Physics and Mathematics 3(177), 80-91 (2013) (in Russian)

2. A.V. Verkhovtsev, A.V. Korol and A.V. Solov'yov, *Quantum and classical phenomena in photoionization of carbon nanostructures*, J. Phys.: Conf. Ser. (accepted for publication) (2013)

Nanoscale phase transitions (Folding, melting, solidification, sublimation, multifragmentation, etc.)

Collaborators: G.B. Sushko[1], A.V. Yakubovich[1], A.V. Solov'yov[1], S.Schramm[2]

[1] MBN@FIAS, [2] FIAS

Short description:
The process of solidification of large nickel clusters is computationally explored. This process has the characteristic features of the first order phase transition occurring in a finite system. The research is focused on the elucidation of correlated dynamics of a large ensemble of particles in the course of the nanoscale liquid-solid phase transition through the computation and analysis of the results of molecular dynamics simulations with the corresponding theoretical model. This problem is of significant importance, because the controlled dynamics of systems on the nanoscale is one of the central topics in the development of modern nanotechnologies.

Main results:
Classical molecular dynamics (MD) simulations of the melting and solidification processes of of the Ni_{2057} cluster were conducted on the time scales up to 65 ns [1]. The many-body Sutton-Chen potential was utilized for the description of the interatomic interaction.

We analyzed the solidification kinetics of the cluster as a function of the over-cooling temperature and shown that the kinetics of the phase transition can be described within the framework of precursor formation theoretical model. Based on that theoretical model we derived various characteristics of the system such as solid-liquid surface tension coefficient, rate of the precursors formation and phase transition temperature for the clusters of arbitrary size.

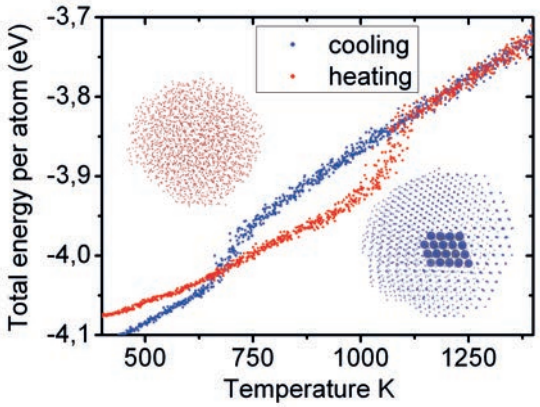


Fig. 1: Dependence of the total energy per atom in heating (red) and cooling (blue) simulations. The insets show the structures of Ni_{2057} in the molten (top-left) and solidified (bottomright) states. A fragment of the crystal structure is shown by blue spheres inside the crystallized structure.

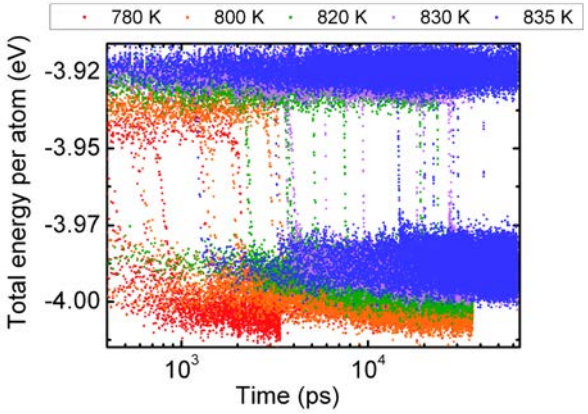


Fig. 2: Time dependence of the total energy per atom for the cluster being initially in the molten state at different temperatures of the thermostat. Red, orange, green, magenta and violet dots correspond to thermostat temperatures of 780, 800, 820, 830 and 835 K, respectively. Note the logarithmic scale on the horizontal time axis. The solidification phase transition occurs earlier in the systems at lower temperature.

Related publications in 2013:

1. Alexander V. Yakubovich, Gennady Sushko, Stefan Schramm, Andrey V. Solov'yov, *Kinetics of liquid-solid phase transition in large nickel clusters*, Phys. Rev. B 88, 035438-(1-9) (2013)

Dynamical processes with bio-macromolecules

Collaborators: A.V. Yakubovich[1], A.V. Solov'yov,[1] W. Greiner[2]

[1] MBN@FIAS, [2] FIAS

Short description:

We present a statistical mechanics formalism for the theoretical description of the process of protein folding $\leftrightarrow$ unfolding transition in water environment. The formalism is based on the construction of the partition function of a protein obeying two-stage-like folding kinetics. Using the statistical mechanics model of solvation of hydrophobic hydrocarbons we obtain the partition function of infinitely diluted solution of proteins in water environment. The calculated dependencies of the protein heat capacities upon temperature are compared with the corresponding results of experimental measurements for staphylococcal nuclease.

Main results:

The constructed partition function of each state is a product of partition function of a protein in a given conformational state, partition function of water molecules in pure water and a partition function of H_2O molecules interacting with the protein. The introduced model includes a number of parameters responsible for certain physical properties of the system. The parameters were obtained from available experimental data and three of them were considered as being variable depending on a particular protein and pH of the solvent. We have compared the predictions of the developed model with the results of experimental measurements of the dependence of the heat capacity on temperature for staphylococcal nuclease. The experimental results were obtained at various pH of solvent. The suggested model is capable to reproduce well within a single framework a large number of peculiarities of the heat capacity profile, such as the temperatures of cold and heat denaturations, the corresponding maximum values of the heat capacities, the temperature range of the cold and heat denaturation transitions, the difference between heat capacities of the folded and unfolded states of the protein.

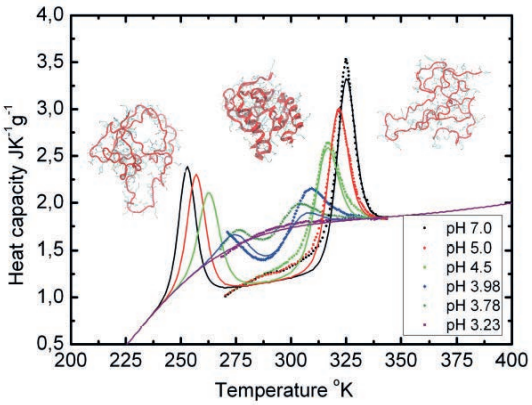


Fig. 1: Dependencies of the heat capacity on temperature for staphylococcal nuclease (PDB ID 1EYD) at different values of pH. Solid lines show results of the developed theoretical model. Symbols present experimental data. Structure of the protein in native and unfolded conformations are shown in temperature regions where the corresponding conformation exists.

Related publications in 2013:

1. A.V. Yakubovich, A.V. Solov'yov, W. Greiner, *Statistical mechanical theory of protein folding in water environment*, pp. 493-508 in "Exciting Interdisciplinary Physics: Quarks and Gluons, Atomic Nuclei, Relativity and Cosmology, Biological Systems" (FIAS Interdisciplinary Science Series), W. Greiner (Ed.) (Springer, Cham Heidelberg New York Dordrecht London, 2013)

Molecular Systems in ubiquitous environment and external fields (electric, magnetic, laser)

Collaborators: A.V. Yakubovich[1], A.V. Solov'yov[1], I.A. Solov'yov[2]

[1] MBN@FIAS, [2] University of Southern Denmark, Odense, Denmark

Short description:

Laser induced acoustic desorption (LIAD) is a procedure of gentle lifting of large neutral biomolecules into the gas phase. In LIAD experiments the biomolecules are deposited on a surface of a relatively thin ($\sim 10\mu$m) metallic foil. The back surface of the foil is irradiated by the laser pulse. The energy of the laser is adsorbed by the material of the foil which consequently causes the propagation of acoustic and thermal waves. The propagating waves induce vibration of the foil material which stimulates the emission of biomolecules from the foil surface to the gas phase.

Main results:

We have considered 13 lysine amino acid deposited on a (111)-nickel surface consisting of four monolayers. The size of the nickel surface in x an y directions was taken equal to 3 nm. The interactions between amino acids were described through the CHARMM22 force field and the interactions between nickel atoms were modeled using the many-body Sutton-Chen potential. Interaction between the atoms of nickel and atoms of lysines were described through the van der Waals potential.

Because of the acceleration of the foil, the loosely bound amino acids are desorbed from the foil surface in the course of the simulation. The desorption rate of the amino acids as a function of the surface acceleration has been analyzed. It was shown that the desorption rate has an exponential dependence on the value of the substrate acceleration. We have shown that in the coordinate frame moving with the speed of the substrate at the initial moment of time, the velocities of the molecules are inversely proportional to the substrate acceleration.

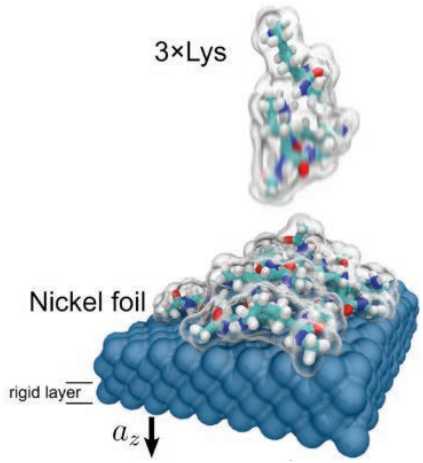


Fig. 1: Evaporation of a cluster of several lysine residues from the surface of a nickel foil. The evaporation is caused by the foil acceleration.

Related publications in 2013:

1. A.V. Yakubovich, I.A. Solov'yov, A.V. Solov'yov, *Molecular dynamics simulations of bio-nano systems*, Phys. Proc. 40, 93-99 (2013)

Collision processes involving clusters and biomolecules

Collaborators: A.V. Solov'yov[1], P. de Vera[2], R. Garcia-Molina[2], I. Abril[2]

[1] MBN@FIAS, [2] Universitat d'Alacant, Spain

Short description:
Impact ionization of complex biological media is studied by means of a newly suggested model.

Main results:

A semiempirical model has been developed [1,2] for calculating the electron emission from any organic compound after ion impact. With the only input of the density and composition of the target we can evaluate its ionization cross sections using plausible approximations. The model is based on the dielectric formalism and makes use of a semiempirical parametrization of the optical energy-loss function of bioorganic compounds. It allows for the calculation of singly differential and total ionization cross sections and related quantities for condensed biological targets, such as liquid water, DNA and its components, proteins, lipids, carbohydrates or cell constituents.

The model shows a very good agreement with experimental data for water, adenine and uracil, and allows one to compare the ionization efficiency of various biological targets as well as the average kinetic energy of the ejected secondary electrons. Due to its simplicity and great predictive effectiveness, the method can be immediately extended to any combination of biological target and charged particle of interest in ion beam cancer therapy.

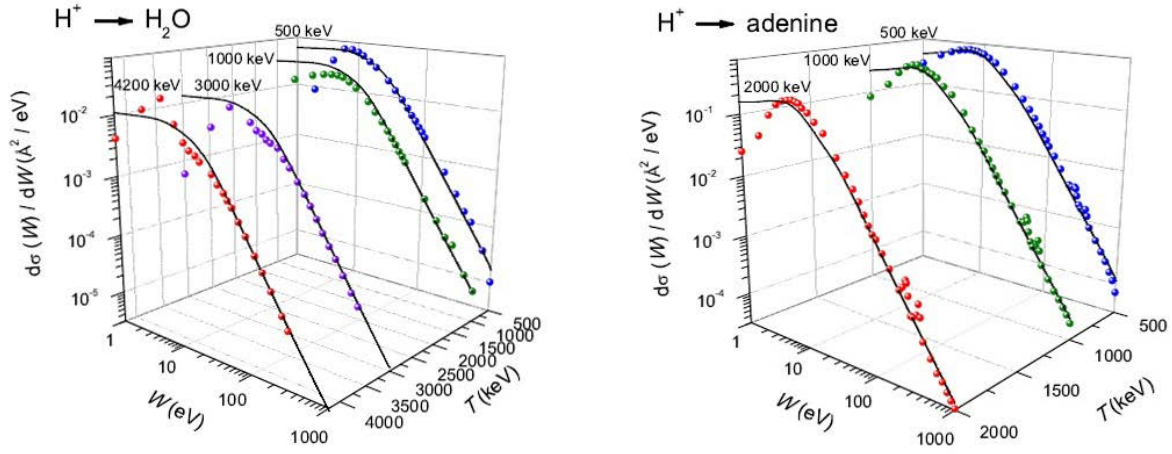


Fig. 1: Singly differential cross sections for ionization of liquid water (left) and solid adenine (right) by protons of several energies obtained with the present model. Symbols represent experimental data for water vapor (left) and for adenine vapor (right).

Related publications in 2013:

1. P. de Vera, R. Garcia-Molina, I. Abril and A.V. Solov'yov, *Semiempirical model for the ion impact ionization of complex biological media*, Phys. Rev. Lett. 110, 148104-(1-5) (2013)

2. P. de Vera, I. Abril, R. Garcia-Molina and A.V. Solov'yov, *Ionization of biomolecular targets by ion impact: input data for radiobiological applications*, J. Phys.: Conf. Ser. 438, 012015-(1-10) (2013)

Photo-processes and optical properties

Collaborators: A.V. Verkhovtsev[1], A.V. Korol[1], A.V. Solov'yov[1], R.G. Polozkov[2], V.K. Ivanov[2]

[1] MBN@FIAS, [2] St. Petersburg State Polytechnic University, Russia

Short description:
Investigation of photoexcitation processes in nanostructures. Special attention is paid to the accounting for the many-body correlation effects.

Main results:

In the recent theoretical study [1], the photoabsorption spectrum of the C_{60} fullerene was calculated within both the ab initio TDDFT-based approach and the model one, based on the plasmon resonance approximation, in the photon energy region up to 100 eV (Figure 1).
It was shown that the main resonant structure in the spectrum is formed due to the collective excitation of both σ and π delocalized electrons of the fullerene, while a prominent peak in the lowenergy region of the spectrum (below 10 eV) is attributed to the collective excitation of the pelectrons only. The theoretical curves were compared to the compiled results of several experimental measurements of photoabsorption of C_{60} (Kafle et al., J. Phys. Soc. Jpn. 77, 014302 (2008)) (open squares).

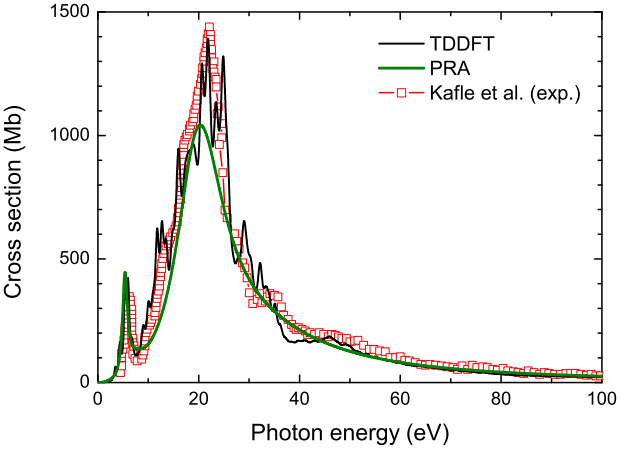


Fig. 1: The photoabsorption cross section of C_{60} calculated within the TDDFT method (thin black line) and the plasmon resonance approximation (thick green line). The curve, obtained within the classical approach, describes both the $(\sigma+\pi)$-and π-plasmons.

In Ref. [1] it was also shown that the peculiarities arising in the spectrum atop the dominating collective excitations of delocalized electrons have the quantum origin. In particular, it was demonstrated that a series of individual peaks can be assigned either to the optically allowed discrete transitions or to ionization of particular molecular orbitals of the system.

In Ref. [2] application of the jellium model for investigation of the electronic structure and photoionization of metal clusters and fullerenes was discussed. Within such an approach the valence electrons are considered either within the Hartree-Fock or the local density approximations. The random phase approximation was utilized to account for the many-electron correlations in the response of a system to an external field. It was shown that the photodetachment cross section and photoelectron angular distribution in metal cluster anions Na_7^-, Na_{19}^-, Na_{57}^- are described reasonably well within the jellium model, while its application to fullerenes requires the use of corrections for a better description of the ground state electron density.

Related publications in 2013:

1. A.V. Verkhovtsev, A.V. Korol, A.V. Solov'yov, *Quantum and classical features of the photoionization spectrum of C_{60}*, Phys. Rev. A 88, 043201-(1-8) (2013)

2. R.G. Polozkov, V.K. Ivanov, A.V. Verkhovtsev, A.V. Korol and A.V. Solov'yov, *New applications of the jellium model for the study of atomic clusters*, J. Phys.: Conf. Ser. 438, 012009-(1-11) (2013)

3. A.V. Korol, A.V. Solov'yov: *Polarizational Bremsstrahlung*. (Springer Heidelberg New York Dordrecht London, 2014) 275 pp. (ISBN 978-3-642-45223-9)

Collective electron excitations

Collaborators: A.V. Verkhovtsev[1], A.V. Korol[1], A.V. Solov'yov[1]

[1] MBN@FIAS

Short description:
Investigation of collective electron excitations (plasmons) and mechanisms of their relaxation in photo-and collision processes in various nanostructures. Special attention is paid to the role plasmon excitations in fullerenes.

Main results:
We studied collective electron excitations (also referred to as plasmons) in the C_{60} fullerene in the processes of photoionization and electron inelastic scattering [1]. To reveal the contribution of collective electron excitations, we utilized the plasmon resonance approximation. It was shown that within such a framework the photoionization cross section is described as a sum of two contributions, which represent two coupled modes of the surface plasmon.

The electron energy loss spectra of C_{60} are described by three contributions, namely by the two modes of the surface plasmon and the volume plasmon.

The results of calculations are in good agreement with experimental data on photoionization and electron inelastic scattering of C_{60}. It was shown that the collective excitations play a significant role in the ionization process and provide a dominant contribution to the spectra.

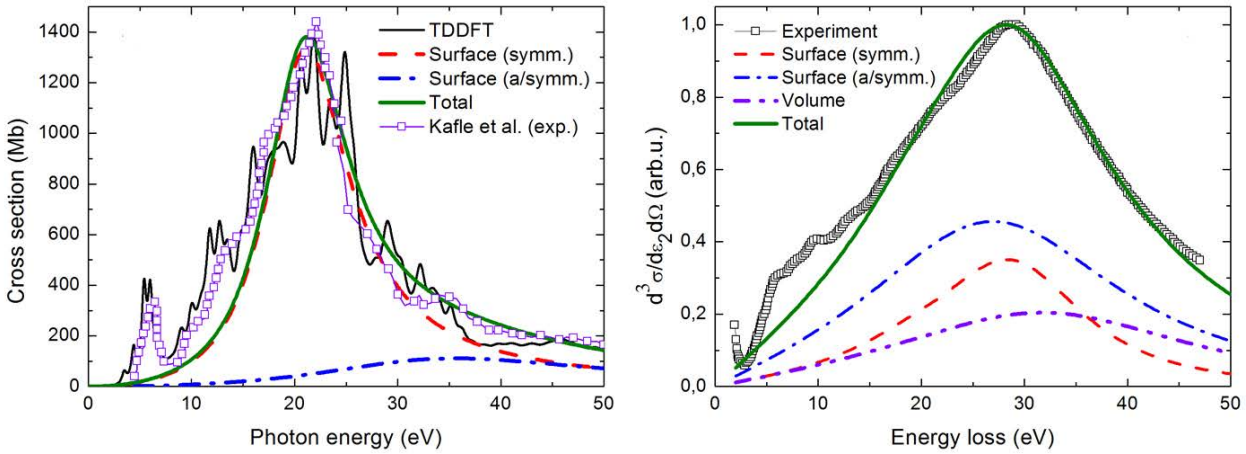


Fig. 1: Left: The photoabsorption cross section of C_{60} calculated within the plasmon resonance approximation (thick green line). Contribution of the symmetric and antisymmetric modes of the surface plasmon are shown by the dashed red and dash-dotted blue lines, respectively. Theoretical curves are compared to the experimental data of Kafle et al. (J. Phys. Soc. Jpn. 77, 014302 (2008)). Right: Comparison of the electron energy loss spectrum, calculated within the plasmon resonance approximation, with the experimental spectra (Bolognesi et al., Eur. Phys. J. D 66, 254 (2012)) measured for the incident energy range 1002-1050 eV and for the scattering angle $\theta = 5^0$. The symmetric and antisymmetric modes of the surface plasmon are shown by the dashed red and the dash-dotted blue lines, respectively; the volume plasmon contribution is shown by the double-dotted purple line. The resulting sum is shown by the thick green line.

Related publications in 2013:

1. A.V. Verkhovtsev, A.V. Korol and A.V. Solov'yov, *Plasmon excitations in photo-and electron impact ionization of fullerenes*, J. Phys.: Conf. Ser. 438, 012011-(1-9) (2013)

Diffusion processes in MBN systems

Collaborators: A.V. Yakubovich[1], A.V. Verkhovtsev[1], G.B. Sushko[1], A.V. Solov'yov[1]

[1] MBN@FIAS

Short description:
We investigate the diffusion process occurring at the interface various MBN systems. A particular attention is paid to diffusion at the interface of transition metals system.

Main results:

• By means of classical MD simulations we studied surface diffusion at the interface of pure nickel and titanium crystals and derived the diffusion coefficient for Ni and Ti atoms in the temperature range 500-700 K. Assuming exponential dependence of the diffusion coefficient on temperature its value at the room temperature was predicted [1].

• We studied diffusion of the Ni_{55} cluster on the titanium surface in the presence of water environment (see Fig. 1). We analyzed the dynamics of nickel atoms in the cluster, described structural rearrangements occurring in the cluster due to the interaction with titanium surface and derived the diffusion coefficient for Ni atoms.

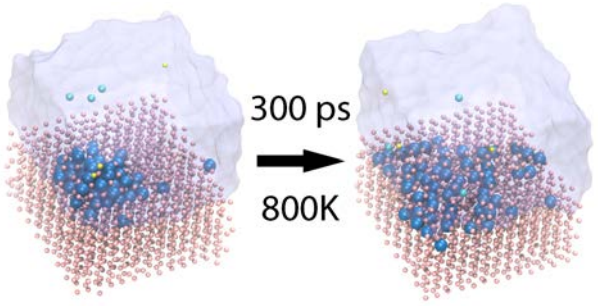


Fig. 1: Diffusion of the Ni_{55} cluster on the surface of titanium in the presence of water environment [1]. After 300 ps at 800 K the cluster disintegrates and the nickel atoms intercalate under the first layer of titanium crystal. Ti and Ni atoms are shown by red and blue colors, respectively. Yellow and light-blue atoms represent sodium and chlorine ions in the solution. Transparent surface shows water atop the titanium surface.

• We calculated the self-diffusion coefficient of nickel atoms located in the central part of the Ni_{2057} cluster at different instances of time (see Fig. 2) [2]. For the analysis, we chose three out five MD trajectories of the Ni_{2057} cluster conducted with a thermostat temperature equal to 820 K. It was demonstrated that for all trajectories considered, the diffusion coefficient drops abruptly at certain moments of time exactly corresponding to the moment of the solidification phase transition. The value of the diffusion coefficient for the molten state is about 2.3×10^{-6} cm^2/s and it is in good correspondence to those reported in other MD-based studies (e.g., Yue et al., J. Chem. Phys. 115, 385 (2001)).

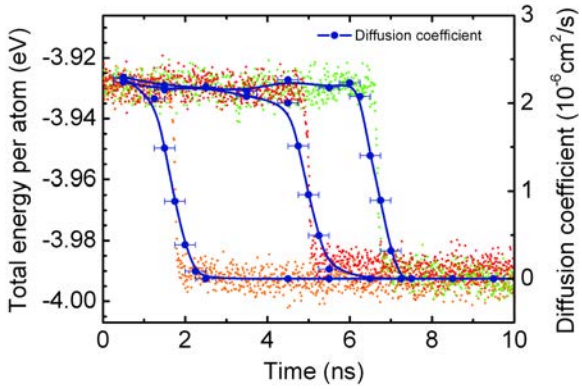


Fig. 2: Time-dependence of the self-diffusion coefficient on nickel atoms located in the central part of Ni_{2057} cluster (right axis) and of the total energy per atom (left axis). Color dots represent different MD trajectories.

Related publications in 2013:

1. A.V. Yakubovich, A.V. Verkhovtsev, M. Hanauske, A.V. Solov'yov, *Computer simulation of diffusion process at interfaces of nickel and titanium crystals*, Comput. Mater. Sci. 76, 60-64 (2013)

2. A.V. Yakubovich, G.B. Sushko, S. Schramm, A.V. Solov'yov, *Kinetics of liquid-solid phase transition in large nickel clusters*, Phys. Rev. B 88, 035438-(1-9) (2013)

Morphological transitions

Collaborators: A.V. Solov'yov[1], C. Bréchignac[2], I.A. Solov'yov[3]

[1] MBN@FIAS, [2] CNRS, France, [3] University of Southern Denmark, Odense, Denmark

Main results:

In continuation of last year's investigation, we have now initiated the study of morphological transition of non-equilibrium fractal shapes by simulating diffusion of particles over a surface using the kinetic Monte Carlo (KMC) method.

Experimentally, those nanofractals formed from deposition and diffusion of preformed silver clusters on cleaved graphite surfaces exhibit dendritic morphologies that are highly sensitive to any perturbation, particularly caused by temperature. We analyzed and characterized the morphological transition both in time and temperature using the recently developed Monte Carlo simulation approach for the description of nanofractal dynamics and compare the obtained results with the corresponding experimental data. The reported results revealed essential and general features of dynamical systems having dendritic shape.

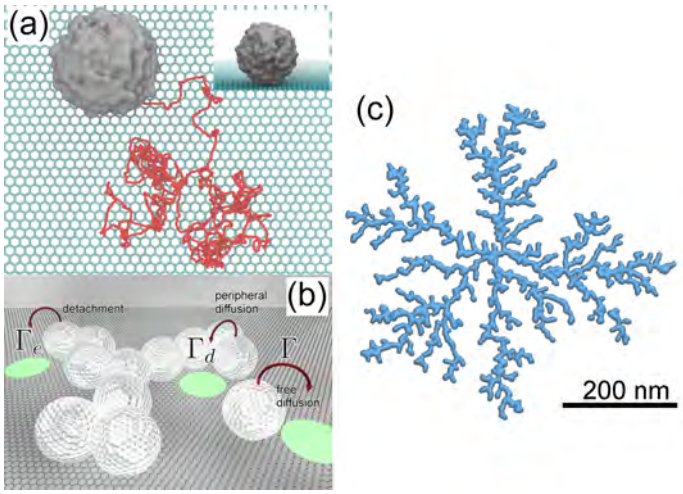


Fig. 1: A deposited silver cluster diffuses over a surface (a). The long time-scale motion of an ensamble of such clusters (b) is parameterized through kinetic rates Γ, Γ_d and Γ_e, corresponding to: the diffusion of a freely deposited cluster over a surface, the diffusion of a cluster along the periphery of an island on surface, and the detachment of a cluster from an island, respectively. Random deposition of new particles on the surface and accounting for the mentioned kinetic processes leads to formation of the fractal structure shown in (c).

Through studying the key elementary kinetic processes of nanocluster dynamics on a surface, shown in Fig. 1, we demonstrated that particle diffusion and detachment controls the shape of the emerging stable islands on a surface.

Related publications in 2013:

1. I.A. Solov'yov, A.V. Solov'yov, N. Kébaili, A. Masson, C. Bréchignac, *Thermally induced morphological transition of silver fractals*, Phys. Stat. Solidi B, doi:10.1002/pssb.201349254 (2013)

2. I.A. Solov'yov, A.V. Solov'yov, *imulation of nanofractal dynamics*, J. Phys.: Conf. Ser. 438, 012006-(1-12) (2013)

Nanostructured materials

Collaborators: A.V. Yakubovich[1], A.V. Verkhovtsev[1], G.B. Sushko[1], A.V. Solov'yov[1]

[1] MBN@FIAS

Short description:
The aim of the study is to model the nanoindentation process and to investigate mechanisms of localized deformation of nanostructured biocompatible materials, nanocrystalline titanium and its alloys, in particular. The study is focused on the investigation of the strength and mechanical properties of films and substrate/coating systems to be used in implants.

Main results:
We performed molecular dynamics simulations of the nanoindentation process of the crystalline titanium [1] and the Ni-Ti alloy [2,3]. We considered the systems consisting of approximately 1,000,000 atoms packed in the hexagonal close packed (hcp) (in case of Ti) or the face-centered cubic (fcc) (in case of Ni-Ti) lattices and studied their interaction with a carbon-based indenter. We considered the three different shapes of the indenter, namely the square, conical and spherical ones. In the performed simulations, the indenter moved with the constant velocity of 10−40 m/s and the maximum penetration depth into the crystal was approximately 3 nm.

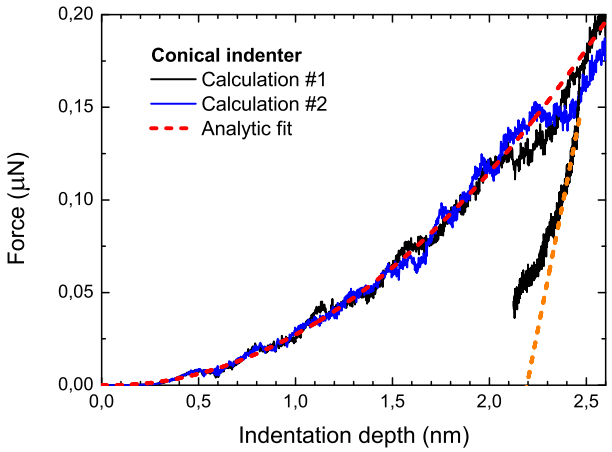


Fig. 1: Dependence of the force acting on the conical indenter on its pathway through the hcp Ti crystal [1].

We observed the dependence of deformations of the crystalline structure on the type of the indenter [1-3]. The molecular dynamics simulations of a full indentation cycle, which includes the loading and unloading stages, were performed. On the basis of such simulations we evaluated mechanical properties of the materials, namely we calculated hardness and reduced Young's modulus. We observed variation of the calculated parameters depending on the intender type and discussed the origin of occurring discrepancies.

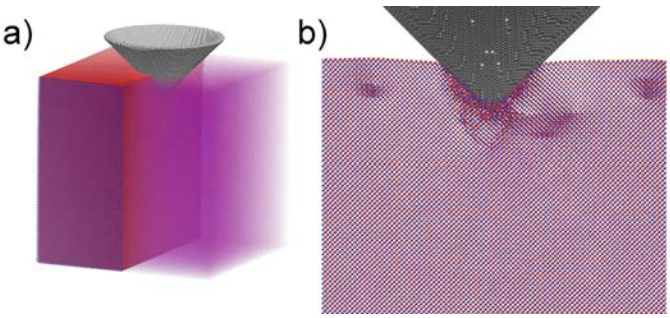


Fig. 2: Left: Nanoindentation of the Ni-Ti sample with a conical indenter. Right: Deformation of the crystalline structure at the penetration depth of 3 nm. Titanium and nickel atoms are shown by red and blue colors, respectively [2].

Related publications in 2013:

1. A.V. Verkhovtsev, A.V. Yakubovich, G.B. Sushko, M. Hanauske and A.V. Solov'yov, *Molecular dynamics simulations of nanoindentation process of titanium crystal*, Comput. Mater. Sci. 76, 20-26 (2013)
2. G.B. Sushko, A.V. Verkhovtsev, A.V. Yakubovich, and A.V. Solov'yov, *Molecular dynamics simulations of nanoindentation of nickel-titanium crystal*, J. Phys.: Conf. Ser. 438, 012021-(1-11) (2013)
3. A.V. Verkhovtsev, G.B. Sushko, A.V. Yakubovich, A.V. Solov'yov, *Benchmarking of classical force fields by ab initio calculations of atomic clusters: Ti and Ni-Ti case*, Comput. Theor. Chem. 1021, 101-108 (2013)

Computer codes for the description of collective electron excitations in MBN systems

Collaborators: A.V. Verkhovtsev[1], A.V. Korol[1], A.V. Solov'yov[1]

[1] MBN@FIAS

Main results:

• We have developed a package of Fortran codes for the description of collective electron excitations (plasmons) which occur in a many-electron system interacting with an external electric field. The codes allow one to describe numerically plasmon excitations which are formed due to electromagnetic irradiation or collisions with charged fast projectiles. The codes are based on the theoretical formalism [1] which describes the formation of plasmon excitations in many-electron systems.

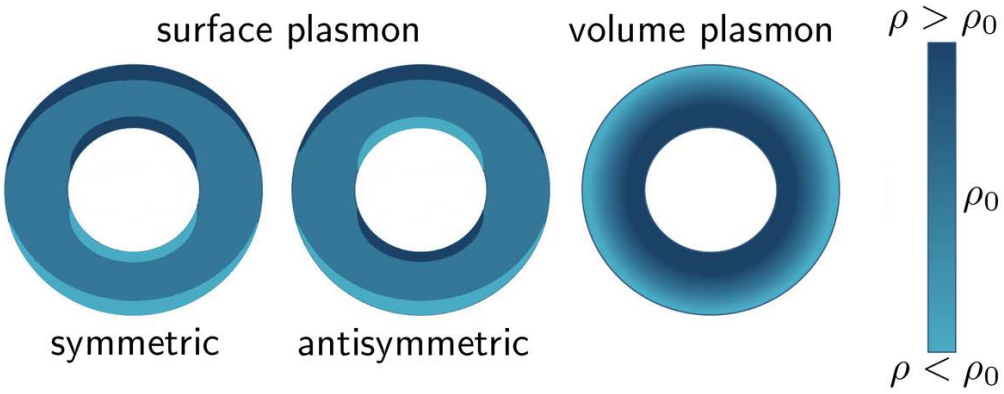


Fig. 1: Representation of the two modes of the surface plasmon (left and middle panels) and of the volume plasmon (right panel) which occur in a spherically symmetric fullerene molecule. Light-blue and dark-blue regions represent the additional positive and negative charge, respectively.

• The codes allow one to calculate:

(a) the photoionization and inelastic scattering cross sections using the so-called plasmon resonance approximation. The inelastic scattering cross sections can be calculated in a broad range of scattering angles;

(b) contributions of various types of plasmon excitations. One can evaluate the contribution of the surface plasmon, which occurs on a surface(s) of the system, as well as of the volume plasmon, which is formed due to local compression of the electron density inside the system. For a fullerene there are two coupled modes of the surface plasmon, the so-called symmetric and antisymmetric ones, which are described, respectively, by the in-phase and out-of-phase motion of the negative charge (Fig. 1).

Related publications in 2013:

1. A.V. Verkhovtsev, A.V. Korol and A.V. Solov'yov, *Plasmon excitations in photo- and electron impact ionization of fullerenes*, J. Phys.: Conf. Ser. 438, 012011-(1-9) (2013)

Simulation of ultra-relativistic electron and positron channeling and radiation in crystals

Collaborators: G.B. Sushko[1], V.G. Bezchastnov[1], A.V. Korol[1], A.V. Solov'yov[1], Walter Greiner[2], V.K. Ivanov[3], R.G. Polozkov[3], I.A. Solov'yov[4]

[1] MBN@FIAS, [2]FIAS, [3] St. Petersburg State Polytechnic University, Russia, [4] University of Southern Denmark, Odense, Denmark

Main results:

Efficient algorithm was applied to simulate trajectories of an ultra-relativistic projectile in a crystalline medium [1-3]. The motion of a projectile is treated classically by integrating the relativistic equations of motion with account for the interaction between the projectile and crystal atoms. The simulated trajectories (see Fig. 1) were used to calculate the dechanneling lengths, the fractions of the channeling particles [2,3] as well as for numerical analysis of the emitted radiation (see Fig. 2) [2]. Calculations of the spectra were performed by means of the Fortran code built upon the revisited algorithm described in Korol et al. J. Phys. G27, 95 (2001) and in [1]. The electron and positron channeling along Si(110) and Si(111) crystallographic planes were studied for the projectile energies 195−855 MeV and different curvatures of the bent crystal.

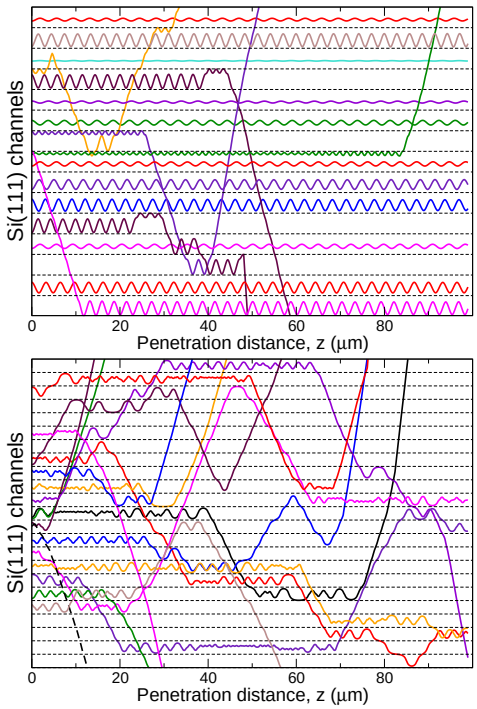


Fig. 1: Simulated trajectories of 855 MeV positrons (top) and electrons (bottom) channeling in $L = 100\mu$m thick silicon crystals along Si(111) planes [2,3].

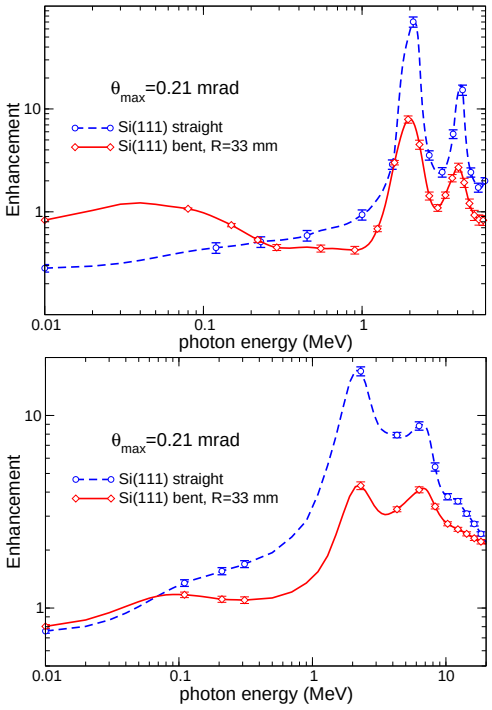


Fig. 2: Enhancement factor calculated for 855 MeV positrons (top) and electrons (bottom) channeled along straight and bent Si (111) plane. The bending radius $R = 33$ mm, the crystal length $L = 50\,\mu$m [2].

Related publications in 2013:

1. G.B. Sushko, V.G. Bezchastnov, I.A. Solov'yov, A.V. Korol, W. Greiner, A.V. Solov'yov, *Simulation of ultra-relativistic electrons and positrons channeling in crystals*, J. Comp. Phys. 252, 404-418 (2013)

2. G.B. Sushko, A.V. Korol, W. Greiner, A.V. Solov'yov, *Sub-GeV electron and positron channeling in straight, bent and periodically bent silicon crystals*, J. Phys.: Conf. Ser. 438, 012018-(1-11) (2013)

3. G.B. Sushko, V.G. Bezchastnov, A.V. Korol, W. Greiner, A.V. Solov'yov, R.G. Polozkov, V.K. Ivanov: *Simulations of electron channeling in bent silicon crystal*, J. Phys.: Conf. Ser. 438, 012019-(1-10) (2013)

Physics of ion beam cancer therapy: Multiscale approach to the physics of radiation damage with ions

Collaborators: A.V. Solov'yov[1], E. Surdutovich[2]

[1] MBN@FIAS, [2] Oakland University, Michigan, USA

Main results:

In 2013, the multiscale approach to the assessment of biodamage resulting upon irradiation of biological media with ions has been further developed. This approach is a phenomenon-based analysis of the scenario that leads to radiation damage with ions. Relevant effects on a variety of scales are considered in order to assess the biological damage as a result of irradiation with ions quantitatively. In 2013, the approach was applied to different experimental conditions, such as irradiation of plasmid DNA and A549-cells. For plasmid DNA, the calculated probabilities of DNA damage were compared to experiments. for A549 cells, a survival curve (the dependence of survival probability on dose) leading to the calculation of the relative biological effectiveness was obtained theoretically and compared to the experiment.

On the basis of experience with these analyses, the recipe for application of the multiscale approach, leading to the calculation of relative biological effectiveness, was formulated. This recipe includes a list of all parameters required for the calculation of relative biological effectiveness. Thus, the multiscale approach can potentially become a tool for predictive calculations of macroscopic qualities based on the microscopic parameters, which can be determined theoretically or experimentally [1].

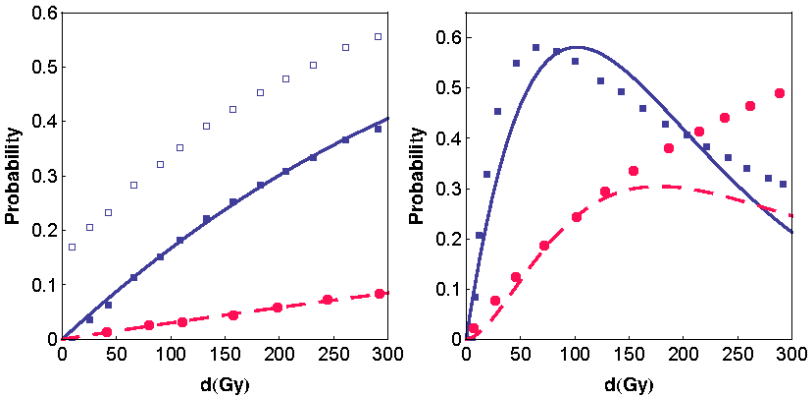


Fig. 1: Probabilities for SSBs and DSBs induced in plasmid DNA by secondary electrons only (left) and by secondary electrons and radicals (right) as a function of dose. Dots correspond to experiments: open squares to the original SSBs, filled squares to the "cleaned" SSBs, and filled circles to DSBs. Calculated probabilities are shown with lines. Solid line corresponds to the probability of SSBs. The dashed line depicts the calculated probability for DSBs.

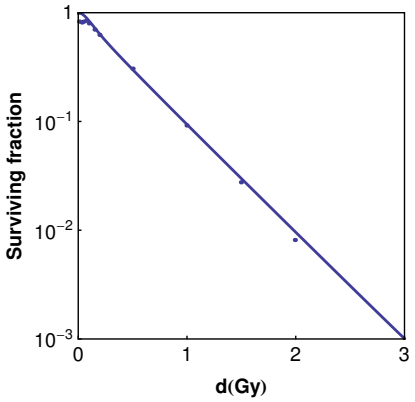


Fig. 2: Survival curves for A549 cells irradiated with a particles. The dots represent the experimental data and the solid line is calculated using the multiscale approach.

Related publications in 2013:

1. E. Surdutovich and A.V. Solov'yov, *Multiscale approach to the physics of radiation damage with ions*, Eur. Phys. J. D (submitted as a Colloquia Paper) (2013); also arXiv:1312.0897 [physics.bio-ph]

2. E. Surdutovich, A.V. Solov'yov, *Multiscale physics of ion-induced radiation damage*, J. Phys.: Conf. Ser. 438, 012014-(1-8) (2013)

Physics of ion beam cancer therapy: Investigation of a possibility of direct thermomechanical biodamage as a result of irradiation with ions

Collaborators: A.V. Yakubovich[1], A.V. Solov'yov[1], E. Surdutovich[2]

[1] MBN@FIAS, [2] Oakland University, Michigan, USA

Short description:
When a heavy ion passes through tissue, a cylindrical shock wave is initiated due to a thermal spike near the ion's trajectory. In this project we investigate the possibility of this shock wave to produce thermo-mechanical damage by a direct rupture of covalent bonds of DNA backbone. The molecular dynamics simulations were used to model the interaction of the shock wave and a DNA molecule.

Main results:
• Full-atom molecular dynamics simulations of the shock wave propagation in a liquid water medium were carried out [1]. Cases of different values of the linear energy transfer (LET) were considered. They correspond to the values of LET in the vicinity of the Bragg peak for carbon, neon, argon and iron ions. In the course of the simulations, the wave interacts with a part of DNA molecule on the surface of nucleosome, as shown in Fig. 1.

• The time dependence of energy in the covalent bonds of the DNA-fragment's backbone has been obtained and the evidence of a strand break has been inferred from these data (Fig. 2). The probability of direct strand breaking by a shock wave has been compared to that due to chemical mechanisms; the dependence of the radius of dominance of shock wave effects on LET has been predicted (Fig. 3).

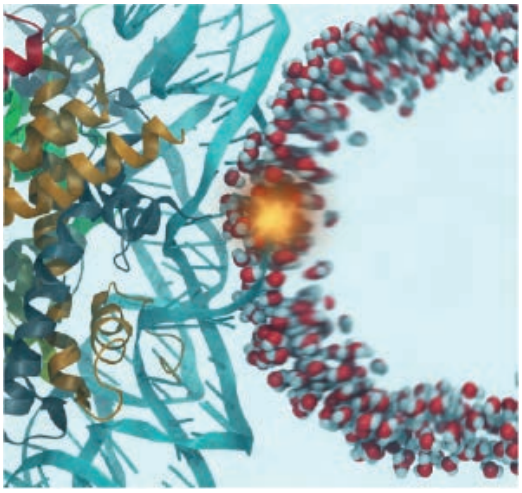


Fig. 1. The cylindrical shock wave front in water (on the right; ion's path is the cylinder axis perpendicular to the figure plane) interacts with a nucleosome (on the left) with a segment of a DNA molecule on the surface.

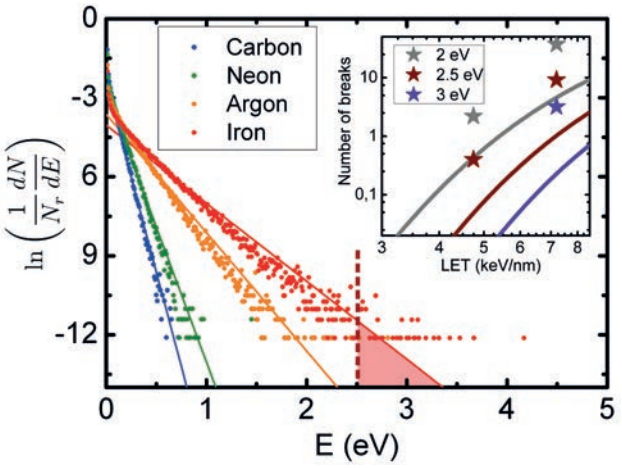


Fig. 2. Logarithm of the normalised number of the covalent bond energy records for a selected DNA fragment per 0.01 eV energy interval versus the bond energy for four values of LET: 0.9, 1.73, 4.745, and 7.195 keV/nm, corresponding to the Bragg peak values for several ions.

Related publications in 2013:

1. E. Surdutovich, A.V. Yakubovich, A.V. Solov'yov, *Biodamage via shock waves initiated by irradiation with ions*, Nature Scientific Reports 3, 1289 (2013)

2. A.V. Yakubovich, E. Surdutovich, A.V. Solov'yov: *Molecular dynamics simulations of thermomechanical radiation damage events*, The 2nd International Conference "Radiation Damage in Biomolecular Systems: Nanoscale Insights into Ion-Beam Cancer Therapy" (2nd NANO-IBCT Conference 2013) (May 20-24, 2013, Sopot, Poland), Book of Abstracts, p. 19 (2013)

Physics of ion beam cancer therapy: Analytical model of ionization and energy deposition by proton beams in subcellular compartments

Collaborators: A.V. Solov'yov[1], E. Surdutovich[2], P. de Vera[3], R. Garcia-Molina[3], I. Abril[3]

[1] MBN@FIAS, [2] Oakland University, Michigan, USA, [3] Universitat d'Alacant, Spain

Main results:

As a part of the multiscale approach to the assessment of biodamage resulting upon irradiation of biological media with ions, an analytical model to evaluate in a fast, simple, and effective manner the energy delivered by proton beams moving through a model cell made of nucleus and cytoplasm, taking into account the energy carried by the secondary electrons generated along the proton tracks, has been developed. The electronic excitation spectra of these subcellular compartments have been properly modeled by means of an empirical parametrization of their dielectric properties. The energy loss rate and target ionization probability induced by swift protons are evaluated by means of the dielectric formalism. With this model, the energy delivered to the cell was calculated as well as the specific energy, and the number of ionizations produced in a typical human cell by a proton beam having energies usually reached around the Bragg peak. It was found that the specific energy delivered to the nucleus is more than twice than that in the cytoplasm for all analyzed proton energy range [1].

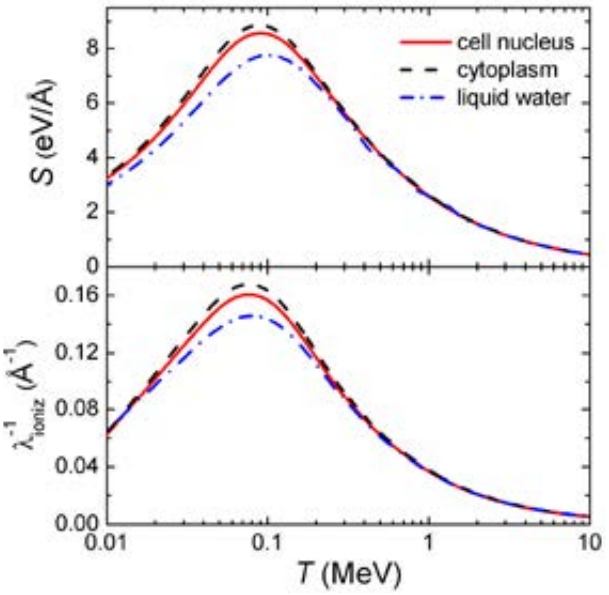


Fig. 1: Upper panel: Stopping power S of cell nucleus, cytoplasm and liquid water for a proton beam, as a function of the incident proton energy. Lower panel: Ionization inverse mean free path $\lambda^{-1}_{\mathrm{ioniz,i}}$ induced by proton beams in cell nucleus, cytoplasm and liquid water, as a function of the kinetic energy of the protons.

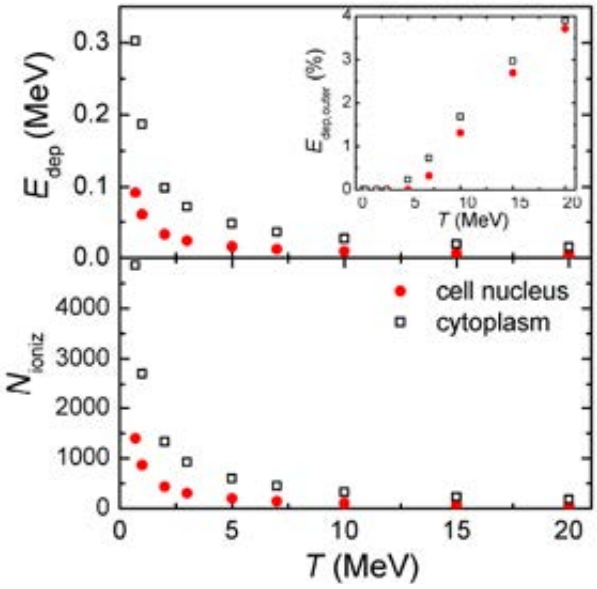


Fig. 2: Deposited energy E_{dep} (upper panel) and number of ionizations N_{ioniz} (lower panel) in the cell nucleus and cytoplasm per incoming proton, as a function of its kinetic energy. The inset shows the percentage of energy deposited in each cell compartment that comes from outside, $E_{\mathrm{dep,outer}}$, transported by secondary electrons.

Related publications in 2013:

1. P. de Vera, E. Surdutovich, I. Abril, R. Garcia-Molina, and A. V. Solov'yov: *Analytical model of ionization and energy deposition by proton beams in subcellular compartments*, Eur. Phys. J. D (submitted for publication) (2013)

Theory of Crystalline Undulator (CU) based novel light sources

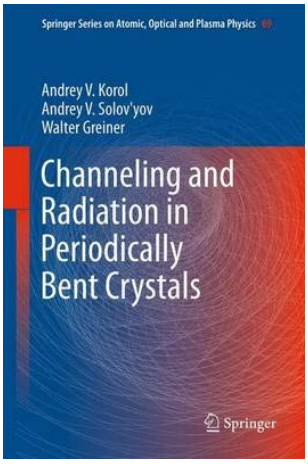
Collaborators: G.B. Sushko[1], V.G. Bezchastnov[1], A.V. Korol[1], A.V. Solov'yov[1], W. Greiner[2] (FIAS); H. Backe[3], W. Lauth[3], U. Uggerhøj[4], S. Connell[5], V. Guidi[6]

[1] MBN@FIAS, [2] FIAS, [3] Mainz University, Germany, [4] Aarhus University, Denmark, [5] Johannesburg University, South Africa, [6] Ferrara University, Italy

Short description:

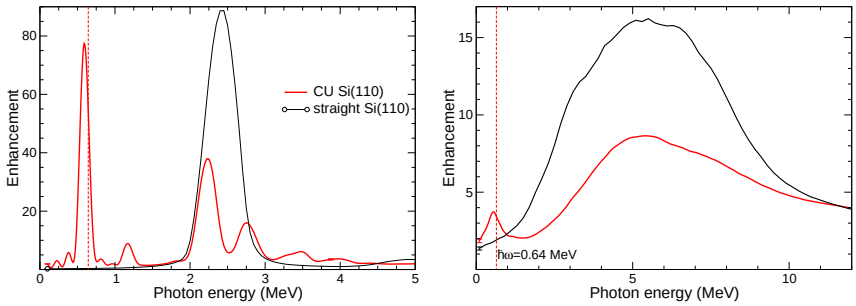
Investigation of the feasibility to construct a powerful source of high-energy ($\hbar\omega \sim 0.1 - 1$ MeV) monochromatic electromagnetic FEL-like radiation by a bunch of ultra-relativistic particles channelling through a periodically bent crystal (crystalline undulator, CU). Potential applications include plasma, nuclear and solid state physics, molecular biology, medicine and technology.

Main results:



• The feasibility of constructing a crystalline undulator and, on its basis, the light sources is a very recent concept. The book [1] represents the underlying fundamental physical ideas as well as the theoretical, experimental and technological advances made during the last one and a half decades in exploring the various features of crystalline undulators and the radiation formed in them. The book is addressed to a wide audience of researches and students since the phenomenon of crystalline undulator entangles the concepts from various research fields, such as material science, beam physics, physics of radiation, solid state physics, acoustics, etc, whereas its investigation implies the use and further elaboration of a variety of theoretical and computational methods, experimental techniques, technological and engineering approaches.
A scheme for a source of coherent electromagnetic radiation was proposed [1,2].

• Preliminary results of numerical simulations of electron and positron channeling and emission spectra are reported for periodically bent silicon crystal [3]. The electron and positron channeling along Si(110) and Si(111) crystallographic planes are studied for the projectile energies 195−855 MeV which corresponds to the energy range at the experiments carried out at Mainz Microtron.



Enhancement of radiation emitted by 855 MeV positrons (left) and electrons (right) channeled in Si(110) over the Bethe-Heitler spectrum. Black solid curves – straight crystals, red solid curves – CUs with $a = 4$Å, $\lambda_u = 9.9\mu$m. The vertical dashed lines mark the energies of the first harmonics of CUR in the forward direction.

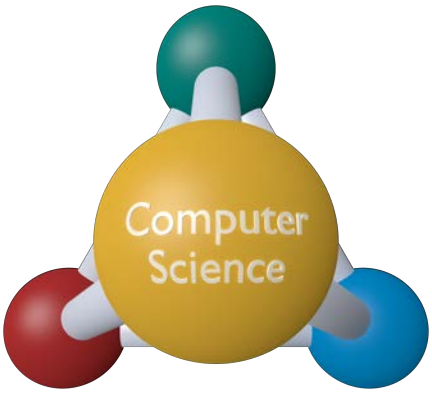
Related publications in 2013:

1. A.V. Korol, A.V. Solov'yov, W. Greiner, *Channeling and Radiation in Periodically Bent Crystals*, (Springer, Heidelberg New York Dordrecht London, 2013) 268 pp.

2. A. Kostyuk, A.V. Korol, A.V. Solov'yov, W. Greiner, *Crystalline Undulator: Current Status and Perspectives*, pp. 399-409 in "Exciting Interdisciplinary Physics: Quarks and Gluons, Atomic Nuclei, Relativity and Cosmology, Biological Systems", W. Greiner (Ed.) (Springer, Cham Heidelberg New York Dordrecht London, 2013)

3. G.B. Sushko, A.V. Korol, W. Greiner, A.V. Solov'yov: *Sub-GeV electron and positron channeling in straight, bent and periodically bent silicon crystals*, J. Phys.: Conf. Ser. 438, 012018-(1-11) (2013)

4.4 Scientific Computing, Information Technology



The KF Particle Finder package for the STAR experiment on the Intel Xeon Phi coprocessor

Collaborators: M. Zyzak[1,2], I. Kisel[1,2,3], I. Kulakov[1,2]

[1] Frankfurt Institute for Advanced Studies, [2] Goethe-Universität Frankfurt am Main, [3] GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt

Modern experiments in high energy physics usually require fast and efficient algorithms for the online short-lived particles reconstruction. The short-lived particles, which can not be registered directly by a detector system but only reconstructed from their decay products, are of the particular importance for the investigation of the all stages of the collision.

The online triggers operate with the modern processor architectures. One of these new architectures is the Intel Xeon Phi coprocessor. The idea of the Intel Xeon Phi is to provide a highly parallel computing platform which at the same time allows to work with standard programming languages and tools (like OpenMP, Intel TBB, Intel Cilk). The card is based on the x86-compatible architecture that provides a possibility to develop applications which can be run both on a CPU and a coprocessor that can greatly reduce the complexity of software development. The Intel Xeon Phi coprocessor of 5100 series contains 60 cores and 8 GB of GDDR5 memory. It operates with larger SIMD vectors then CPU: 16 floats can be packed together. The hyperthreading strategy of the card is also more agressive: 4 hardware threads can be run simultaneously on each core that gives in total 240 threads. The vector processing unit (VPU) of each core has 128 512-bit vector registers divided among the threads, thus providing 32 registers per thread. In addition, there are eight 16-bit mask registers per thread, which are part of the vector register file. The mask can be used to mark active elements of the SIMD-vector during calculations. Also the core contains 32 kB of L1 cache for data and 32 kB for instructions and 0.5 MB of L2 cache. The cores are connected through a bidirectional ring bus (see Fig. 1).

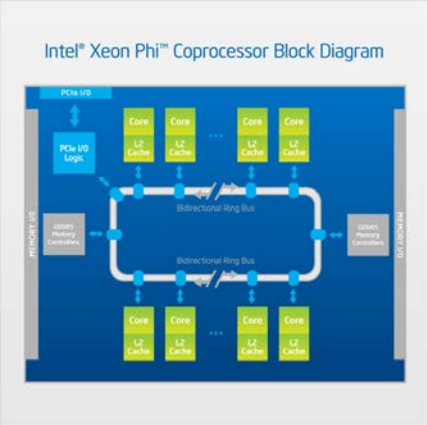


Figure 1: Block-diagram of the Intel Xeon Phi architecture: all cores are connected through the bus with each other and with the DDR5 memory.

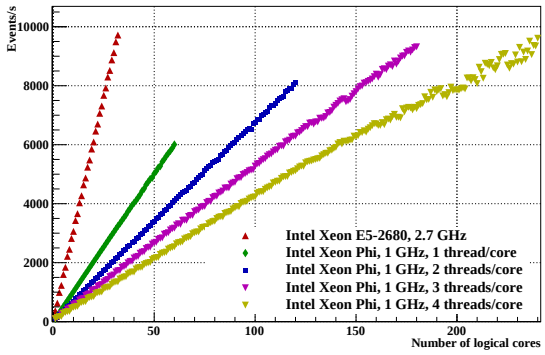


Figure 2: Scalability of the KF Particle Finder package with minimum bias U+U events at 200 AGeV on the Intel Xeon Phi.

The KF Particle Finder was adapted for the STAR experiment and tested with minimum bias U+U events at 200 AGeV (see Fig. 2). The package was tested on the example of K^0_s, Λ, Ξ^- and Ω^- reconstruction. It shows the linear scalability for cases of operation of one, two, three or four hardware threads per core. The speedup of 1.8 due to the hyperthreading was reached. The performance achieved on the card is about of the performance of two Intel Xeon E5-2680 CPUs. The vectorization of the package gives the speedup factor of 8.43 on the Xeon Phi. The ideal speedup of 16 was not reached due to the data repack required by the algorithm. The speedup factors of 3.67 and 4.67 were obtained using SSE (with the width of the SIMD vector of 4) and AVX instruction sets (with the width of the SIMD vector of 8) respectively.

Summarising, the KF Particle Finder package was adapted for the Intel Xeon Phi and allows to process about 10000 events/s.

The parallel Cellular Automaton track finder for the CBM experiment

Collaborators: V. Akishina[1,2,3], I. Kisel[1,2,4]

[1] Goethe-Universität Frankfurt am Main, [2] GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt,
[3] Joint Institute for Nuclear Research, Dubna, Russia, [4] Frankfurt Institute for Advanced Studies

The CBM experiment at FAIR is being designed to study heavy-ion collisions at extremely high interaction rates (up to 10 MHz) and high track multiplicities (up to 1000). Since the beam in the CBM experiment will have no bunch structure, but continuous, the groups of events may be close or overlapped in time. Measurements in this case will be 4D (x, y, z, t). Thus, the reconstruction of time slices rather than events will be needed. In addition to such high input rate and complicated event topology, the full event reconstruction and selection will be done at the First Level Even Selection (FLES) stage. In this respect, both the speed of the reconstruction algorithms and their efficiency are crucial. The Cellular Automaton (CA) track finder is fast and robust and thereby is used both for the online and offline track reconstruction in the CBM experiment. The algorithm creates short track segments in each three neighbouring stations, then combines them into track-candidates and selects the best tracks according to the maximum length and minimum χ^2 criteria.

Algorithm step	Fraction of total time
Initialisation	2 %
Triplets construction	90.4 %
Tracks construction	4.1%
Final stage	3.4%

Table 1: Percent fraction of different algorithm steps in the total execution time on a sigle core.

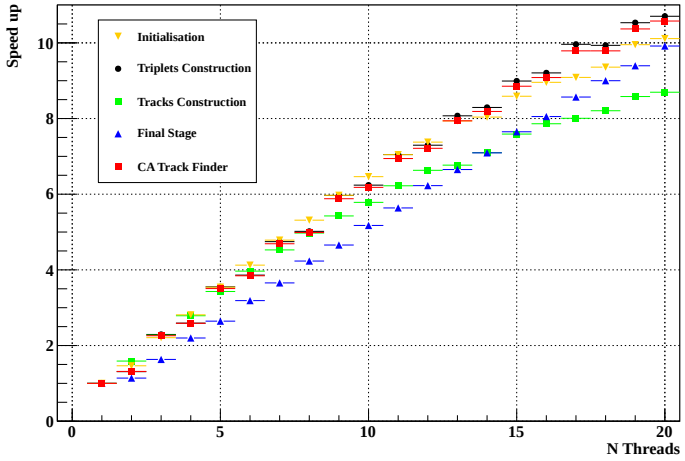


Figure 1: Speed up factor due to parallelisation for different steps and the full algorithm on Intel Xeon E7-4860 CPU with 10 physical cores and hyperthreading for the case of 100 mbias events grouped.

The standalone FLES package was used to investigate the stability of the CA track reconstruction with respect to a track multiplicity per event. For the study 1000 minimun bias Au+Au UrQMD events at 25 AGeV was simulated. As the first step towards 4D tracking a number of minimum bias events (up to 100) were packed into one group with no time measurement taken into account. The group was treated by the CA track finder as a single event and the regular reconstruction procedure was performed. The dependence of the track reconstruction efficiency on the track multiplicity is stable. In particular, the efficiency of the algorithm decreases only by 4% for 100 minimum bias events in one group, comparing to the case of a single minimum bias event. The speed of the algorithm was studied as a function of track multiplicity. The time, which the algorithm needs to proceed a grouped event, behaves as a second order polynomial with respect to a number events in the group. Due to this fact, the CA track finder needs less than 2 seconds in order to reconstruct a grouped event combined of 100 minimum bias events, that corresponds to about 10 000 reconstructed tracks.

Each step of the algorithm was parallelilized inside the event with the use of OpenMP and Pthreads interfaces. Contributions of the algorithm steps in total execution time are given in the Table 1. The parallelisation of the algorithm was optimised for the case of 100 mbias events in group and tested on Intel Xeon E7-4860 processor. The algorithm shows linear scalability (Figure 1). Due to hyperthreading one can expect speed up factor about 13 on such a CPU in the ideal case. The acheived speed up factor is 10.6 for the full CA track finder reconstruction algorithm on 10 physical cores CPU with hyperthreading.

Cellular Automaton track finder for STT and barell MVD detectors in the PANDA experiment

Collaborators: I. Kisel[1,2,3], I. Kulakov[1,2], M. Zyzak[1,2]

[1] Frankfurt Institute for Advanced Studies, [2] Goethe-Universität Frankfurt am Main, [3] GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt

PANDA is a future fixed-target experiment at FAIR (GSI, Germany), that will produce up to $2 \cdot 10^7$ antiproton-proton or antiproton-nucleus collisions per second. The core tracking detectors of PANDA are the Straw Tube Tracker (STT) and the Micro Vertex Detector (MVD). Fast and efficient track reconstruction in STT and MVD is required.

The cellular automaton (CA) track reconstruction approach has been used successfully in several HEP experiments. It is simple, efficient, local and parallel. The algorithm has been applied to the STT and MVD detectors in the following steps. 1) To solve left-right ambiguity the algorithm starts with creating two individual virtual hits on each STT tube: one on the left side, one — on the right. 2) The STT detector is divided into 26 hexogonal layers and treated toghether with 4 MVD barrel layers. 3) Track segments are created from each 3-6 virtual hits (the length depends on dimensionality of hits) in neighboring layers. 4) Parameters of the track segments are estimated using the Kalman filter. 5) Track segments are connected into tracks using their neighbour relations. 6) If tracks are reconstructed in parts, they are merged using the Kalman filter.

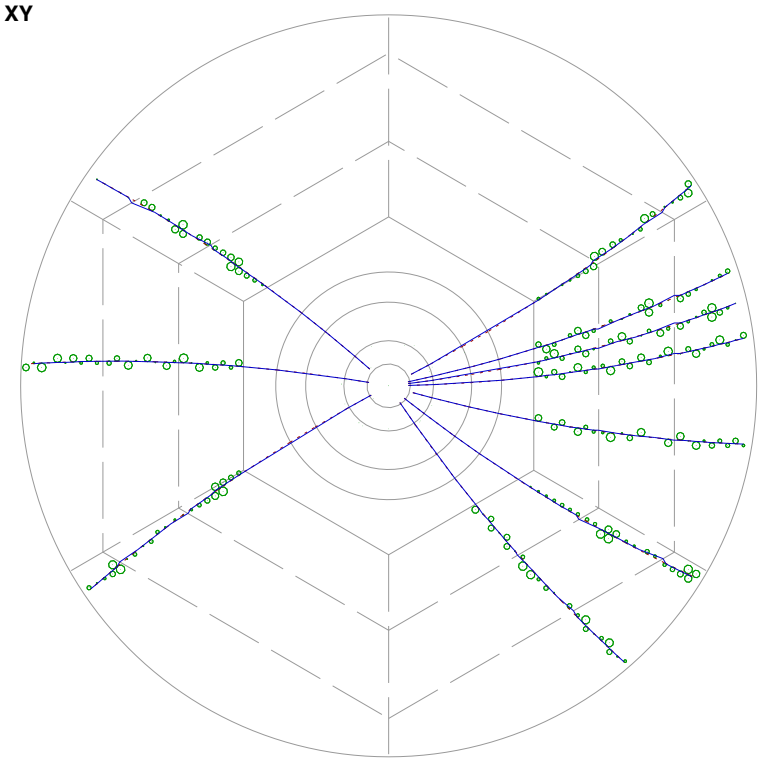


Figure 1: Tracks reconstructed by the CA track finder in the STT and barrel MVD detectors. Drift circles in STT and hits positions in MVD are shown in green. Reconstructed tracks are shown as blue lines. Monte-Carlo trajectories of particles are show as red dashed lines.

For tests 100 events with 10 primary muons at $p_t = 1$ GeV/c have been generated. Tests of the time and efficiency have been performed on a computer with Intel Xeon E7-4860 processor. An example of event with reconstructed muon tracks is shown in Fig. 1. The reconstruction time per event is 8 ms with the reconstruction efficiency of 99.4%.

Development of computer tools for graphical processors

Collaborators: A.V. Yakubovich[1], G.B. Sushko[1], A.V. Solov'yov[1], S. Schramm[2]

[1] MBN@FIAS, [2] FIAS

Short description:

The aim of this project is to exploit the advantages of a novel superiorly fast computational devices – special graphical cards, which are available at the novel supercomputer center LOEWE-CSC. The numerical solution of the MD equations becomes a challenging task if one studies systems consisting of a large number of atoms. As the calculation of forces essentially implies the same type of calculation repeated many times, this task is ideally suited to be implemented using a parallel-programming approach. If there are only few different types of forces involved, a single-instruction multiple-data (SIMD) hardware environment can be adopted in a natural way, since the same instructions are used for all pairs of particles. Graphics processor units (GPUs) fulfil these requirements in an ideal way.

Main results:

We have developed a software tool to get use of GPU facilities. The computer code developed includes a specific force fields for modeling the carbon-based materials, metal clusters and mixed carbon-metal systems, treating composite alloys of transition metals. The code is written using OpenCL technology, which provides portability across different types of GPUs and other types of computing units.

In 2013, various properties of metallic clusters have been studied using the code. The speedup of MD simulations of melting/solidification of nickel clusters of different sizes can be up to two orders of magnitude as compared for the CPU and GPU versions of the code (see Fig. 1). These results are consistent with theoretical estimation of performance of GPU and CPU in single precision.

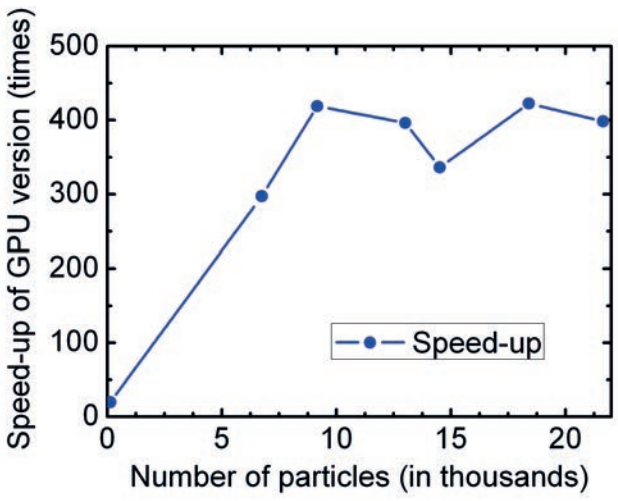


Fig. 1: Speedup of the computational time for the GPU version of the code developed as compared to the CPU version [1]. Related publications in 2013:

Related publications in 2013:

1. A.V. Yakubovich, G.B. Sushko, S. Schramm, A.V. Solov'yov, *Kinetics of liquid-solid phase transition in large nickel clusters*, Phys. Rev. B 88, 035438-(1-9) (2013)

Features of a fully renewable US energy system

Collaborators: Sarah Becker[1], Bethany A. Frew[2], Gorm B. Andresen[3], Timo Zeyer[3], Anders A. Søndergaard[3], Stefan Schramm[1], Martin Greiner[3], and Mark Z. Jacobson[2]

[1]Frankfurt Institute for Advanced Studies [2]Department of Civil and Environmental Engineering, Stanford University, Stanford, CA, USA [3]Department of Mathematics, Department of Physics and Aarhus School of Engineering, Aarhus University, Denmark

We investigate a renewable-based electricity system for the contiguous US. Novel (potential) wind and solar PV generation time series are derived from weather data of unprecedented length and resolution, 32 years with hourly time steps and $40 \times 40\,\mathrm{km}^2$ grid cells. From these, general features of a future electricity system with a high share of renewables are derived, such as storage and backup energy needs with growing shares of wind and solar PV power or transmission grid extensions that reduce surplus energy production, which occurs when renewable production does not happen at the times when electricity is needed. Furthermore, the transition to a renewable energy system is looked at, and optimal build-up pathways with respect to different objectives are found.

Two of these are shown for the example region of California in the figure below. On the left, the build-up map optimized for least surplus production is seen, on the right, the map optimized for least cost. In the left panel, wind energy is observed to lead to less surplus energy because it correlates better with the load. Consequently, the surplus-minimal mix lies at about 70% to 90% wind for the largest part of the build-up. The cost-optimal mix (right panel), by contrast, starts sharply favouring solar power. Up to a gross renewable share of 30% to 40%, solar PV is installed almost exclusively, because in this example, solar PV is assumed to have lower installation costs. However, when renewables reach a share of 30% to 40%, it becomes cheaper to install wind instead of solar. This is because if at this point more solar PV were installed, it would lead to more surplus production, which cannot be sold and thus effectively raises total costs. From this we deduce that it is essential to keep a mixed portfolio of generation technologies instead of settling too early for the one with the lowest installation costs.

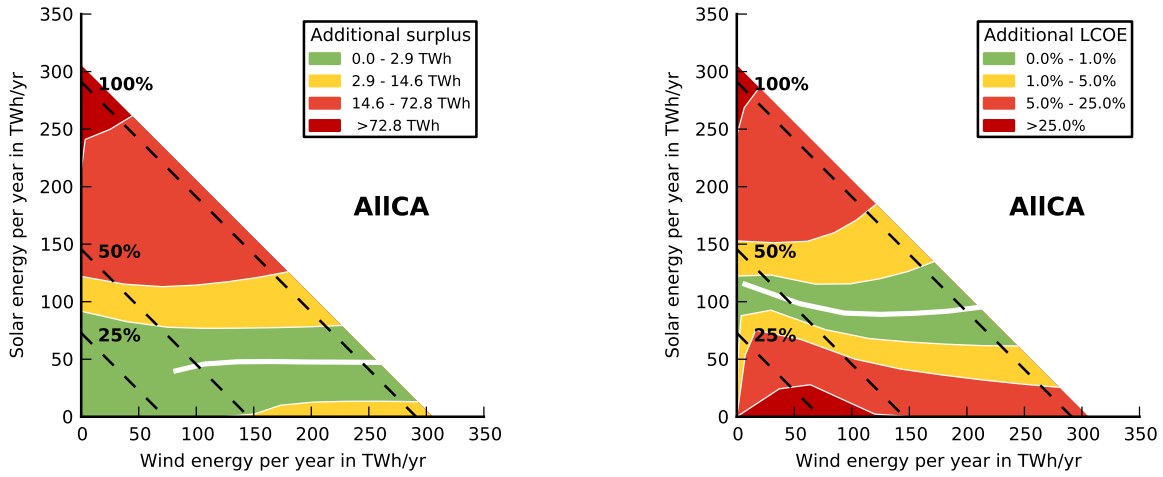


Figure 1: Left: Wind and solar PV build-up leading to minimal surplus energy. Right: Build-up leading to minimal levelized costs of electricity (LCOE) of renewables, for a setting in which solar PV is has lower installation costs per unit of energy generated than wind power. In both panels, on the x-axis the amount of installed wind capacity is indicated (converted to the total power production), on the y-axis, analogously the amount of installed solar PV capacity. The total gross share of renewables is denoted by the black dashed lines, which mark 25%, 50% and 100% gross share. The build-up can be traced on any path out of the origin towards the upper right. The optimal build-up (either surplus-minimal or cost-minimal) is shown as a white line. In the green area, surplus energy or costs are larger than optimal by less than 1%, in the yellow area, by less than 5%, in the red area, by less than 25%, and in the dark red area, by more than 25%.

5. Talks and Publications

Conference and Seminar Talks by FIAS Members 2013

Maximilian Attems

- Extreme QCD in and out of Equilibrium, Schladming, Austria, 23 Feb. - 2 March 2013: *Longitudinal thermalization via the Chromo-Weibel Instability*
- Vienna Theory Lunch Seminar, University of Vienna, Austria7 May 2013, *Kinetic models of ultrarelativistic heavy ion collisions*
- High energy, high density and hot QCD (h3QCD), ECT*, Trento, Italy, 17-21 June 2013: *The Chromo-Weibel instability in an expanding background*
- Workshop on Transport Theory in Heavy Ion Collisions, Schmitten, Germany, 15-17 July 2013: *Towards a new transport approach: Simulations of a hot pion gas*
- Nuclear Physics and RIKEN Theory Seminar, Brookhaven National Laboratory, Upton, NY, USA, 1 Nov. 2013: *Realtime evolution of non-Abelian plasma instabilities*
- Physics Seminar, Baruch College, New York, NY, USA, 4 Nov. 2013: *Filamentation instability in non-Abelian plasma*
- QCD Seminar, Kent State University, Kent, OH, USA, 7 Nov. 2013: *Chromo-Weibel filaments in the Quark-Gluon Plasma*
- Nuclear Physics Seminar, Ohio State University, Columbus, OH, USA, 12 Nov. 2013: *Longitudinal thermalization via the Chromo-Weibel instability*
- Theory Seminar, Lawrence Berkeley National Laboratory, Berkeley, CA, USA, 13 Nov. 2013: *Realtime evolution of Chromo-Weibel instabilities*

Jussi Auvinen

- Triangle Nuclear Theory Colloquium, Duke University, Durham, NC, USA, 6 March 2013: *Collision energy evolution of flow variables and particle spectra in a hybrid model*
- 8th International Workshop on Critical Point and Onset of Deconfinement (CPOD 2013), Napa, CA, USA, 11-15 March 2013: *Collision energy evolution of elliptic and triangular flow in a hybrid model*
- Workshop on Transport Theory in Heavy Ion Collisions, Schmitten, Germany, 15-17 July: *Thermalization, scattering rates and other checks in a pion box*
- FAIRNESS 2013: Workshop for young scientists with research interests focused on physics at FAIR, Berlin, Germany, 15-21 Sept. 2013: *Evolution of elliptic and triangular flow as a function of beam energy in a hybrid model*

Sarah Becker

- DPG spring meeting, section condensed matter, Regensburg, March 2013: *Transmission grid extensions during the build-up of a fully renewable European electricity supply*
- Atmosphere and Energy Seminar, Department of Civil and Environmental Engineering, Stanford University, Stanford, CA, USA, April 2013: *Transmission grid extensions during the build-up of a fully renewable European electricity supply*
- 8th SDEWES conference, Dubrovnik, Croatia, Sept. 2013: *What can transmission do for a fully renewable Europe?*

Hamza Berrehrah

- International Conference “Strangeness in Quark Matter 2013” (SQM-2013), Birmingham, United Kingdom, 22-27 July 2013: *Towards the dynamic study of on- and off-shell heavy quarks in the Quark-Gluon-Plasma*

Marcus Bleicher

- EMMI Workshop on Fluctuations, Darmstadt, Germany, 12 Feb. 2013: *Hadronization and the QCD phase diagram*
- EMMI Workshop Prospects and Challenges, Darmstadt, Germany, 14 Feb. 2013: *Transport Models in Heavy Ion Collisions*
- Workshop "Quarks, Gluons, and Hadronic Matter under Etreme Conditions II", St. Goar, Germany, 20 March 2013: *Open Questions in Hybrid Models for Heavy Ion Collisions*
- 2nd Caribbean Symposium on Cosmology, Gravitation, Nuclear and Astroparticle Physics (STARS2013), Havana, Cuba, 29 Apr. 2013: *Mini-Review on Mini-Black Holes from the Mini-Big Bang*
- XXXI Max Born Symposium and HIC for FAIR Workshop, Wroclaw, Poland, 15 June 2013: *Hybrid Modeling of Heavy Ion Collisions*
- 14th International Conference on Strangeness in Quark Matter (SQM2013), Birmingham, UK, 21 July 2013: *Opening Talk - Theory*
- 9th Workshop Relativistic Aspects of Nuclear Physics (RANP2013), Rio de Janeiro, Brazil, 25 Sept. 2013: *Mini-Review on Mini-Black Holes from the Mini-Big Bang*

Elena Bratkovskaya

- Seminar talk at JINR, Dubna, Russia, 29 Jan. 2013: *Physics at Nuclotron and NICA energies*
- 29th Winter Workshop on Nuclear Dynamics (WWND 2013), Squaw Valley, CA, USA, 3-10 Feb. 2013: *Parton-hadron matter in- and out-off equilibrium*
- EMMI Workshop "Fluctuations and Correlations and QCD Phase Transition", GSI, Darmstadt, Germany, 11-12 Feb. 2013: *Charge fluctuations in transport models*
- International Workshop "Frontiers in Nuclear Physics", Guadeloupe, France, 11-15 March 2013: *Dynamics of the sQGP*
- STARS2013 – 2nd Caribbean Symposium on Cosmology, Gravitation, Nuclear and Astroparticle Physics / SMFNS2013 – 3rd International Symposium on Strong Electromagnetic Fields and Neutron Stars, Havana/Varadero, Cuba, 4-10 May 2013: *Parton-hadron dynamics in heavy-ion collisions*
- International Workshop "Electromagnetic Probes of Strongly Interacting Matter", ECT*, Trento, Italy, 20-24 May 2013: *Dilepton and photon production in HSD/PHSD*
- International Conference "Strangeness in Quark Matter 2013" (SQM-2013), Birmingham, United Kingdom, 22-27 July 2013: *Strongly interacting parton-hadron matter in- and out-off equilibrium*
- Seminar talk at JINR, Dubna, Russia, 7 August 2013: *The properties of parton-hadron matter from heavy-ion collisions*
- 9th International Workshop "Relativistic Aspects of Nuclear Physics" (RANP2013), Rio de Janeiro, 23-27 Sept. 2013: *Dynamical description of strongly interacting parton-hadron matter*
- 5th International Workshop "High Energy Physics in the LHC Era" (HEP-2013), Valparaso, Chile, 16-20 Dec. 2013: *Dynamics of strongly interacting parton-hadron matter*

Alessandro Brillante

- International conference "The modern physics of compact stars and relativistic gravity", Yerevan, Armenia, 18-21 Sept. 2013: *Equilibrium properties and oscillation frequencies of charged spheres in GR*
- EMMI Rapid Reaction Task Force meeting on Quark Matter in Compact Stars, Frankfurt, Germany, 7-14 Oct. 2013: *Radial oscillations in neutral and charged compact stars*

Lucas Burigo

- HIC for FAIR Physics Day, Expert Group 1Frankfurt, Germany, 18 Feb. 2013, : *Monte Carlo simulations in heavy-ion cancer therapy*,
- NanoBiC Stipendiatentreffen, Beilstein-Institut, Frankfurt, Germany, 19 Feb. 2013: *Monte Carlo simulations of microdosimetric data for heavy ion beams*
- 9th Geant4 Space Users' Workshop, Barcelona, Spain, 4-6 March 2014: *Geant4-based simulations of microdosimetric data for high charge and energy particles*,
- FAIRNESS 2013: Workshop for young scientists with research interests focused on physics at FAIR, Berlin, Germany, 15-21 Sept. 2013: *Radiation fields from hze particles studied with Geant4-based simulations*
- Geant4 2013 International User Conference, Bordeaux, France, 7-9 Oct. 2013: *Microdosimetry Spectra and RBE of Protons, Helium, Lithium and Carbon nuclei in water studied with Geant4-based Simulation*
- Seminar talk at Technische Universität Darmstadt, Darmstadt, Germany, 18 Oct. 2013: *Radiation effects in future space exploration missions*
- Excellence Award Presentations, HGS-HIRe Graduate Day, Worms, Germany, 24-25 Oct. 2013: *Radiation effects by ions in ion beam cancer therapy and space exploration missions*

Daniel Cabrera

- FAIRNESS 2013: Workshop for young scientists with research interests focused on physics at FAIR, Berlin, Germany, 15-21 Sept. 2013: *Strange and heavy mesons in hadronic matter*

Pramod Chandrashekhariah

- 8th International Conference on Computer Vision Theory and Applications (VISAPP 2013), Barcelona, Spain, 21-24 Feb. 2013: *Let it Learn: A Curious Vision System for Autonomous Object Learning*

Christoph Hartmann

- Deptartment of Neuroscience, Institute of Experimental Medicine AS CR, Prague, Czech Republic, 3 Dec. 2013: *Self-organized learning and inference explain key properties of neural variability*

Hendrik van Hees

- GSI Theory Seminar, Darmstadt, Germany, 9 Jan. 2013: *Nonequilibrium quark-pair and photon production*
- Talk at the EMMI Rapid Reaction Task Force Kick-Off Meeting, GSI, Darmstadt, Germany, 12-13 Feb. 2013: *Electromagnetic probes in heavy-ion collisions*
- Annual Spring Meeting, Section "Hadrons and Nuclei", Deutsche Physikalische Gesellschaft, Dresden, Germany, March 4-8: *Thermal Photons at RHIC and LHC*
- International Workshop "Electromagnetic Probes of Strongly Interacting Matter", ECT*, Trento, Italy, 20-24 May 2013: *EM spectra at CERN-SPS*
- XXXI Max Born Symposium and HIC for FAIR Workshop, Wroclaw, Poland, 14-16 June 2013: *Dynamics of the chiral phase transition*
- Workshop on Transport Theory in Heavy Ion Collisions, Schmitten, Germany, 15-17 July 2013: *Dynamics of the chiral phase transition*
- European Physical Society Conference on High Energy Physics (EPSHEP 2013), Stockholm, Sweden, 18-24 July 2013: *Heavy quarks in heavy-ion collisions*

- EMMI Rapid Reaction Task Force: Emissivity of matter under extreme conditions, dileptons and chiral symmetry: established connections and missing links, GSI, Darmstadt, Germany, 5-15 Oct. 2013: *Thermal Photons at RHIC and LHC*
- Invited Lecture, SERC School on Modern Theories of Nuclear Reactions, Indian Institute of Technology, Roorkee, India, 1-12 Oct. 2013: *Phenomenology of heavy-ion collisions*
- First SaporeGravis Workshop (SGW 2013), Nantes, France, 2-5 Dec. 2013: *Charm and beauty production in AA collisions in a Fokker-Planck approach*

Christoph Herold

- 8th International Workshop on Critical Point and Onset of Deconfinement (CPOD 2013), Napa, CA, USA, 11-15 March 2013: *Domain formation and density fluctuations as a signal for the QCD first-order phase transition*
- FAIRNESS 2013: Workshop for young scientists with research interests focused on physics at FAIR, Berlin, Germany, 15-21 Sept. 2013: *How spinodal decomposition influences observables at FAIR energies*

Pasi Huovinen

- Exited QCD 2013, Sarajevo, Bosnia-Herzegovina, 3-9 Feb. 2013: *Lattice QCD based equation of state at finite baryon density*
- EMMI Workshop "Fluctuations and Correlations and QCD Phase Transition", GSI, Darmstadt, 11-12 Feb. 2013: *EoS and hydrodynamic evolution in heavy ion collisions*
- Seminar talk at University of Jyväskylä, Jyväskylä, Finland, 1 March 2013: *Dynamical freeze-out in hydrodynamics*
- DPG Frühjahrstagung 2013, Dresden, 4-8 March 2013: *Lattice QCD based equation of state at finite baryon density*
- EMMI Nuclear and Quark matter seminar, GSI, Darmstadt, 13 March 2013: *Hydrodynamical models at various collision energies*
- Three lectures at International School on Quark-Gluon Plasma and Heavy Ion Collisions, Siena, Italy, 9-13 July 2013: *Hydrodynamics*
- Strangeness in Quark Matter (SQM 2013), Birmingham, UK, 22-27 July 2013: *Dynamical freeze-out in event-by-event hydrodynamics*

  Seminar talk at University of Turin, Turin, Italy, 9 Oct 2013: *Dynamical freeze-out in event-by-event hydrodynamics*
- Two lectures at Peking University, Beijing, China, 12-13 Nov. 2013: *Hydrodynamics for heavy-ion collisions*
- Seminar talk at Peking University, Beijing, China, 14 Nov. 2013: *Lattice QCD equation of state for hydrodynamical models*
- New Frontiers in QCD 2013, Yukawa Institute for Theoretical Physics, Kyoto, Japan, 18 Nov. - 20 Dec. 2013: *Dynamical freeze-out in event-by-event hydrodynamics*

Yury Karpenko

- FAIRNESS 2013: Workshop for young scientists with research interests focused on physics at FAIR, Berlin, Germany, 15-21 Sept. 2013: *Beam energy scan using a hydro+cascade model*

Matthias Kaschube

- Seminar talk at Max-Planck Florida Institute for Neuroscience, Jupiter, FL, USA, May 2013

– Complex Nonlinear Systems: From Basic Science to Applications, Samarkand, Uzbekistan, 7-11 Oct. 2013: *Neural response properties in the visual cortex shaped by recurrent networks*

Andrei Korol

– Seminar talk at Peking University, Beijing, China, 17 July 2013: *Crystalline undulator as a novel light source*

– Sixth International Symposium "Atomic Cluster Collisions" (ISACC 2013), Wuhan-Chongqing, China, 18-23 July 2013: *Collective electron excitations in photo- and electron impact ionization of fullerenes*

Thomas Lang

– 8th International Workshop on Critical Point and Onset of Deconfinement (CPOD 2013), Napa, CA, USA, 11-15 March 2013: *Heavy quarks in the UrQMD hybrid approach*

Volker Lindenstruth

– Digital Business Forum, ATKearny CIO Winter Summit Grindelwald, Switzerland, 1 March 2013: *Quarks und Bytes*

– ZKI Frühjahrstagung, Frankfurt, Germany, 12 March 2013: *Kühlkonzept des neuen HPC-Systems an der GSI Darmstadt*

– Paderborn Center for Parallel Computing, Feierstunde zur Inbetriebnahme des neuen Hochleistungsrechners, Paderborn, Germany, 15 March 2013: *Anwendungen von Murphys Gesetz beim Bau von Supercomputern*

– ATA-Tagung, Konstanz, Germany, 4 April 2013: *Hocheffiziente und kosteneffiziente Rechenzentren – neue Architekturen und Konzepte*

– Seminar talk, University of Göttingen, Göttingen, Germany, 24 July 2013: *GSI Green-IT Cube*

– "Best in Cloud" Awards Ceremony, Frankfurt, Germany, 24 Oct. 2013: *Quarks and Bytes*

– ABB Data Center Forum 2013, Ladenburg, Germany, 5 Nov. 2013: *Trends für die Architektur der Hochleistungsrechner*

– Seminar talk, University of Regensburg, Regensburg, Germany, 12 Dec. 2013: *LQCD on GPGPUs on fast computers*

Yury Malyshkin

– Joint International Conference on Supercomputing in Nuclear Applications and Monte Carlo (SNA & MC 2013), Paris, France, 27-31 Oct. 2013: *Monte Carlo modeling of minor actinide burning in fissile spallation targets*

Rudy Marty

– DPG Frühjahrstagung 2013, Dresden, Germany, 25 Feb.-1 March 2013: *Molecular dynamics description of an expanding $q/\bar{q}$ plasma with the NJL model and applications to heavy ion collisions*

– Workshop on Transport Theory in Heavy Ion Collisions, Schmitten, Germany, 15-17 July 2013: *Dynamical hadronization with an NJL approach*

– International Conference "Strangeness in Quark Matter 2013" (SQM-2013), Birmingham, United Kingdom, 22-27 July 2013: *Transport coefficients from the Nambu-Jona-Lasinio model for $SU(3)_f$*

– International Conference "Initial Stages in High-Energy Nuclear Collisions" (IS-2013), Illa da Toxa, Spain, 8-14 Sept. 2013: *The influence of initial conditions on the final observables for heavy-ion collisions at RHIC energies*

– International Workshop on Particle Correlations and Femtoscopy (WPCF-2013), Acireale, Italy, 5-8 Nov. 2013, : *The influence of initial conditions on the final observables for heavy-ion collisions at RHIC energies*

Igor Mishustin

– International Workshop "Frontiers in Nuclear Physics", Guadeloupe, France, 11-15 March 2013: *Modeling Nuclear Equation of State for Compact Stars and Supernovae,*

– International Symposium "Nuclear Physics: Presence and Future", Boppard, Germany, 29 May-5 June 2013: *Possible production of neutron-rich heavy nuclei in spallation targets*

– 4th International Conference on Nuclear Fragmentation (NUFRA2013), Kemer (Antalya), Turkey, 29 Sept.-6 Oct. 2013: *Possible production of neutron-rich (super)heavy nuclei in spallation targets*

– International Workshop on Supercritical Fields, FIAS, Frankfurt, Germany, 4-5 Nov. 2013: *Antimatter cluster production from the Dirac Sea*

Marlene Nahrgang

– 8th International Workshop on Critical Point and Onset of Deconfinement (CPOD 2013), Napa, CA, USA, 11-15 March 2013: *Dynamic Enhancement of Fluctuation Signals at the QCD Phase Transition*

– FAIRNESS 2013: Workshop for young scientists with research interests focused on physics at FAIR, Berlin, Germany, 15-21 Sept. 2013: *Compressed Baryonic Matter experiment at FAIR: Theory overview*

– First SaporeGravis Workshop (SGW 2013), Nantes, France, 2-5 Dec. 2013, *Azimuthal correlations of heavy flavors in AA collisions*

Piero Nicolini

– DPG Frühjahrstagung, Fachverbände Gravitation und Relativitätstheorie, Jena, Germany, 25 Feb.-1 March 2013: *Black holes, classicalization, dimensional reduction and holography*

– COST Workshop "The biggest accelerators in space and on earth", CERN, Geneva, Switzerland, 18-22 March 2013: *Black holes, classicalization, dimensional reduction and holography*

– Physics Colloquium, Goethe University, Frankfurt, Germany, 18 Dec. 2013: *Journey to the shortest scale*

Hannah Petersen

– Workshop "Excited QCD 2013", Bjelasnica Mountain, Sarajevo, Bosnia-Herzegovina, 3-9 Feb. 2013: *Quantifying initial state fluctuations in heavy ion collisions*

– International Workshop "Frontiers in Nuclear Physics", Guadeloupe, France, 11-15 March 2013: *Collective flow in heavy ion collisions*

– Kuratoriumssitzung der Deutsche Telekom Stiftung, Bonn, Germany, 24 May 2013: *Erfolgreiche Nachwuchsförderung*

– CBM group meeting, GSI, Germany, 14 June 2013: *Dynamical description of heavy ion collisions at FAIR*

– Workshop on Sampling Particles on the Cooper-Frye Transition Surface, Schmitten, Germany, 18-20 July 2013: *Global conservation laws for sampling particles*

– Workshop on Knowledge Extraction via Comparison of Complex Computational Models to Massive Data Sets, SAMSI, Research Triangle Park, NC, USA, 29-31 July 2013: *Dynamical modeling of heavy ion collisions - Applying visualization tools and statistical analysis*

– 2nd workshop on initial state fluctuations and final state correlations, Chengdu, China, 11-15 August 2013: *Hydro overview*
– Seminar talk at Peking University, Beijing, China, 16 Aug. 2013: *Big Bang in the Laboratory and the role of fluctuations*
– Future Trends in High-Energy Nuclear Collisions, Beijing, China, 19-22 August 2013: *Transport theory and relativistic heavy ion collisions*
– Relativistic Aspects of Nuclear Physics 2013, Rio de Janeiro, Brasil, 23-27 Sept. 2013: *Bumpy initial conditions and a double-hump structure*
– EMMI Physics Days 2013, GSI, Darmstadt, Germany, 19 Nov. 2013: *Initial state fluctuations and anisotropic flow in heavy ion collisions at high temperatures and densities*

Viola Priesemann

– BCCN Seminar, Max Planck Institute for Dynamics and Self-Organization, Göttingen, 18 June 2013: *Self- organized criticality as a universal brain state from wakefulness to deep sleep?*
– Computational Neuroscience Conference (Workshop), Paris, France, 18 July 2013: *Learning more by sampling less: Subsampling advances model selection*
– Conference on Criticality and the Brain, Capri, Italy, 6 Sept. 2013: *Self-organized criticality as a universal brain state from wakefulness to deep sleep?*
– "BrainModes" Conference, Amsterdam, The Netherlands, 2 Dec. 2013: *Self-organized criticality as a universal brain state?*

Igor Pshenichnov

– 4th International Conference on Nuclear Fragmentation (NUFRA2013), Kemer (Antalya), Turkey, 29 Sept.-6 Oct. 2013: *Transmutation of minor actinides in accelerator-driven systems*

Philip Rau

– 8th International Workshop on Critical Point and Onset of Deconfinement (CPOD 2013), Napa, CA, USA, 11-15 March 2013: *QCD equation of state from a chiral hadronic model including quark degrees of freedom*

Chihiro Sasaki

– 8th International Workshop on Critical Point and Onset of Deconfinement (CPOD 2013), Napa, CA, USA, 11-15 Mar. 2013: *Effective Gluon Potential and Yang-Mills Thermodynamics*
– EMMI Kick-Off Meeting, GSI, Darmstadt, Germany, 11-12 Feb. 2013, *Effective Gluon potential and Yang-Mills thermodynamics*
– 4th session of APCTP-WCU Focus Program "From dense matter to compact stars in QCD and in hQCD", Pohang, Korea, 22 Apr. 2013: *Revisiting Yang-Mills thermodynamics: role of the Polyakov loop*
– Seminar talk at Hiroshima University, Hiroshima, Japan, 24 April 2013: *Revisiting Yang-Mills thermodynamics: role of the Polyakov loop*
– XXXI Max Born Symposium and HIC for FAIR Workshop, Wroclaw, Poland, 14-16 June 2013: *Yang-Mills thermodynamics: an effective theory approach*
– International Conference on new Frontiers in Physics (ICNFP 2013) Kolymbari, Crete, Greece, 28 Aug-5 Sept. 2013, : *Yang-Mills Thermodynamics: an Effective Theory Approach*
– 9th Relativistic Aspects of Nuclear Physics workshop (RANP), Rio de Janeiro, Brazil, 27 Sept. 2013: *Yang-Mills thermodynamics: an effective theory approach*

– German-Japanese Seminar, Regensburg, Germany, 8 Nov. 2013: *QCD thermodynamics from effective theories*
– New Frontiers in QCD 2013 (NFQCD), Yukawa Institute for Theoretical Physics, Kyoto, Japan, 27 Nov.2013: *Fluctuations and the QCD phase structure from effective theories*
– New Frontiers in QCD 2013 (NFQCD), Yukawa Institute for Theoretical Physics, Kyoto, Japan, 28 Nov. 2013: *Chiral thermodynamics with charm*

Stefan Schramm

– International Symposium "Nuclear Physics: Presence and Future", Boppard, Germany, 29 May-5 June 2013: *Compact Stars - How exotic can they be?*
– International Conference on the Structure of Baryons (Baryons2013), Glasgow, Scotland, 24-28 June 2013: *Modeling quark-hadron matter at high temperature and density*
– Sixth International Workshop on Astronomy and Relativistic Astrophysics (IWARA-2013), Rio de Janeiro, 29 Sept.-3 Oct. 2013: *Exotic matter in compact stars - Limits and consequences*

Wolf Singer

– Schauspiel Frankfurt, M. Friedman im Gesprch mit Wolf Singer, Frankfurt, 22 Jan. 2013: *Wahnsinn!*
– 2. Basler Tagung für Versicherungsrecht und Versicherungspsychiatrie, Basel, Switzerland, 25 Jan. 2013: *Zur Beurteilung von Fehlverhalten für das es keine klinische Diagnose gibt*
– Tibethaus Frankfurt, 31 Jan. 2013: *Die Suche nach den neuronalen Grundlagen von Bewusstsein – Ein schwieriges Unterfangen*
– Münchner Kompetenzzentrum Ethik, Ludwig-Maximilians-Universität München, 5 Feb. 2013: *Neurobiologische Grundlagen für Verantwortlichkeit und Schuldfähigkeit*
– Symposium der EKHN-Stiftung, Frankfurt, Germany, 9 Feb. 2013: *Im Netz der Neuronen. Wie bringt das Gehirn unser Selbst hervor?*
– Wilhelm Wundt Distinguished Guest Lecture, Max Planck Institute for Human Cognitive and Brain Science, Leipzig, Germany, 11 March 2013: *The dynamic brain: Time as coding space in cortical processing*
– "Prepare for Life! Raising Awareness for Early Literacy Education", Stiftung Lesen, Leipzig, Germany, 12 March 2013: *Aktuelle Erkenntnisse aus der Hirnforschung zur Entwicklung des kindlichen Gehirns*
– Initiative Gehirnforschung Steiermark, Dialogreihe "Geist und Gegenwart", Graz, Austria, 15 April 2013: *Selbsterfahrung und neurobiologische Forschung – Zwei konfliktträchtige Erkenntnisquellen*
– The Pontifical Academy of Sciences, Working group "On the road to humanity – Via Humanitatis", Rome, Vatican City, 19-21 April 2013: *The emergence of consciousness: The interplay of genetic and epigenetic factors*
– NEURONUS 2013, IBRO & IRUN Neuroscience Forum, Krakow, Poland, 9-11 May 2013: *The dynamic brain: Time as coding space in cortical processing*
– Dynamics Days Europe XXIII, Madrid, Spain, 3-7 June 2013: *Time as coding space for information processing in the cerebral cortex*
– Transylvanian Experimental Neuroscience Summer School (TENSS), Pike Lake, Romania, 1-17 June 2013: *General aspects about synchrony and oscillations*
– GABA Conference on inhibitory interactions in brain plasticity, Krakow, Poland, 5-7 Sept. 2013: *The changing face of inhibition: From gain control to the back-bone of dynamical coordination*

- Vortragsreihe “Das Leben im 21. Jahrhundert“, Cronstetten-Stiftung Frankfurt, Germany, 12 Sept. 2013: *Wer regiert im Kopf? Philosophische Implikationen der Hirnforschung*
- 37th ESNR Annual Meeting, European Society of Neuroradiology, Frankfurt, Germany, 30 Sept. 2013: *Imaging in neuroscience*
- Mind and Life Europe Symposium for Contemplative Studies Berlin, Germany, 10-13 October 2013: *Neuronal mechanisms underlying behavioural modifications*
- “Visual Function in the Brain”, A Festschrift for Ralph Freeman, Berkeley, CA, USA, 14 Nov. 2013: *Time frames*
- Labday, Max Planck Institute for Biophysical Chemistry, Göttingen, Germany, 19 Nov. 2013: *The cerebral cortex: More enigmatic than ever?*
- 3rd Joint Inter-Academy Symposium of the Israel Academy of Sciences and Humanities “Stability and Plasticity: Advances in Understanding Neuronal Representations”, Jerusalem, Israel, 1-2 Dec. 2013: *The dynamic brain: The role of temporal coordination in normal and disturbed cognitive functions*
- Heller Lecture in Computational Neuroscience, The Hebrew University, Jerusalem, Jerusalem, Israel, 3 Dec. 2013: *Philosophical implications of brain research: Discrepancies between first and third person perspective*

Andrey V. Solov’yov

- Workshop on Nanostructured Titanium-based Alloys for Medical Applications: Mechanical Properties and Biocompatibility, Ein Gedi, Israel, 21-23 January 2013
- International Symposium on Science of Clusters, Nanoparticles and Nanoscale Materials (SOCNAM), Jaipur, India, 4-7 March 2013
- 2nd NANO-IBCT Conference “Radiation Damage of Biomolecular Systems: Nanoscale insights into Ion-Beam Cancer Therapy”, Sopot, Poland, 20-24 May 2013: *Multiscale physics of ion beam cancer therapy*
- 2nd NANO-IBCT Conference “Radiation Damage of Biomolecular Systems: Nanoscale insights into Ion-Beam Cancer Therapy”, Sopot, Poland, 20-24 May 2013: *Action MP1002/Nano-IBCT: Nanoscale insights into ion beam cancer therapy*
- International Symposium “Nuclear Physics: Presence and Future”, Boppard, Germany, 29 May - 5 June 2013: *Crystalline Undulator as a novel light source and perspectives for crystalline undulator based gamma laser*
- Seminar talk at Department of Physics, Imperial College, London, United Kingdom, June 2013
- Seminar talk at Department of Physical Sciences, The Open University, Milton Keynes, United Kingdom, June 2013
- Sixth International Symposium “Atomic Cluster Collisions” (ISACC 2013), Wuhan-Chongqing, China, 18-23 July 2013: *MBN Explorer - a powerful, universal tool for simulating multiscale complex molecular structure and dynamics: case studies*
- International Conference on Computational Modelling of Nanostructured Materials (ICCMNM 2013), Frankfurt, Germany, 4-6 Sept. 2013: *MBN Explorer - a unified tool for simulating complex molecular structure and dynamics: application to nanomaterials*
- 7th Annual Progress Conference (APC) of the COST Domain Committee Materials, Physics and Nanosciences, Reykjavik, Iceland, 11-12 Sept. 2013
- International Workshop on the creation of a RADAM Database, (Nano-IBCT COST Action MP1002), Caen, France, 1-2 October 2013

– 16th International Symposium on Microdosimetry (MICROS 2013), Treviso, Italy, 20-25 Oct. 2013: *New multiscale approach to radiation action*
– Colloquium talk at Science Faculty, University of Namur, Namur, Belgium, Nov. 2013
– Workshop "Theory Days on Advances in Biomolecule Irradiation", Toulouse, France, 27-29 Nov. 2013: *Multiscale physics of radiation damage phenomena*
– Physics Colloquium, Department of Physics, Goethe University Frankfurt, Germany, 11 Dec. 2013, : *Multiscale physics of ion beam cancer therapy: nanoscale insights*

Gennady Sushko

– International Conference on Computational Modelling of Nanostructured Materials (ICCMNM 2013), Frankfurt, Germany, 4-6 Sept. 2013: *Full-atom molecular dynamics simulations of nanoindentation of Ti and NiTi materials*

Jochen Triesch

– Institut für Neuro- und Bioinformatik, Universität zu Lübeck, 17 January 2013: *Self-Organization and unsupervised learning in recurrent networks*
– Workshop Temporal Dynamics in Learning: Networks & Neural Data, Janelia Farm, Ashburn, VA, USA, 13-16 May 2013: *Self-Organization and unsupervised learning in recurrent networks*
– International Workshop on "Intrinsic Motivations and Open-Ended Development in Animals, Humans, and Robots (IMOD-2013)", Rome, Italy, 6-8 June 2013: *Intrinsically Motivated Learning in Active Perception*
– Transylvanian Experimental Neuroscience Summer School (TENSS), Pike Lake, Romania, 1-17 June 2013: *Modeling neuronal circuits*
– Institute of Neural Information Processing, University of Ulm, 24 June 2013: *Infants in Control: Rapid Anticipation of Action Outcomes in a Gaze-Contingent Paradigm*
– Department of Psychological and Brain Sciences, Indiana University, Bloomington, IN, USA, 4 October 2013: *Infants in Control: Rapid Anticipation of Action Outcomes in a Gaze-Contingent Paradigm*
– Department of Psychological and Brain Sciences, Indiana University, Bloomington, IN, USA, 7 October 2013: *Self-Organization and unsupervised learning in recurrent networks*

  Cognitive Science Department, UC San Diego, CA, USA, 4 November 2013: *Efficient Coding in Active Perception*

Alexey Verkhovtsev

– 11th International Conference "Advanced Carbon Nanostructures" (ACNS 2013), St. Petersburg, Russia, 1-5 July 2013: *Electron excitations in photo- and electron impact ionization of fullerenes*
– Sixth International Symposium "Atomic Cluster Collisions" (ISACC 2013), Wuhan-Chongqing, China, 18-23 July 2013: *Quantum and classical features in photoionization of atomic clusters*
– International Conference on Mathematical Modeling in Physical Sciences (IC-MSQUARE 2013), Prague, Czech Republic, 1-5 Sept. 2013: *Investigation of quantum and classical phenomena in photoionization of atomic clusters*
– International Conference on Computational Modelling of Nanostructured Materials (ICCMNM 2013), Frankfurt, Germany, 4-6 Sept. 2013: *Quantum mechanical and classical molecular dynamics simulations for the validation of force fields for the multiscale description of nanoparticles and diffusion driven processes*

– Seminar talk at Department of Experimental Physics, St. Petersburg State Polytechnic University, St. Petersburg, Russia, 11 Sept. 2013: *Dynamics of electron excitation in fullerenes*
– Seminar talk at Department of Quantum Mechanics, St. Petersburg State University, St. Petersburg, Russia20 Sept. 2013: *Dynamics of electron excitation in fullerenes*
– Seminar talk at St. Petersburg State Polytechnic University, St. Petersburg, Russia, 18 Dec. 2013

Alexander Yakubovich

– Workshop on Nanostructured Titanium-based Alloys for Medical Applications: Mechanical Properties and Biocompatibility, Ein Gedi, Israel, 21-23 January 2013: *Quantum mechanical calculations of Ti metallic clusters and crystal structures, diffusion processes at interfaces and nanoindendentation. Potential improvement and calculations of the dissociation barriers on grain boundaries*
– Workshop on RADAM Database development, Innsbruck, Austria, 20-22 Feb. 2013: *Development of the RADAM database*
– Intenational Symposium on Size Selected Clusters (S^3C 2013), Davos, Switzerland, 4-8 March 2013: *Kinetics of liquid-solid phase transition in large nickel clusters*
– 2nd NANO-IBCT Conference “Radiation Damage of Biomolecular Systems: Nanoscale insights into Ion-Beam Cancer Therapy”, Sopot, Poland, 20-24 May 2013: *Molecular dynamics simulations of thermo-mechanical radiation damage events*

FIAS conference abstracts and posters 2013

International Conference on Computational and Systems Neuroscience (COSYNE 2013)

28 Feb. - 3 March 2013, Salt Lake City, UT, USA

- Constantin A. Rothkopf, Dana Ballard, *Eye movements depend on the intrinsic reward structure in a natural navigation task*, Poster I-65
- M. Schottdorf, W. Keil, M. Schnabel, D.M. Coppola, S. Löwel, L.E. White, M. Kaschube, F. Wolf *Do orientation preference maps arise from hexagonal retinal ganglion cell mosaics?*, Poster II-44
- W. Keil, F. Wolf, J.-D. Florez-Weidinger, M. Kaschube, M. Schnabel, D.M. Coppola, S. Löwel, L.E. White, *Is there a critical area size for the transition from interspersed to columnar V1 architecture*, Poster II-84
- Daniela Pamplona, Jochen Triesch, Constantin A. Rothkopf, *Eye's imaging process explains ganglion cells anisotropies*, Poster II-79
- J Lücke, J. Shelton, P. Sterne, P., Berkes, J. Bornschein, A.-S., Sheikh, *Combining Feed-Forward Processing and Sampling For Neurally Plausible Encoding Models*. Poster III-28.

Annual Spring Meeting, Section "Gravitation and Relativity", Deutsche Physikalische Gesellschaft,

25 Feb.- 1 March 2013, Jena, Germany

- Piero Nicolini, Jonas Mureika, Euro Spallucci, *Black holes, classicalization, dimensional reduction and holography*, Talk GR1.3
- Antonia Micol Frassino, *Van der Waals behavior and gauge/gravity duality*, Talk GR1.4

Annual Spring Meeting, Section "Hadrons and Nuclei", Deutsche Physikalische Gesellschaft,

4-8 March, Dresden, Germany

- Stephan Endres, Marcus Bleicher, *Studies of dilepton production with the UrQMD transport model*, Talk HK4.4
- Andreas Hennig, Michael Elvers, Janis Endres, Andreas Heinz, Desiree Radeck, Deniz Savran, Volker Werner, Andreas Zilges, *Inelastic Proton Scattering on* ^{96}Ru, Talk HK5.5
- Alexei Larionov, Markus Bleicher, Albrecht Gillitzer, Mark Strikman, *Charmonium production in* $\bar{p}$*-nucleus reactions at low energies*, Talk HK17.9
- Jacob Beller, Tobias Beck, Nadia Benouaret, Vera Derya, Bastian Löher, Norbert Pietralla, Christopher Romig, Deniz Savran, Marcus Scheck, Linda Schnorrenberger, Werner Tornow, Markus Zweidinger, *Detaillierte Untersuchung des Zerfallsverhaltens der Scherenmode in* ^{156}Gd, Talk HK20.7
- Felix Rettig, Stefan Kirsch, Volker Lindenstruth, *ALICE TRD GTU Online Tracking Performance in* $\sqrt{s}$ *=7 - 8 TeV pp collisions*, Talk HK22.6
- Thomas Lang, *Heavy quarks in a (3+1) dimensional hybrid approach*, Talk HK29.7
- Chihiro Sasaki and Krzysztof Redlich, *Effective gluon potential and Yang-Mills thermodynamics*, Talk HK30.8
- Alex Meistrenko, Christian Wesp, Hendrik van Hees, Carsten Greiner, *Nichtgleichgewichtsdynamik und Transport auerhalb der Mean-Field-Näherung in effektiven Modellen der QCD*, Talk HK39.7
- Olena Linnyk, Elena Bratkovskaya, Wolfgang Cassing, *Dileptons and photons produced in relativistic heavy ion collisions at SPS, RHIC and LHC*, Talk HK 40.1
- Hendrik van Hees, Ralf Rapp, Charles Gale, *Thermal Photons at RHIC*, Talk 40.7
- Stanislaus Janowski, Denis Parganlija, Francesco Giacosa, Dirk H. Rischke *Phenomenology of the Scalar-Isoscalar Resonances* $f_0(1370)$*,* $f_0(1500)$ *and* $f_0(1710)$, Talk HK 44.2

- Hannu Holopainen, Pasi Huovinen, *Dynamical freeze-out in hydrodynamics*, Talk HK62.5
- Gunnar Graef, *Resolving substructures in the emission geometry using azimuthal sensitive HBT*, Talk HK62.6
- Rudy Marty, Elena Bratkovskaya, *Molecular dynamics description of an expanding q/qbar plasmawith the NJL model and applications to heavy ion collisions*, Talk HK62.8
- Igor Kulakov, Maksym Zyzak, *Detector Independent Cellular Automaton Algorithm for Track Reconstruction*, Talk HK63.2
- Valentina Akishina, Ivan Kisel, Igor Kulakov, Maksym Zyzak, *The Cellular Automaton track finder at high track multiplicities*, Talk HK63.3
- Pasi Huovinen, *Lattice QCD based equation of state at finite baryon density*, Talk HK63.4
- Christoph Herold, Marcus Bleicher, *Domain formation and density fluctuations as a signal for the QCD first order phase transition*, Talk HK63.6
- Dexu Lin, Alexei Larionov, Yue Ma, Igor Mishustin, Frank Maas, *Search for antiproton-*^{15}N *Bound State in PANDA*, Talk HK65.5
- Anja Habersetzer, Francesco Giacosa, Dirk H. Rischke, *t Spectral Functions within a Linear Sigma Model with Electroweak Interactions*, Talk HK73.6
- Jochen Gerhard, Volker Lindenstruth, Marcus Bleicher, *Hydrodynamics on graphic cards*, Talk HK74.3
- Frank Michler, Hendrik van Hees, Dennis Dean Dietrich, Stefan Leupold, Carsten Greiner, *Off-equilibrium photon production during the chiral phase transition*, Talk HK74.5
- Bjørn Baeuchle, Marcus Bleicher, Andreas Grimm, *Direct Photons at FAIR*, Talk HK74.6
- Joel Silva, Enrico Fiori, Johann Isaak, Bastian Loher, Deniz Savran, Matjaz Vencelj, Roland Wirth, *Pulse shape analysis using CsI(Tl) Crystals*, Poster HK52.15
- Khaled Teilab, Susanna Gallas, Francesco Giacosa, Dirk H. Rischke, *Light meson production in nucleon-nucleon reactions*, Poster HK54.6

Annual Spring Meeting, Section "Condensed Matter", Deutsche Physikalische Gesellschaft,

10-15 March 2013, Regensburg, Germany

- Sarah Becker, Rolando A. Rodriguez, Gorm B. Andresen, Stefan Schramm, Martin Greiner, *Transmission grid extensions during the build-up of a fully renewable European electricity supply*, Talk DY11.8
- Martin Greiner, Sarah Becker, Rolando Rodriguez, Tue Jensen, Timo Zeyer, Anders Soendergaard, Gorm Andresen, *A 100% renewable power system in Europe*, Plenary Talk DY20.4

Annual Spring Meeting, Section "Atomic Physics", Deutsche Physikalische Gesellschaft,

18-22 March 2013, Hannover, Germany

- Oliver Matula, Armen Hayrapetyan, Stephan Fritzsche, Andrey Surzhykov, *Angular distribution of electrons emitted in photoionization with twisted photons*, Talk A16.5

Symposium on Size Selected Clusters (S^3C 2013)

3-8 March 2013, Davos, Switzerland

- A.V. Yakubovich, G. Sushko, S. Schramm, A.V. Solov'yov, *Kinetics of liquid-solid phase transition in large nickel clusters*, Book of Abstracts p. 39
- I.A. Solov'yov, G. Sushko, A.V. Yakubovich, A.V. Korol, A.V. Solov'yov: *From atoms to clusters, macromolecules and crystals: a unified approach for simulating of complex molecular structure and dynamics* Book of Abstracts p. 110

- V. Verkhovtsev, A.V. Korol, A.V. Solov'yov, *Electron excitations in photo- and electron impact ionization of fullerenes*, Book of Abstracts p. 113
- I.A. Solov'yov, G. Sushko, A.V. Yakubovich, A.V. Korol, A.V. Solov'yov, *From atoms to clusters, macromolecules and crystals: a unified approach for simulating of complex molecular structure and dynamics*, Poster
- A.V. Verkhovtsev, A.V. Korol, A.V. Solov'yov, *Electron excitations in photo- and electron impact ionization of fullerenes*, Poster

International Conference on Nuclear Data for Science and Technology

4-8 March 2013, New York, NY, USA

- Yu. Malyshkin, I. Pshenichnov, I. Mishustin, W. Greiner, *Interaction of Fast Nucleons with Actinide Nuclei Studied with Geant4*, Poster PR77

Epigenetics and Chromatin: Interactions and processes

11-13 March 2013, Boston, MA, USA

- F. Natale, A. Rapp, W. Yu, M. Durante, G. Taucher-Scholz, Maria C. Cardoso, *Genome-wide multi-parametric analysis of H2AX or γH2AX distributions during ionizing radiation-induced DNA damage response*, Epigenetics & Chromatin, 6 (Suppl 1) p. 58 (2013); Abstract

13th Annual Meeting of the Vision Sciences Society (VSS2013)

10-15 May 2013, Naples, FL, USA

- Quan Wang, Jantina Bolhuis, Constantin Rothkopf, Thorsten Kolling, Monika Knopf, Jochen Triesch, *Infants in Control - Rapid Learning of Action Outcomes by 6 and 8-Month-Olds in a Gaze-Contingent Paradigm* Journal of Vision 13(9), 922
- Constantin Rothkopf, Paul Schrater, *Optimally adapting heuristics: humans quickly abandon the constant bearing angle strategy*, Journal of Vision 13(9), 122

2nd NANO-IBCT Conference 2013 "Radiation Damage in Biomolecular Systems: Nanoscale Insights into Ion-Beam Cancer Therapy"

20-24 May 2013, Sopot, Poland

- A.V. Solov'yov, *COST Action MP1002/Nano-IBCT: Nanoscale insights into ion beam cancer therapy*, Book of abstracts p. 15
- A.V. Solov'yov, E. Surdutovich,, A.V. Yakubovich, *Multiscale physics of ion beam cancer therapy*, Book of abstracts p. 17
- A.V. Yakubovich, E. Surdutovich, A.V. Solov'yov, *Molecular dynamics simulations of thermo-mechanical radiation damage events*, Book of abstracts p. 19
- P. de Vera, R. Garcia-Molina, I. Abril, A.V. Verkhovtsev, E. Surdutovich, A. V. Solov'yov, *Ion beam propagation and electron production in realistic cellular environments*, Book of abstracts p. 38
- M. Krämer, E. Scifoni, A. Eichhorn, C. Wälzlein, M. Durante, *Treatment planning for ion beam radiotherapy*, Book of abstracts p. 43
- P. de Vera, R. Garcia-Molina, I. Abril, E. Surdutovich, A.V. Solov'yov, *Ion beam propagation and electron production in realistic cellular environments*, Book of abstracts p. 96 (Poster)
- G.B. Sushko, M.A. Panshenskov, S.S. Kazenyuk, A.V. Yakubovich, I.A. Solov'yov, A.V. Solov'yov *MBN Explorer as a tool for modeling DNA damage*, Book of abstracts p. 98 (Poster)
- A.V. Verkhovtsev, A.V. Korol, A.V. Solov'yov, *Collective electron excitations in atomic clusters and nanoparticles*, Book of abstracts p. 102 (Poster)

52nd Annual Conference of the Particle Therapy Co-Operative Group (PTCOG 52)

2-8 June 2013, Essen, Germany

– Lucas Burigo, Igor Pshenichnov, Igor Mishustin, Marcus Bleicher, *Radiation fields from protons, helium, lithium and carbon nuclei in water studied with Geant4-based simulations*, Poster
– Igor Pshenichnov, Lucas Burigo, Igor Mishustin, Marcus Bleicher, *Monte Carlo modeling of microdosimetry spectra for therapeutic carbon-ion beams in water*, Poster

11th International Conference "Advanced Carbon Nanostructures" (ACNS 2013)

1-5 July 2013, St. Petersburg, Russia

– A.V. Verkhovtsev, A.V. Korol, A.V. Solov'yov: *Electron excitations in photo- and electron impact ionization of fullerenes*, Book of Abstracts p. 102
– Carbon Nanostructures A.I. Dyrin, A.V. Verkhovtsev, R.G. Polozkov, V.K. Ivanov, A.V. Korol, A.V. Solov'yov: *Structured pseudopotential correction to the jellium model for fullerenes*, Book of Abstracts p. 154
– A.I. Dyrin, A.V. Verkhovtsev, R.G. Polozkov, V.K. Ivanov, A.V. Korol, A.V. Solov'yov, *Structured pseudopotential correction to the jellium model for fullerenes*, Poster

Mathematical Modeling and Computational Physics (MMCP 2013)

8-12 July 2013, Dubna, Russia

– V.P. Akishina, I.V. Kisel, I.S. Kulakov, M.V. Zyzak, *Cellular automaton track finder at high track multiplicities*, Book of Abstracts p. 25

Twenty Second Annual Computational Neuroscience Meeting: CNS*2013

13-18 July 2013, Paris, France

– Dmitry Tsigankov and Matthias Kaschube, *Two generic mechanisms for emergence of direction selectivity coexist in recurrent neural networks*, BMC Neurosci. 14(Suppl 1), P204
– Viola Priesemann, Mario Valderrama, Michael Wibral, Michel Le Van Quyen, *Neuronal avalanches change from wakefulness to deep sleep – a study of intracranial depth recordings in humans*, BMC Neurosci. 14(Suppl 1), P237
– Patricia Wollstadt, Raul Vicente, Michael Wibral, *Graphical analyses in delay interaction networks*, BMC Neurosci. 14(Suppl 1), P413
– Viola Priesemann, Michael Wibral and Jochen Triesch, *Learning more by sampling less: subsampling effects are model specific*, BMC Neurosci. 14(Suppl 1), P414

Sixth International Symposium "Atomic Cluster Collisions" (ISACC 2013)

18-23 July 2013, Wuhan-Chongqing, China

– A.V. Verkhovtsev, A.V. Korol, A.V. Solov'yov, *Quantum and classical phenomena in photoionization of atomic clusters*, Book of Abstracts, p. 31
– G.B. Sushko, M.A. Panshenskov, A.V. Yakubovich, I.A. Solov'yov, A.V. Solov'yov, *MBN Explorer – a powerful, universal tool for simulating multiscale complex molecular structure and dynamics: case studies*, Book of Abstracts, p. 35
– A.V. Verkhovtsev, A.V. Korol, A.V. Solov'yov, *Collective electron excitations in photo- and electron impact ionization of fullerenes*, Book of Abstracts, p. 41

International Conference "Strangeness in Quark Matter 2013" (SQM-2013),

22-27 July 2013, Birmingham, United Kingdom:

– D. Cabrera, *Strange meson spectral functions and cross sections in hot and dense nuclear matter*, Poster
– D. Cabrera, L. Abreu, F. Llanes-Estrada, J. Torres-Rincon, *Heavy meson interactions in a hadronic gas: chiral symmetry, unitarization and transport properties*, Poster

– R. Marty, E. Bratkovskaya, W. Cassing, J. Aichelin, *The influence of initial conditions on the final observables for heavy-ion collisions at RHIC energies*

Proceedings of the 35th Annual Meeting of the Cognitive Science Society (GogSci2013)

31 July - 3 Aug. 2013, Berlin, Germany

– Johan Kwisthout, Iris van Rooij, Matteo Colombo, Carlos Zednik, William A. Phillips, *Constraints on Bayesian Explanation*, Book of Abstracts p. 87

International Conference on Computational Modelling of Nanostructured Materials (ICCMNM 2013)

3-6 Sept. 2013, Frankfurt, Germany

– Gennady B. Sushko, Alexander V. Yakubovich, Alexey Verkhovtsev, Andrey V. Solov'yov, *Full-atom molecular dynamics simulations of nanoindentation of Ti and NiTi materials*, Book of Abstracts p. 26
– Alexey V. Verkhovtsev, Alexander V. Yakubovich, Gennady B. Sushko and Andrey V. Solov'yov, *Quantum mechanical and classical molecular dynamics simulations for the validation of force fields for the multiscale description of nanoparticles and diffusion driven processes*, Book of Abstracts p. 43
– Gennady B. Sushko, Mikhail A. Panshenskov, Alexander V. Yakubovich, Ilia A. Solov'yov, Andrey V. Solov'yov, *MBN Explorer – A powerful, universal tool for simulating multiscale complex molecular structure and dynamics: application to nanomaterials*, Book of Abstracts p. 52

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– F. Bauer, M. Kaschube, *Processing textures in a smooth visual map and a salt-and-pepper organization*, Poster W117
– D. Tsigankov, M. Kaschube, *Two distinct mechanisms for emergence of direction selectivity coexist in generic random recurrent neural networks*, Poster W118
– J. Weidinger, W. Keil, D. Tsigankov, M. Schnabel, M. Kaschube, F. Wolf F, *Understanding order and disorder in visual cortical circuits through self-organization*, Poster T118
– P. Chandrashekhariah, J. Triesch, *An active stereo vision-based object tracking on iCub Robot*, Poster T95
– P. Chandrashekhariah, S. Forestier, L. Lonini, C. Rothkopf, B. Shi, C. Teulière, J. Triesch, C. Zhang, Y. Zhao, *Intrinsically Motivated Learning in Active Perception*, Poster T120
– H.Friedrich, T. Fernandes, Ch. von der Malsburg, V. Ramesh, *Software Platform and Integration Framework for Rapid Cognitive Systems Engineering*, Poster T67
– R. N. Hota, V. Ramesh, *Video Surveillance – Case study for cognitive vision*, Poster T68
– V. Ramesh, Ch. von der Malsburg, *Systems Engineering for Visual Cognition*, Poster T99

EMBo|EMBL Symposium "Seeing is Believing – Imaging the Processes of Life"

3-6 Oct. 2013, Heidelberg, Germany

– Z. Khan, Y.-C. Wang, E.-F. Wischaus, M. Kaschube, *EDGE4D a tool for quantitative 4D analyses of epithelial folding during Drosophila gastrulation*

6th International Conference on Hard and Electromagnetic Probes of High-Energy Nuclear Collisions (Hard Probes 2013)

4-8 Nov. 2013, Stellenbosch, South Africa

– H. Petersen, *Using a Monte Carlo simulation for comparisons of the elastic energy loss of heavy and light quarks in a strongly interacting medium*, Poster

Neuroscience 2013

9-13 Nov. 2013, San Diego, CA, USA

- D. Tsigankov, M. Kaschube, *Two distinct mechanisms for emergence of direction selectivity coexist in generic random recurrent neural networks*, Abstract 359.12/WW13
- M. Kaschube, D. Tsigankov, S.D. van Hooser, A. Sederberg, *Visual training-induced decrease in noise correlation indicates a dominant role of recurrent connections in visual cortical motion processing*, Abstract 359.19/WW20
- R. A. Galuske, N. G. Jähner, C.A. Rothkopf, S. Vögler, J. Triesch, *Topographic and functional organization of feedback connections from middle suprasylvian sulcus to primary visual cortex in the cat*, Abstract 602.05
- F. Roux, M. Wibral, W. Singer, J. Aru, P. Uhlhaas *The phase of thalamic alpha activity entrains cortical gamma-band activity in parietal cortex: evidence from resting state meg recordings*, Abstract 425.12/H14
- T.M. van Leeuwen, M. Wibral, A. Sauer, P. J. Uhlhaas, W. Singer, L. Melloni, *Neural synchronization during bottom-up and top-down visual processing in grapheme-color synesthetes and schizophrenia patients*, Abstract 550.17/RR17

FIAS Publications 2013

In the following all publications from the year 2013 with at least one author quoting the FIAS affiliation are presented. The first listing collects the papers published in regular journals. In the second listing contributions to conference proceedings are displayed, as well as papers which have not (yet) been published in print, but are publicly available on a preprint server. Conference abstracts or posters are not included. A further section lists published books.

A. Journal publications

[1] E. Abbas and others (ALICE collaboration), "Centrality dependence of the pseudorapidity density distribution for charged particles in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV," *Phys. Lett. B* **726** (2013) 610–622, arXiv:1304.0347 [nucl-ex].

[2] E. Abbas and others (ALICE collaboration), "Charmonium and e^+e^- pair photoproduction at mid-rapidity in ultra-peripheral Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV," *Eur. Phys. J. C* **73** (2013) 2617, arXiv:1305.1467 [nucl-ex].

[3] E. Abbas and others (ALICE collaboration), "J/Ψ Elliptic Flow in Pb-Pb Collisions at $\sqrt{s_{NN}} = 2.76$ TeV," *Phys. Rev. Lett.* **111** (2013) 162301, arXiv:1303.5880 [nucl-ex].

[4] E. Abbas and others (ALICE collaboration), "Mid-rapidity anti-baryon to baryon ratios in pp collisions at $\sqrt{s} = 0.9, 2.76$ and 7 TeV measured by ALICE," *Eur. Phys. J. C* **73** (2013) 2496, arXiv:1305.1562 [nucl-ex].

[5] E. Abbas and others (ALICE collaboration), "Performance of the ALICE V0 system," *Journal of Instrumentation* **8** (2013) P10016, arXiv:1306.3130 [nucl-ex].

[6] B. Abelev and others (ALICE collaboration), "Anisotropic flow of charged hadrons, pions and (anti-)protons measured at high transverse momentum in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV," *Phys. Lett. B* **719** (2013) 18–28, arXiv:1205.5761 [nucl-ex].

[7] B. Abelev and others (ALICE collaboration), "Centrality Dependence of Charged Particle Production at Large Transverse Momentum in Pb–Pb Collisions at $\sqrt{s_{NN}} = 2.76$ TeV," *Phys. Lett. B* **720** (2013) 52–62, arXiv:1208.2711 [hep-ex].

[8] B. Abelev and others (ALICE collaboration), "Centrality dependence of π, K, and p production in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV," *Phys. Rev. C* **88** (2013) 044910, arXiv:1303.0737 [hep-ex].

[9] B. Abelev and others (ALICE collaboration), "Centrality determination of Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV with ALICE," *Phys. Rev. C* **88** (2013) 044909, arXiv:1301.4361 [nucl-ex].

[10] B. Abelev and others (ALICE collaboration), "Charge correlations using the balance function in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV," *Phys. Lett. B* **723** (2013) 267–279, arXiv:1301.3756 [nucl-ex].

[11] B. Abelev and others (ALICE collaboration), "Charged kaon femtoscopic correlations in pp collisions at $\sqrt{s} = 7$ TeV," *Phys. Rev. D* **87** (2013) 052016, arXiv:1212.5958 [hep-ex].

[12] B. Abelev and others (ALICE collaboration), "Charge separation relative to the reaction plane in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV," *Phys. Rev. Lett.* **110** (2013) 012301, arXiv:1207.0900 [nucl-ex].

[13] B. Abelev and others (ALICE collaboration), "Coherent J/Ψ photoproduction in ultra-peripheral Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV," *Phys. Lett. B* **718** (2013) 1273–1283, arXiv:1209.3715 [nucl-ex].

[14] B. Abelev and others (ALICE collaboration), "Directed flow of charged particles at mid-rapidity relative to the spectator plane in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV," *Phys. Rev. Lett.* **111** (2013) 232302, arXiv:1306.4145 [nucl-ex].

[15] B. Abelev and others (ALICE collaboration), "D meson elliptic flow in noncentral Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV," *Phys. Rev. Lett.* **111** (2013) 102301, arXiv:1305.2707 [nucl-ex].

[16] B. Abelev and others (ALICE collaboration), "Energy Dependence of the Transverse Momentum Distributions of Charged Particles in pp Collisions Measured by ALICE," *Eur. Phys. J. C* **73** (2013) 2662, arXiv:1307.1093 [nucl-ex].

[17] B. Abelev and others (ALICE collaboration), "K^0_S and Λ production in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV," *Phys. Rev. Lett.* **111** (2013) 222301, arXiv:1307.5530 [nucl-ex].

[18] B. Abelev and others (ALICE collaboration), "Long-range angular correlations on the near and away side in -Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV," *Phys. Lett. B* **719** (2013) 29–41, arXiv:1212.2001 [nucl-ex].

[19] B. Abelev and others (ALICE collaboration), "Long-range angular correlations of pi, K and p in p–Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV," *Phys. Lett. B* **726** (2013) 164–177, arXiv:1307.3237 [nucl-ex].

[20] B. Abelev and others (ALICE collaboration), "Measurement of electrons from beauty hadron decays in pp collisions at $\sqrt{s} = 7$ TeV," *Phys. Lett. B* **721** (2013) 13–23, arXiv:1208.1902 [hep-ex].

[21] B. Abelev and others (ALICE collaboration), "Measurement of inelastic, single- and double-diffraction cross sections in proton–proton collisions at the LHC with ALICE," *Eur. Phys. J. C* **73** (2012) 2456, arXiv:1208.4968 [hep-ex].

[22] B. Abelev and others (ALICE collaboration), "Measurement of the inclusive differential jet cross section in pp collisions at $\sqrt{s} = 2.76$ TeV," *Phys. Lett. B* **722** (2013) 262–272, arXiv:1301.3475 [nucl-ex].

[23] B. Abelev and others (ALICE collaboration), "Multiplicity dependence of two-particle azimuthal correlations in pp collisions at the LHC," *JHEP* **1309** (2013) 049, arXiv:1307.1249 [nucl-ex].

[24] B. Abelev and others (ALICE collaboration), "Net-Charge Fluctuations in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV," *Phys. Rev. Lett.* **110** (2013) 152301, arXiv:1207.6068 [nucl-ex].

[25] B. Abelev and others (ALICE collaboration), "Pseudorapidity density of charged particles in p-Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV," *Phys. Rev. Lett.* **110** (2013) 032301, arXiv:1210.3615 [nucl-ex].

[26] B. Abelev and others (ALICE collaboration), "Transverse Momentum Distribution and Nuclear Modification Factor of Charged Particles in p+Pb Collisions at $\sqrt{s_{NN}} = 5.02$ TeV," *Phys. Rev. Lett.* **110** (2013) 082302, arXiv:1210.4520 [nucl-ex].

[27] T. Aeschbacher, E. Schmidt, M. Blatter, C. Maris, O. Duss, F. H.-T. Allain, P. Güntert, and M. Schubert, "Automated and assisted RNA resonance assignment using NMR chemical shift statistics," *Nucleic Acids Research* **41** (2013) e172.

[28] A. Andronic, D. Blaschke, P. Braun-Munzinger, J. Cleymans, K. Fukushima, L. McLerran, H. Oeschler, R. Pisarski, K. Redlich, C. Sasaki, H. Satz, and J. Stachel, "Hadron production in ultra-relativistic nuclear collisions: Quarkyonic matter and a triple point in the phase diagram of QCD," *Nucl. Phys. A* **837** (2013) 65–86.

[29] M. Attems, A. Rebhan, and M. Strickland, "Instabilities of an anisotropically expanding non-Abelian plasma: 3D+3V discretized hard-loop simulations," *Phys. Rev. D* **87** (2013) 025010, arXiv:1207.5795 [hep-ph].

[30] J. Auvinen and H. Petersen, "Evolution of elliptic and triangular flow as a function of $\sqrt{s_{NN}}$ in a hybrid model," *Phys. Rev. C* **88** (2013) 064908, arXiv:1310.1764 [nucl-th].

[31] N. S. Ayvazyan, G. Colucci, D. H. Rischke, and A. Sedrakian, "Rotating hybrid compact stars," *Astronomy and Astrophysics* **559** (2013) A118, arXiv:1308.3053 [astro-ph].

[32] M. Bach, V. Lindenstruth, O. Philipsen, and C. Pinke, "Lattice QCD based on OpenCL," *Computer Physics Communications* **184** (2013) 2042–2052, arXiv:1209.5942 [hep-lat].

[33] A. Bagaria, V. Jaravine, and P. Güntert, "Estimating structure quality trends in the Protein Data Bank by equivalent resolution," *Computational Biology and Chemistry* **46** (2013) 8–15.

[34] D. H. Ballard, D. Kit, C. A. Rothkopf, and B. Sullivan, "A Hierarchical Modular Architecture for Embodied Cognition," *Multisensory Research* **26** (2013) 177–204.

[35] D. Banas, A. Gumberidze, S. Trotsenko, A. V. Volotka, A. Surzhykov, H. F. Beyer, F. Bosch, A. Bräuning-Demian, S. Fritzsche, S. Hagmann, C. Kozhuharov, A. Kumar, X. Ma, R. Mann, P. H. Mokler, D. Sierpowski, U. Spillmann, S. Tashenov, Z. Stachura, A. Warczak, and T. Stöhlker, "Two-photon energy distribution from the decay of the 2^1S_0 state in He-like uranium," *Phys. Rev. A* **A87** (2013) 062510.

[36] F. Becattini, M. Bleicher, T. Kollegger, T. Schuster, J. Steinheimer, and R. Stock, "Hadron Formation in Relativistic Nuclear Collisions and the QCD Phase Diagram," *Phys. Rev. Lett.* **111** (2013) 082302, arXiv:1212.2431 [nucl-th].

[37] F. Becattini, V. Chandra, L. D. Zanna, and E. Grossi, "Relativistic distribution function for particles with spin at local thermodynamical equilibrium," *Ann. Phys. (NY)* **336** (2013) 32–49, arXiv:1303.3431 [nucl-th].

[38] F. Becattini, L. Csernai, and D. J. Wang, "Lambda Polarization in Peripheral Heavy Ion Collisions," *Phys. Rev. C* **88** (2013) 034905, arXiv:1304.4427 [nucl-th].

[39] V. V. Begun, M. Gazdzicki, and M. I. Gorenstein, "Hadron-Resonance Gas at Freeze-out: Reminder on the Importance of Repulsive Interactions," *Phys. Rev. C* **88** (2013) 024902, arXiv:1208.4107 [nucl-th].

[40] V. V. Begun, V. P. Konchakovski, M. I. Gorenstein, and E. L. Bratkovskaya, "Strongly intensive measures for multiplicity fluctuations," *J. Phys. G: Nucl. Part. Phys.* **40** (2013) 045109, arXiv:1205.6809 [nucl-th].

[41] J. Beller, N. Pietralla, J. Barea, M. Elvers, J. Endres, C. Fransen, J. Kotila, O. Möller, A. Richter, T. R. Rodríguez, C. Romig, D. Savran, M. Scheck, L. Schnorrenberger, K. Sonnabend, V. Werner, A. Zilges, and M. Zweidinger, "Constraint on $0\nu\beta\beta$ Matrix Elements from a Novel Decay Channel of the Scissors Mode: The Case of ^{154}Gd," *Phys. Rev. Lett.* **111** (2013) 172501.

[42] S. Bernius, M. Hanauske, B. Dugall, and W. König, "Exploring the effects of a transition to open access: Insights from a simulation study," *Journal of the American Society for Information Science and Technology* **64** (2013) 701–726.

[43] J. Bornschein, M. Henniges, and J. Lücke, "Are V1 Simple Cells Optimized for Visual Occlusions? A Comparative Study," *PLoS Computational Biology* **9** (2013) e1003062.

[44] A. Borschevsky, M. Ilias, V. A. Dzuba, V. V. Flambaum, and P. Schwerdtfeger, "Relativistic study of nuclear-anapole-moment effects in diatomic molecules," *Phys. Rev. A* **88** (2013) 022125.

[45] M. S. Borysova, O. D. Borysov, I. A. Karpenko, V. M. Shapoval, and Y. M. Sinyukov, "Tubular initial conditions and ridge formation," *Advances in High Energy Physics* **2013** (2013) 209182, arXiv:1309.1881 [nucl-th].

[46] P. Bozek, W. Broniowski, and G. Torrieri, "Mass hierarchy in identified particle distributions in proton-lead collisions," *Phys. Rev. Lett.* **111** (2013) 172303, arXiv:1307.5060 [nucl-th].

[47] E. L. Bratkovskaya, J. Aichelin, M. Thomere, S. Vogel, and M. Bleicher, "System size and energy dependence of dilepton production in heavy-ion collisions at 1-2 GeV/nucleon energies," *Phys. Rev. C* **87** (2013) 064907, arXiv:1301.0786 [nucl-th].

[48] L. Buchner, E. Schmidt, and P. Güntert, "Peakmatch: a simple and robust method for peak list matching," *J. of Biomolecular NMR* **55** (2013) 267–277.

[49] K. A. Bugaev, D. R. Oliinychenko, J. Cleymans, A. I. Ivanytskyi, I. N. Mishustin, E. G. Nikonov, and V. V. Sagun, "Chemical Freeze-out of Strange Particles and Possible Root of Strangeness Suppression," *Europhys. Lett.* **104** (2013) 22002, arXiv:1308.3594 [hep-ph].

[50] L. Burigo, I. Pshenichnov, I. Mishustin, and M. Bleicher, "Microdosimetry of radiation field from a therapeutic ^{12}C beam in water: A study with Geant4 toolkit," *Nucl. Inst. Meth. B* **310** (2013) 37–53, arXiv:1211.3648 [physics.med-ph].

[51] N. Buyukcizmeci, A. S. Botvina, I. N. Mishustin, R. Ogul, M. Hempel, J.Schaffner-Bielich, F.-K. Thielemann, S. Furusawa, K. Sumiyoshi, S. Yamada, and H. Suzuki, "A comparative study of statistical models for nuclear equation of state of stellar matter," *Nucl. Phys.* **A907** (2013) 13–54, arXiv:1211.5990 [nucl-th].

[52] N. Buyukcizmeci, A. S. Botvina, J. Pochodzalla, and M. Bleicher, "Mechanisms for production of hypernuclei beyond the neutron and proton drip lines," *Phys. Rev. C* **88** (2013) 014611, arXiv:1307.3652 [nucl-th].

[53] G. Buzsáki, N. Logothetis, and W. Singer, "Scaling Brain Size, Keeping Timing: Evolutionary Preservation of Brain Rhythms," *Neuron* **80** (2013) 751–764.

[54] C. Caesar and others (R3B Collaboration), "Beyond the Neutron Drip-Line: The Unbound Oxygen Isotopes ^{25}O and ^{26}O," *Phys. Rev. C* **88** (2013) 034313, arXiv:1209.0156 [nucl-ex].

[55] G. Cao, L. He, and P. Zhuang, "BCS-BEC quantum phase transition and collective excitations in two-dimensional Fermi gases with p- and d-wave pairings," *Phys. Rev. A* **87** (2013) 013613, arXiv:1211.2470 [cond-mat].

[56] W. Cassing, O. Linnyk, T. Steinert, and V. Ozvenchuk, "Electrical conductivity of hot QCD matter," *Phys. Rev. Lett.* **110** (2013) 182301, arXiv:1302.0906 [hep-ph].

[57] R. Chatterjee, H. Holopainen, I. Helenius, T. Renk, and K. J. Eskola, "Elliptic flow of thermal photons from an event-by-event hydrodynamic model," *Phys. Rev. C* **88** (2013) 034901, arXiv:1305.6443 [hep-ph].

[58] O. Civitarese, P. O. Hess, and D. A. Amor-Quiroz, "Generalized variational procedure: An application to non-perturbative QCD," *Int. J. Mod. Phys. E* **22** (2013) 1350071, arXiv:1302.6020 [hep-th].

[59] C. E. Coleman-Smith, Petersen, and R. L. Wolpert, "Classification of initial state granularity via 2D Fourier expansion," *J. Phys. G: Nucl. Part. Phys.* **40** (2013) 095103.

[60] G. Colucci, A. Sedrakian, and D. H. Rischke, "Leading-order nucleon self-energy in relativistic chiral effective field theory," *Phys. Rev. C* **88** (2013) 015209, arXiv:1303.1270 [nucl-th].

[61] G. O. Deák, J. Triesch, A. Krasno, K. de Barbaro, and M. Robledo, "Learning to share: The emergence of joint attention in human infancy," in *Cognition and brain development: Converging evidence from various methodologies*, B. R. Kar, ed., pp. 173–210. American Psychological Association, Wachington, DC, 2013.

[62] L. D. Zanna, V. Chandra, G. Inghirami, V. Rolando, A. Beraudo, A. D. Pace, G. Pagliara, A. Drago, and F. Becattini, "Relativistic viscous hydrodynamics for heavy-ion collisions with ECHO-QGP," *Eur. Phys. J. C* **73** (2013) 2524, arXiv:1305.7052 [nucl-th].

[63] V. Derya, J. Endres, M. Elvers, M. N. Harakeh, N. Pietralla, C. Romig, D. Savran, M. Scheck, F. Siebenhühner, V. I. Stoica, H. J. Wörtche, and A. Zilges, "Study of the pygmy dipole resonance in ^{94}Mo using the $(\alpha, \alpha'\gamma)$ coincidence technique," *Nucl. Phys.* **A905** (2013) 94–107.

[64] V. Dexheimer, J. Steinheimer, R. Negreiros, and S. Schramm, "Hybrid Stars in an SU(3) Parity Doublet Model," *Phys. Rev. C* **87** (2013) 015804, arXiv:1206.3086 [astro-ph.HE].

[65] G. Diaz, J. Cooper, C. Rothkopf, and M. Hayhoe, "Saccades to future ball location reveal memory-based prediction in a virtual-reality interception task," *Journal of Vision* **13** (2013) 20.

[66] A. Drozdov, A. Grigoriev, and Y. Malyshkin, "Assessment of thunderstorm neutron radiation environment at altitudes of aviation flights," *Journal of Geophysical Research: Space Physics* **118** (2013) 947–955.

[67] A. T. D'yachenko, K. A. Gridnev, and W. Greiner, "Calculation of heavy ion collisions within the framework of the modified hydrodynamic approach," *J. Phys. G: Nucl. Part. Phys.* **40** (2013) 085101.

[68] W. I. Eshraim, S. Janowski, F. Giacosa, and D. H. Rischke, "Decay of the pseudoscalar glueball into scalar and pseudoscalar mesons," *Phys. Rev. D* **87** (2013) 054036, arXiv:1208.6474 [hep-ph].

[69] E. M. L. Fink, A. Schießer, R. Berger, and M. C. Holthausen, "Fragmentation reactions of $Si_2Cl_6^+$ radical dot in the gas phase –A quantum-chemical and mass-spectrometric assessment," *Int. J. Mass Spectrom.* **354-355** (2013) 378–390.

[70] T. Fischer, K. Langanke, and G. Martinez-Pinedo, "Neutrino-pair emission from nuclear de-excitation in core-collapse supernova simulations," *Phys. Rev. C* **88** (2013) 065804, arXiv:1309.4271 [astro-ph].

[71] W. Florkowski, R. Maj, R. Ryblewski, and M. Strickland, "Hydrodynamics of anisotropic quark and gluon fluids," *Phys. Rev. C* **87** (2012) 034914, arXiv:1209.3671 [nucl-th].

[72] W. Florkowski, R. Ryblewski, and M. Strickland, "Anisotropic Hydrodynamics for Rapidly Expanding Systems," *Nucl. Phys. A* **916** (2013) 249–259, arXiv:1304.0665 [nucl-th].

[73] W. Florkowski, R. Ryblewski, and M. Strickland, "Testing viscous and anisotropic hydrodynamics in an exactly solvable case," *Phys. Rev. C* **88** (2013) 024903, arXiv:1305.7234 [nucl-th].

[74] S. E. Folias, S. Yu, A. Snyder, D. Nikolić, and J. E. Rubin, "Synchronisation hubs in the visual cortex may arise from strong rhythmic inhibition during gamma oscillations," *European Journal of Neuroscience* **38** (2013) 2864–2883.

[75] P. Fries, D. Nikolić, and W. Singer, "The gamma cycle," *Trends in Neurosciences* **30** (2013) 309–316.

[76] K. Fukushima and C. Sasaki, "The phase diagram of nuclear and quark matter at high baryon density," *Progress in Particle and Nuclear Physics* **72** (2013) 99–154, arXiv:1301.6377 [hep-ph].

[77] C. Garcia-Recio, J. Nieves, O. Romanets, L. L. Salcedo, and L. Tolos, "Hidden charm N and Δ resonances with heavy-quark symmetry," *Phys. Rev. D* **87** (2013) 074034, arXiv:1302.6938 [hep-ph].

[78] C. Garcia-Recio, J. Nieves, O. Romanets, L. L. Salcedo, and L. Tolos, "Odd parity bottom-flavored baryon resonances," *Phys. Rev. D* **87** (2013) 034032, arXiv:1210.4755 [hep-ph].

[79] M. Gascon, L. Schnorrenberger, B. Pietras, H. Alvarez-Pol, D. Cortina-Gil, P. D. Fernandez, I. Duran, J. Glorius, D. Gonzalez, D. Perez-Loureiro, N. Pietralla, D. Savran, and K. Sonnabend, "Characterization of a CsI(Tl) array coupled to avalanche photodiodes for the Barrel of the CALIFA calorimeter at the NEPTUN tagged gamma beam facility," *Journal of Instrumentation* **8** (2013) P10004.

[80] M. Gazdzicki, M. I. Gorenstein, and M. Mackowiak-Pawlowska, "Normalization of Strongly Intensive Quantities," *Phys. Rev. C* **88** (2013) 024907, arXiv:1303.0871 [nucl-th].

[81] E. Genc, J. Bergmann, W. Singer, and A. Kohler, "Surface Area of Early Visual Cortex Predicts Individual Speed of Traveling Waves During Binocular Rivalry," *Cerebral Cortex* (2013) . Online first.

[82] J. Gerhard, V. Lindenstruth, and M. Bleicher, "Relativistic Hydrodynamics on Graphic Cards," *Computer Physics Communications* **184** (2013) 311–319, arXiv:1206.0919 [hep-ph].

[83] P. M. Goddard, N. Cooper, V. Werner, G. Rusev, P. D. Stevenson, A. Rios, C. Bernards, A. Chakraborty, B. P. Crider, J. H. Kelley, E. Kwan, E. E. P. J. Glorius, N. Pietralla, R. Raut, C. Romig, D. Savran,

L. Schnorrenberger, M. K. Smith, K. Sonnabend, A. P. Tonchev, W. Tornow, and S. W. Yates, "Dipole response of ^{76}Se above 4 MeV," *Phys. Rev. C* **88** (2013) 064308, arXiv:1305.7338 [nucl-ex].

[84] M. Grahl and D. H. Rischke, "Functional renormalization group study of the two-flavor linear sigma model in the presence of the axial anomaly," *Phys. Rev. D* **88** (2013) 056014, arXiv:1307.2184 [hep-th].

[85] M. Grahl, E. Seel, F. Giacosa, and D. H. Rischke, "$O(2)$ model in polar coordinates at nonzero temperature," *Phys. Rev. D* **87** (2013) 096014.

[86] D. K. Gridnev, "Why there is no Efimov effect for four bosons and related results on the finiteness of the discrete spectrum," *Journal of Mathematical Physics* **54** (2012) 042105, arXiv:1210.5147 [math-ph].

[87] D. K. Gridnev, "Universal angular probability distribution of three particles near zero-energy threshold," *J. Phys. A: Math. Theor.* **46** (2013) 115204.

[88] D. K. Gridnev, P. Ojeda, and M. E. Garcia, "Selecting fast-folding proteins by their rate of convergence," *Phys. Rev. E* **87** (2013) 012714, arXiv:1204.0342 [physics.bio-ph].

[89] C. Grützner, M. Wibral, L. M. Sun, D. Rivolta, W. Singer, K. Maurer, and P. J. Uhlhaas, "Deficits in high- ($>$ 60 Hz) gamma-band oscillations during visual processing in schizophrenia," *Frontiers in Human Neuroscience* **7** (2013) 88.

[90] M. Guerra, P. Amaro, C. I. Szabo, A. Gumberidze, P. Indelicato, and J. P. Santos, "Analysis of the charge state distribution in an ECRIS Ar plasma using high-resolution x-ray spectra," *J. Phys. B: At. Mol. Opt. Phys.* **46** (2013) 065701.

[91] A. Gumberidze, D. B. Thorn, C. J. Fontes, B. Najjari, H. L. Zhang, A. Surzhykov, A. Voitkiv, S. Fritzsche, D. Banaś, H. Beyer, W. Chen, R. D. DuBois, S. Geyer, R. E. Grisenti, S. Hagmann, M. Hegewald, S. Hess, C. Kozhuharov, R. Märtin, I. Orban, N. Petridis, R. Reuschl1, A. Simon, U. Spillmann, M. Trassinelli, S. Trotsenko, G. Weber, D. F. A. Winters, N. Winters, D. Yu, and T. Stöhlker, "Electron- and Proton-Impact Excitation of Hydrogenlike Uranium in Relativistic Collisions," *Phys. Rev. Lett.* **110** (2013) 213201.

[92] G. Gürdal, E. A. Stefanova, P. Boutachkov, D. A. Torres, G. J. Kumbartzki, N. Benczer-Koller, Y. Y. Sharon, L. Zamick, S. J. Q. Robinson, T. Ahn, V. Anagnostatou, C. Bernards, M. Elvers, A. Heinz, G. Ilie, D. Radeck, D. Savran, V. Werner, and E. Williams, "Measurements of $g(4_1^+, 2_2^+)$ in ^{70,72,74,76}Ge: Systematics of low-lying structures in $30 \leq Z \leq 40$ and $30 \leq N \leq 50$ nuclei," *Phys. Rev. C* **88** (2013) 014301.

[93] R. Haslinger, G. Pipa, L. Lewis, D. Nikolić, Z. Williams, and E. Brown, "Encoding Through Patterns: Regression Tree-Based Neuronal Population Models," *Neural Computation* **25** (2013) 1953–1993.

[94] M. He, H. van Hees, P. B. Gossiaux, R. J. Fries, and R. Rapp, "Relativistic Langevin Dynamics in Expanding Media," *Phys. Rev. E* **88** (2013) 032138, arXiv:1305.1425 [nucl-th].

[95] L. He, X.-G. Huang, H. Hu, and X.-J. Liu, "BCS-BEC crossover at finite temperature in spin-orbit coupled Fermi gases," *Phys. Rev. A* **87** (2013) 053616, arXiv:1303.4136 [cond-mat].

[96] L. He and X.-G. Huang, "Superfluidity and collective modes in Rashba spin-orbit coupled Fermi gases," *Ann. Phys. (NY)* **337** (2013) 163–207, arXiv:1207.2810 [cond-mat].

[97] L. He, S. Mao, and P. Zhuang, "BCS-BEC crossover in relativistic Fermi systems," *Int. J. Mod. Phys. A* **28** (2013) 1330054, arXiv:1311.6704 [cond-mat].

[98] F. Hefke, R. Schmuck, and P. Güntert, "Prediction of peak overlap in NMR spectra," *Journal of Biomolecular NMR* **56** (2013) 113–123.

[99] M. Hempel, V. Dexheimer, S. Schramm, and I. Iosilevskiy, "Noncongruence of the nuclear liquid-gas and deconfinement phase transitions," *Phys. Rev. C* **88** (2013) 014906, arXiv:1302.2835 [nucl-th].

[100] C. Herold, M. Nahrgang, I. Mishustin, and M. Bleicher, "Chiral fluid dynamics with explicit propagation of the Polyakov loop," *Phys. Rev. C* **87** (2013) 014907, arXiv:1301.1214 [nucl-th].

[101] T. Hirano, P. Huovinen, K. Murase, and Y. Nara, "Integrated dynamical approach to relativistic heavy ion collisions," *Progress in Particle and Nuclear Physics* **70** (2013) 106–158.

[102] D. C. Hochhaus, B. Aurand, M. Basko, B. Ecker, T. Kühl, T. Ma, F. Rosmej, B. Zielbauer, and P. Neumayer, "X-ray radiographic expansion measurements of isochorically heated thin wire targets," *Physics of Plasmas* **20** (2013) 062703.

[103] P. Huovinen, "Hydrodynamics at RHIC and LHC: What have we learned?," *Int. J. Mod. Phys. E* **22** (2013) 1330029, arXiv:1311.1849 [nucl-th].

[104] J. Isaak, D. Savran, M. Krtick, M. Ahmed, J. Beller, E. Fiori, J. Glorius, J. Kelley, B. Löher, N. Pietralla, C. Romig, G. Rusev, M. Scheck, L. Schnorrenberger, J. Silva, K. Sonnabend, A. Tonchev, W. Tornow, H. Weller, and M. Zweidinger, "Constraining nuclear photon strength functions by the decay properties of photo-excited states," *Phys. Lett. B* **727** (2013) 361–365.

[105] M. Isi, J. Mureika, and P. Nicolini, "Self-Completeness and the Generalized Uncertainty Principle," *JHEP* **1311** (2013) 139, arXiv:1310.8153 [hep-th].

[106] I. A. Karpenko, Y. M. Sinyukov, and K. Werner, "Uniform description of bulk observables in the hydrokinetic model of A+A collisions at the BNL Relativistic Heavy Ion Collider and the CERN Large Hadron Collider," *Phys. Rev. C* **87** (2013) 024914, arXiv:1204.5351 [nucl-th].

[107] H. Kempf, H. Hatzikirou, M. Bleicher, and M. Meyer-Hermann, "In Silico Analysis of Cell Cycle Synchronisation Effects in Radiotherapy of Tumour Spheroids," *PLOS Computational Biology* **9** (2013) e1003295.

[108] H. Kogure, Y. Handa, M. Nagata, N. Kanai, P. Güntert, K. Kubota1, and N. Nameki, "Identification of residues required for stalled-ribosome rescue in the codon-independent release factor YaeJ," *Nucleic Acids Research* (2013) . Online first.

[109] A. K. Kohara, E. Ferreira, and T. Kodama, "Amplitudes and observables in pp elastic scattering at $\sqrt{s} = 7$ TeV," *Eur. Phys. J. C* **73** (2013) 2326.

[110] A. V. Korol and A. Solov'yov, "Atomic cluster collisions," *Eur. Phys. J. D* **67** (2013) 1.

[111] T. Lang and M. Bleicher, "Possibility for J/ψ suppression in high multiplicity proton-proton collisions at $\sqrt{s_{NN}} = 7$ TeV," *Phys. Rev. C* **87** (2013) 024907, arXiv:1302.0655 [hep-ph].

[112] K. Langanke, "The Facility for Antiproton and Ion Research: A new era for supernova dynamics and nucleosynthesis," in *Zooming in: The Cosmos at High Resolution*, R. von Berlepsch, ed., Reviews in Modern Astronomy 23, pp. 83–104. Wiley-VCH, 2013.

[113] K. Langanke and G. Martínez-Pinedo, "Pairing in Heated Nuclei in the Shell Model Monte Carlo Approach," in *Fifty Years of Nuclear BCS – Pairing in Finite Systems*, R. A. Broglia and V. Zelevinsky, eds., pp. 154–168. World Scientific, 2013.

[114] A. Larionov, M. Bleicher, A. Gillitzer, and M. Strikman, "Charmonium production in antiproton-nucleus reactions at low energies," *Phys. Rev. C* **87** (2013) 054608, arXiv:1303.0236 [nucl-th].

[115] C. M. Lewis and A. E. Lazar, "Orienting Towards Ensembles: From Single Cells to Neural Populations," *Journal of Neuroscience* **33** (2013) 2.

[116] Q. Li, C. Shen, and M. Bleicher, "System size dependence of the non-monotonous pion freeze-out volume excitation function," *Cent. Eur. J. Phys.* (2013) 1131–1136.

[117] Y.-J. Lin, T. Ikeya, P. Güntert, and L.-S. Chang, "NMR Solution Structure of a Chymotrypsin Inhibitor from the Taiwan Cobra Naja naja atra," *Molecules* **18** (2013) 8906–8918.

[118] O. Linnyk, W. Cassing, J. Manninen, E. L. Bratkovskaya, P. B. Gossiaux, J. Aichelin, T. Song, and C. M. Ko, "Dilepton production in proton-proton and Pb+Pb collisions at $\sqrt{s_{NN}}$ =2.76 TeV," *Phys. Rev. C* **87** (2013) 014905, arXiv:1208.1279 [nucl-th].

[119] O. Linnyk, V. Konchakovski, W. Cassing, and E. L. Bratkovskaya, "Photon elliptic flow in relativistic heavy-ion collisions: hadronic versus partonic sources," *Phys. Rev. C* **88** (2013) 034904, arXiv:1304.7030 [nucl-th].

[120] P. M. Lo, B. Friman, O. Kaczmarek, K. Redlich, and C. Sasaki, "Polyakov loop fluctuations in SU(3) lattice gauge theory and an effective gluon potential," *Phys. Rev. D* **88** (2013) 074502, arXiv:1307.5958 [hep-lat].

[121] P. M. Lo, B. Friman, O. Kaczmarek, K. Redlich, and C. Sasaki, "Probing deconfinement with Polyakov loop susceptibilities," *Phys. Rev. D* **88** (2013) 014506, arXiv:1306.5094 [hep-lat].

[122] B. Löher, V. Derya, T. Aumann, J. Beller, N. Cooper, M. Duchene, J. Endres, E. Fiori, J. Isaak, J. Kelley, M. Knörzer, N. Pietralla, C. Romigh, D. Savran, M. Scheck, H. Scheit, J. Silva, A. Tonchev, W. Tornow, H. Weller, V. Werner, and A. Zilges, "The high-efficiency $\gamma-$-ray spectroscopy setup γ^3 at $HI\gamma S$," *Nucl. Inst. Meth. A* **723** (2013) 136–142.

[123] L. Lonini, C. Dimitrakakis, C. Rothkopf, and J. Triesch, "Generalization and Interference in Human Motor Control," in *Computational and Robotic Models of the Hierarchical Organization of Behavior*, G. Baldassarre and M. Mirolli, eds., Springer Series in Cognitive and Neural Systems, pp. 155–176. Springer, 2013.

[124] L. Lonini, S. Forestier, C. Teulière, Y. Zhao, B. E. Shi, and J. Triesch, "Robust Active Binocular Vision through Intrinsically Motivated Learning," *Front. Neurorobotics* **7** (2013) 20.

[125] S. Lottini and G. Torrieri, "Quarkyonic Percolation and deconfinement at finite density and number of colors," *Phys. Rev. C* **88** (2012) 024912, arXiv:1204.3272 [nucl-th].

[126] D. Maldonado-Mundo, L. He, P. Ohberg, and M. Valiente, "Non-Galilean response of Rashba coupled Fermi gases," *Phys. Rev. A* **88** (2013) 053609, arXiv:1303.2628 [cond-mat.quant-gas].

[127] M. Mannarelli, C. Manuel, and L. Tolos, "Phonon contribution to the shear viscosity of a superfluid Fermi gas in the unitarity limit," *Ann. Phys. (NY)* **336** (2013) 12–35.

[128] C. Manuel, J. Tarrus, and L. Tolos, "Bulk viscosity coefficients due to phonons in superfluid neutron stars," *J. Cosmol. Astropart. Phys.* **7** (2013) 003, arXiv:1302.5447 [astro-ph].

[129] C. Manuel and L. Tolos, "Shear viscosity and the r-mode instability window in superfluid neutron stars," *Phys. Rev. D* **88** (2012) 043001, arXiv:1212.2075 [astro-ph.SR].

[130] R. Marty and J. Aichelin, "Molecular dynamics description of an expanding $q/\bar{q}$ plasma with the Nambu–Jona-Lasinio model and applications to heavy ion collisions at energies available at the BNL Relativistic Heavy Ion Collider and the CERN Large Hadron Collider," *Phys. Rev. C* **87** (2013) 034912, arXiv:1210.3476 [hep-ph].

[131] R. Marty, E. Bratkovskaya, W. Cassing, J. Aichelin, and H. Berrehrah, "Transport coefficients from the Nambu-Jona-Lasinio model for $SU(3)_f$," *Phys. Rev. C* **88** (2013) 045204, arXiv:1305.7180 [hep-ph].

[132] F. Merz, F. Gaunitz, F. Dehghani, C. Renner, J. Meixensberger, A. Gutenberg, A. Giese, K. Schopow, C. Hellwig, M. Schäfer, ManfredBauer, H. Stöcker, G. Taucher-Scholz, M. Durante, and I. Bechmann, "Organotypic slice cultures of human glioblastoma reveal different susceptibilities to treatments," *Neuro-Oncology* **15** (2013) 670–681.

[133] T. Metzinger, "The myth of cognitive agency: subpersonal thinking as a cyclically recurring loss of mental autonomy," *Front. Psychology* **4** (2013) 931.

[134] T. Metzinger, "Why are dreams interesting for philosophers? The example of minimal phenomenal selfhood, plus an agenda for future research," *Front. Psychology* **4** (2013) 746.

[135] F. Michler, H. van Hees, D. D. Dietrich, S. Leupold, and C. Greiner, "Off-equilibrium photon production during the chiral phase transition," *Ann. Phys. (NY)* **336** (2013) 331–393, arXiv:1208.6565 [nucl-th].

[136] G. T. Montelione, M. Nilges, A. Bax, P. Güntert, T. Herrmann, J. S. Richardson, C. D. Schwieters, W. F. Vranken, G. W. Vuister, D. S. Wishart, H. M. Berman, G. J. Kleywegt, and J. L. Markley, "Recommendations of the wwPDB NMR Validation Task Force," *Structure* **21** (2013) 1563–1570.

[137] K. Morita, B. Friman, K. Redlich, and V. Skokov, "Net quark number probability distribution near the chiral crossover transition," *Phys. Rev. C* **88** (2013) 034903, arXiv:1301.2873 [hep-ph].

[138] A. Mroczko-Wasowicz and D. Nikolić, "Colored alphabets in bilingual synesthetes," in *The Oxford Handbook of Synesthesia*, J. Simner and E. M. Hubbard, eds., pp. 165–180. Oxford University Press, 2013.

[139] J. Mureika and P. Nicolini, "Self-completeness and spontaneous dimensional reduction," *Eur. Phys. J. Plus* **128** (2013) 78, arXiv:1206.4696 [hep-th].

[140] X. Na, R. Xu, F. Weber, and R. Negreiros, "On the Transport Properties of a Quark-Hadron Coulomb Lattice in the Cores of Neutron Stars," *Phys. Rev. D* **86** (2013) 123016, arXiv:1208.5022 [astro-ph].

[141] T. Nagata, K. Tsuda, N. Kobayashi, P. Güntert, S. Yokoyama, and Y. Muto, "^{1}H, ^{13}C, and ^{15}N resonance assignments of the dsRBDs of mouse RNA helicase A," *Biomolecular NMR Assignments* **7** (2013) 69–73.

[142] M. Nahrgang, C. Herold, S. Leupold, I. Mishustin, and M. Bleicher, "The impact of dissipation and noise on fluctuations in chiral fluid dynamics," *J. Phys. G: Nucl. Part. Phys.* **40** (2013) 055108.

[143] R. Negreiros, S. Schramm, and F. Weber, "Impact of rotation-driven particle repopulation on the thermal evolution of pulsars," *Phys. Lett. B* **718** (2013) 1176–1180, arXiv:1103.3870 [astro-ph].

[144] P. Neumayer, B. Aurand, R. A. C. Fraga, B. Ecker, R. E. Grisenti, A. Gumberidze, D. C. H. A. Kalinin, M. C. Kaluza, T. K. J. Polz, R. Reuschl, Stöhlker, D. Winters, N. Winters, and Z. Yin, "Evidence for ultra-fast heating in intense-laser irradiated reduced-mass targets," *Physics of Plasmas* **19** (2013) 122708.

[145] P. Nicolini, A. Orlandi, and E. Spallucci, "The Final Stage of Gravitationally Collapsed Thick Matter Layers," *Advances in High Energy Physics* **2013** (2013) 812084.

[146] H. Niemi, G. S. Denicol, H. Holopainen, and P. Huovinen, "Event-by-event distributions of azimuthal asymmetries in ultrarelativistic heavy-ion collisions," *Phys. Rev. C* **87** (2013) 054901, arXiv:1212.1008 [nucl-th].

[147] D. Nikolić, P. Fries, and W. Singer, "Gamma oscillations: precise temporal coordination without a metronome," *Trends in Cognitive Sciences* **17** (2013) 54–55.

[148] J. Orts, B. Vögeli, R. Riek, and P. Güntert, "Stereospecific assignments in proteins using exact NOEs," *J. of Biomolecular NMR* **57** (2013) 211–218.

[149] V. Ozvenchuk, O. Linnyk, M. I. Gorenstein, E. L. Bratkovskaya, and W. Cassing, "Shear and bulk viscosities of strongly-interacting 'infinite' parton-hadron matter within the Parton-Hadron-String (PHSD) transport approach," *Phys. Rev. C* **87** (2013) 064903, arXiv:1212.5393 [hep-ph].

[150] V. Ozvenchuk, O. Linnyk, M. I. Gorenstein, E. L. Bratkovskaya, and W. Cassing, "Dynamical equilibration of strongly-interacting 'infinite' parton matter within the Parton-Hadron-String Dynamics transport approach," *Phys. Rev. C* **C87** (2013) 024901, arXiv:1203.4734 [nucl-th].

[151] R. Paatelainen, K. J. Eskola, H. Holopainen, and K. Tuominen, "Multiplicities and p_T spectra in ultrarelativistic heavy ion collisions from a next-to-leading order improved perturbative QCD plus saturation plus hydrodynamics model," *Phys. Rev. C* **87** (2013) 044904, arXiv:1211.0461 [hep-ph].

[152] W.-G. Paeng, H. K. Lee, M. Rho, and C. Sasaki, "Interplay between ω-Nucleon Interaction and Nucleon Mass in Dense Baryonic Matter," *Phys. Rev. D* **88** (2013) 105019, arXiv:1303.2898 [nucl-th].

[153] S. Pal and W. Greiner, "Production of antinuclei and hypernuclei in a relativistic Hagedorn resonance gas model," *Phys. Rev. C* **87** (2013) 054905.

[154] Y. M. Palenzuela, L. F. Ruiz, A. Karpov, and W. Greiner, "Systematic study of decay properties of heaviest elements," *Bulletin of the Russian Academy of Sciences: Physics* **76** (2013) 1165–1171.

[155] D. Pamplona, J. Triesch, and C. Rothkopf, "Power spectra of the natural input to the visual system," *Vision Research* **83** (2013) 66–75.

[156] J. Pang, J. Wang, and L. He, "Pairing fluctuation effects in a strongly coupled color superfluid/superconductor," *Phys. Rev. D* **88** (2013) 054017, arXiv:1211.1225 [nucl-th].

[157] D. Parganlija, P. Kovacs, G. Wolf, F. Giacosa, and D. H. Rischke, "Meson vacuum phenomenology in a three-flavor linear sigma model with (axial-)vector mesons," *Phys. Rev. D* **87** (2013) 014011, arXiv:1208.0585 [hep-ph].

[158] H. Petersen and B. Müller, "Possibility of event shape selection in relativistic heavy ion collisions," *Phys. Rev. C* **88** (2013) 044918, arXiv:1305.2735 [nucl-th].

[159] W. A. Phillips, "The Coordination of Probabilistic Inference in Neural Systems," in *Computing Nature*, G. Dodig-Crnkovic and R. Giovagnoli, eds., vol. 7 of *Studies in Applied Philosophy, Epistemology and Rational Ethics*, pp. 61–70. Springer, 2013.

[160] W. A. Phillips, "Neuronal inference must be local, selective, and coordinated," *Behavioral and Brain Sciences* **36** (2013) 222–223.

[161] W. A. Phillips and S. M. Silverstein, "The coherent organization of mental life depends on mechanisms for context-sensitive gain-control that are impaired in schizophrenia," *Front. Psychology* **4** (2013) 307.

[162] D. N. Poenaru, R. A. Gherghescu, and W. Greiner, "Alpha- Cluster- and Fission Decay of Superheavy Nuclei," *Romanian Journal of Physics* **58** (2013) 1157–1166.

[163] D. N. Poenaru, R. A. Gherghescu, and W. Greiner, "Nuclear inertia and the decay modes of superheavy nuclei," *J. Phys. G: Nucl. Part. Phys.* **40** (2013) 105105.

[164] S. xue Qin and D. H. Rischke, "Quark spectral function and deconfinement at nonzero temperature," *Phys. Rev. D* **88** (2013) 056007, arXiv:1304.6547 [nucl-th].

[165] A. Ramos, L. Tolos, R. Molina, and E. Oset, "The width of the omega meson in the nuclear medium," *Eur. Phys. J. A* **49** (2013) 148, arXiv:1306.5921 [nucl-th].

[166] P. Rau, J. Steinheimer, S. Schramm, and H. Stöcker, "Chiral Hadronic Mean Field Model including Quark Degrees of Freedom," *J. Phys. G: Nucl. Part. Phys.* **40** (2013) 085001, arXiv:1302.3836 [hep-ph].

[167] C. Romig, J. Beller, J. Glorius, J. Isaak, J. H. Kelley, E. Kwan, N. Pietralla, V. Y. Ponomarev, A. Sauerwein, D. Savran, M. Scheck, L. Schnorrenberger, K. Sonnabend, A. P. Tonchev, W. Tornow, H. R. Weller, A. Zilges, and M. Zweidinger, "Low-lying dipole strength of the open-shell nucleus Mo-94," *Phys. Rev. C* **2013** (2013) 044331.

[168] D. M. Rossi *et al.*, "Measurement of the Dipole Polarizability of the Unstable Neutron-Rich Nucleus Ni-68," *Phys. Rev. Lett.* **111** (2013) 242503.

[169] S. Rothe, A. N. Andreyev, S. Antalic, A. Borschevsky, L. Capponi, T. E. Cocolios, H. D. Witte, E. Eliav, D. V. Fedorov, V. N. Fedosseev, D. A. Fink, S. Fritzsche, L. Ghys, M. Huyse, N. Imai, U. Kaldor, Y. Kudryavtsev, U. Köster, J. F. W. Lane, J. Lassen, V. Liberati, K. M. Lynch, B. A. Marsh, K. Nishio, D. Pauwels, V. Pershina, L. Popescu, T. J. Procter, D. Radulov, S. Raeder, M. M. Rajabali, E. Rapisarda, R. E. Rossel, K. Sandhu, M. D. Seliverstov, A. M. Sjödin, P. V. den Bergh, P. V. Duppen, M. Venhart, Y. Wakabayashi, and K. D. A. Wendt, "Measurement of the first ionization potential of astatine by laser ionization spectroscopy," *Nature Communications* **4** (2013) 1835.

[170] N. Rothen, D. Nikolić, U. M. Jürgens, A. Mroczko-Wasowicz, J. Cock, and B. Meier, "Psychophysiological evidence for the genuineness of swimming-style colour synaesthesia," *Consciousness and Cognition* **22** (2013) 35–46.

[171] C. A. Rothkopf and D. H. Ballard, "Learning and Coordinating Repertoires of Behaviors with Common Reward: Credit Assignment and Module Activation," in *Computational and Robotic Models of the Hierarchical Organization of Behavior*, G. Baldassarre and M. Mirolli, eds., Springer Series in Cognitive and Neural Systems, pp. 99–125. Springer, 2013.

[172] C. A. Rothkopf and D. H. Ballard, "Modular inverse reinforcement learning for visuomotor behavior," *Biological Cybernetics* **107** (2013) 477–490.

[173] F. Roux, M. Wibral, W. Singer, J. Aru, and P. J. Uhlhaas, "The Phase of Thalamic Alpha Activity Modulates Cortical Gamma-Band Activity: Evidence from Resting-State MEG Recordings," *Journal of Neuroscience* **33** (2013) 17827–17835.

[174] B. Sancristóbal, R. Vicente, J. M. Sancho, and J. Garcia-Ojalvo, "Emergent bimodal firing patterns implement different encoding strategies during gamma-band oscillations," *Front. Comput. Neurosci.* **7** (2013) 18.

[175] L. M. Satarov, I. N. Mishustin, and W. Greiner, "Evolution of antibaryon abundances in the early universe and in heavy-ion collisions," *Phys. Rev. C* **88** (2013) 024908, arXiv:1305.4046 [hep-ph].

[176] Y. D. Sato, "Frequency Gradient with Respect to Temperature for Determination of Classification of the Phase Response Curve," *Chinese Physics Letters* **30** (2013) 128201.

[177] Y. Sato, "Transition frequencies in the neuronal oscillator," *Europhys. Lett.* **102** (2013) 58004.

[178] Y. Sato, "An Optimal Power-Law of Synchrony and Lognormally Synaptic Weighted Hub Network," *Chinese Physics Letters* **30** (2013) 098701.

[179] Y. D. Sato and Y. Kuriya, "Multi scale elastic graph matching for face detection," *EURASIP Journal on Advances in Signal Processing* **2013** (2013) 175.

[180] D. Savran, T. Aumann, and A. Zilges, "Experimental studies of the Pygmy Dipole Resonance," *Progress in Particle and Nuclear Physics* **70** (2013) 210–245.

[181] E. Schmidt, J. Gath, B. Habenstein, F. Ravotti, K. S. M. Huber, L. Buchner, A. Böckmann, B. H. Meier, and P. Güntert, "Automated solid-state NMR resonance assignment of protein microcrystals and amyloids," *Journal of Biomolecular NMR* **56** (2013) 243–254.

[182] E. Schmidt and P. Güntert, "Reliability of exclusively NOESY-based automated resonance assignment and structure determination of proteins," *J. of Biomolecular NMR* **57** (2013) 193–204.

[183] L. Schnorrenberger, D. Savran, J. Glorius, K. Lindenberg, B. Löher, N. Pietralla, and K. Sonnabend, "Characterization of γ-ray detectors using the photon tagger NEPTUN for energies up to 20 MeV," *Nucl. Inst. Meth. A* **735** (2014) 19–23.

[184] T. Schönenbach, G. Caspar, P. O. Hess, T. Boller, A. Müller, M. Schäfer, and W. Greiner, "Experimental tests of pseudo-complex General Relativity," *Mon. Not. R. Astron. Soc.* **430** (2013) 2999–3009, arXiv:1209.2815 [gr-qc].

[185] L. Scocchia, G. M. Cicchini, and J. Triesch, "What's "up"? Working memory contents can bias orientation processing," *Vision Research* **78** (2013) 46–55.

[186] L. Scocchia, M. Valsecchi, K. R. Gegenfurtner, and J. Triesch, "Visual Working Memory Contents Bias Ambiguous Structure from Motion Perception," *PLOS ONE* **8** (2013) e59217.

[187] V. M. Shapoval, P. Braun-Munzinger, I. A. Karpenko, and Y. M. Sinyukov, "Femtoscopic scales in $p+p$ and $p+Pb$ collisions in view of the uncertainty principle," *Phys. Lett. B* **725** (2013) 139–147, arXiv:1304.3815 [hep-ph].

[188] V. M. Shapoval, Y. M. Sinyukov, and I. A. Karpenko, "Emission source functions in heavy ion collisions," *Phys. Rev. C* **88** (2013) 064904, arXiv:1308.6272 [hep-ph].

[189] W. Singer, "Cortical dynamics revisited," *Trends in Cognitive Sciences* **17** (2013) 616–626.

[190] Y. M. Sinyukov, S. V. Akkelin, I. A. Karpenko, and V. M. Shapoval, "Femtoscopic and Nonfemtoscopic Two-Particle Correlations in A plus A and p plus p Collisions at RHIC and LHC Energies," *Advances in High Energy Physics* **2013** (2013) 198928.

[191] I. A. Solov'yov, A. V. Solov'yov, N. Kébaili, A. Masson, and C. Bréchignac, "Thermally induced morphological transition of silver fractals," *physica status solidi (b)* (2013) . Online first.

[192] J. Steinheimer, J. Aichelin, and M. Bleicher, "Nonthermal p/π ratio at LHC as a consequence of hadronic final state interactions," *Phys. Rev. Lett.* **110** (2013) 042501, arXiv:1203.5302 [nucl-th].

[193] H. Stöcker and C. Sturm, "FAIR – The Facility for Antiproton and Ion Research," *Romanian Journal of Physics* **58** (2013) 1023–1030.

[194] L. Sun, N. Castellanos, C. G. D. Koethe, D. Rivolta, M. Wibral, L. Kranaster, W. Singer, M. F. Lewekee, and P. J. Uhlhaas, "Evidence for dysregulated high-frequency oscillations during sensory processing in medication-naive, first episode schizophrenia," *Schizophrenia Research* **150** (2013) 519–525.

[195] E. Surdutovich and A. V. Solov'yov, "Multiscale physics of ion-induced radiation damage," *Applied Radiation and Isotopes* (2013) . Online first.

[196] E. Surdutovich, A. V. Yakubovich, and A. V. Solov'yov, "Biodamage via shock waves initiated by irradiation with ions," *Scientific Reports* **3** (2013) 1289.

[197] G. B. Sushko, V. G. Bezchastnov, I. A. Solov'yov, A. V. Korol, W. Greiner, and A. V. Solov'yov, "Simulation of Ultra-Relativistic Electrons and Positrons Channeling in Crystals with MBN Explorer," *Journal of Computational Physics* **252** (2013) 404–418, arXiv:1307.6771 [physics.acc-ph].

[198] V. N. Tarasov, K. A. G. D. K. Gridnev, D. V. Tarasov, S. Schramm, X. Vinñas, and W. Greiner, "Stability peninsulas on the neutron drip line," *Int. J. Mod. Phys. E* **22** (2013) 1350009.

[199] S. Tikole, V. Jaravine, V. Y. Orekhov, and P. Güntert, "Effects of NMR Spectral Resolution on Protein Structure Calculation," *PLOS ONE* **8** (2013) e68567.

[200] L. Tolos, "Charming mesons with baryons and nuclei," *Int. J. Mod. Phys. E* **22** (2013) 1330027, arXiv:1309.7305 [nucl-th].

[201] L. Tolos and J. M. Torres-Rincon, "D-meson propagation in hot dense matter," *Phys. Rev. D* **88** (2013) 074019, arXiv:1306.5426 [hep-ph].

[202] G. Torrieri, S. Vogel, and B. Baeuchle, "Photon Signals from Quarkyonic Matter," *Phys. Rev. Lett.* **111** (2013) 012301, arXiv:1302.1119 [nucl-th].

[203] J. Triesch, "Imitation Learning Based on an Intrinsic Motivation Mechanism for Efficient Coding," *Front. Psychology* **4** (2013) 800.

[204] P. J. Uhlhaas, F. Roux, and W. Singer, "Thalamocortical Synchronization and Cognition: Implications for Schizophrenia?," *Neuron* **77** (2013) 997–999.

[205] P. J. Uhlhaas and W. Singer, "High-frequency oscillations and the neurobiology of schizophrenia," *Dialogues in Clinical Neuroscience* **15** (2013) 301–313.

[206] D. Varentsov, A. Bogdanov, V. Demidov, A. A. Golubev, A. Kantsyrev, P. M. Lang, D. N. Nikolaev, N. Markov, F. Natale, L. Shestov, P. Simoniello, G. Smirnov, and M. Durante, "First biological images with high-energy proton microscopy," *Physica Medica* **29** (2013) 208–213.

[207] P. de Vera, R. Garcia-Molina, I. Abril, and A. V. Solov'yov, "Semiempirical Model for the Ion Impact Ionization of Complex Biological Media," *Phys. Rev. Lett.* **110** (2013) 148104.

[208] A. V. Verkhovtsev, M. Hanauske, A. V. Yakubovich, and A. V. Solov'yov, "Characterization of small pure and Ni-doped titanium clusters: Ab initio versus classical approaches," *Computational Materials Science* **76** (2013) 80–88.

[209] A. V. Verkhovtsev, G. B. Sushko, A. V. Yakubovich, and A. V. Solov'yov, "Benchmarking of classical force fields by ab initio calculations of atomic clusters: Ti and Ni-Ti case," *Computational and Theoretical Chemistry* **1021** (2013) 101–106.

[210] A. V. Verkhovtsev, A. V. Yakubovich, G. B. Sushko, M. Hanauske, and A. V. Solov'ov, "Molecular dynamics simulations of the nanoindentation process of titanium crystal," *Computational Materials Science* **76** (2013) 20–26.

[211] B. Vögeli, P. Güntert, and R. Riek, "Multiple-state ensemble structure determination from eNOE spectroscopy," *Molecular Physics* **111** (2013) 437–454.

[212] C. Wälzlein, M. Durante, E. Scifoni, and M. Krämer, "Advancing the modeling in particle therapy: from track structure to treatment planning," *Applied Radiation and Isotopes* (2013) . Online first.

[213] Q. Wang, J. Bolhuis, C. Rothkopf, T. Kolling, M. Knopf5, and J. Triesch, "Infants in Control – Rapid Learning of Action Outcomes by 6 and 8-Month-Olds in a Gaze-Contingent Paradigm," *Journal of Vision* **13** (2013) 922.

[214] S. Weigelt, W. Singer, and A. Kohler, "Feature-Based Attention Affects Direction-Selective fMRI Adaptation in hMT," *Cerebral Cortex* **23** (2013) 2169–2178.

[215] K. Werner, I. Karpenko, T. Pierog, M. Bleicher, and K. Mikhailov, "Femtoscopy within a hydrodynamic approach based on flux tube initial conditions," *Physics of Particles and Nuclei Letters* **9** (2013) 244–247.

[216] M. Wibral, N. Pampu, V. Priesemann, F. Siebenhühner, H. Seiwert, M. Lindner, J. T. Lizier, and R. Vicente, "Measuring Information-Transfer Delays," *PLOS ONE* **8** (2013) e55809.

[217] R. Wirth, E. Fiori, B. Löher, D. Savran, J. Silva, H. A. Pol, D. C. Gil, B. Pietras, T. Bloch, T. Kröll, E. Nácher, A. Perea, O. Tengblad, M. Bendel, M. Dierigl, R. Gernhäuser, T. L. Bleis, and M. Winkel, "Particle identification using clustering algorithms," *Nucl. Inst. Meth. A* **717** (2013) 77–82.

[218] T. Xia, L. He, and P. Zhuang, "Three-flavor Nambu–Jona-Lasinio model at finite isospin chemical potential," *Phys. Rev. D* **88** (2013) 056013, arXiv:1307.4622 [hep-ph].

[219] A. V. Yakubovich, G. Sushko, S. Schramm, and A. V. Solov'yov, "Kinetics of liquid-solid phase transition in large nickel clusters," *Phys. Rev. B* **88** (2013) 035438, arXiv:1210.3559 [physics.atm-clus].

[220] A. V. Yakubovich, A. V. Verkhovtsev, M. Hanauske, and A. V. Solov'yov, "Computer simulation of diffusion process at interfaces of nickel and titanium crystals," *Computational Materials Science* **76** (2013) 60–64.

[221] H. Yépe-Martínez, G. Morales-Hernández, P. O. Hess, G. Lévai, and P. R. Fraser, "Renormalization of coherent state variables, within the geometric mapping of algebraic models," *Int. J. Mod. Phys. E* **22** (2013) 1350022, arXiv:1212.0345 [nucl-th].

[222] V. I. Zagrebaev and W. Greiner, "Production of heavy trans-target nuclei in multinucleon transfer reactions," *Phys. Rev. C* **87** (2013) 034608.

[223] P. Zheng, "Threshold Complex-Valued Neural Associative Memory," *IEEE Transactions on Neural Networks and Learning Systems* **99** (2013) .

[224] P. Zheng, C. Dimitrakakis, and J. Triesch, "Network Self-Organization Explains the Statistics and Dynamics of Synaptic Connection Strengths in Cortex," *PLoS Comput. Biol.* **9(1)** (2013) e1002848.

[225] Q. Zhi, E. Caurier, J. J. Cuenca-García, K. Langanke, G. Martínez-Pinedo, and K. Sieja, "Shell-model half-lives including first-forbidden contributions for r-process waiting-point nuclei," *Phys. Rev. C* **87** (2013) 025803, arXiv:1301.5225 [nucl-th].

[226] B. Abelev and others (ALICE collaboration), "Multiplicity dependence of the average transverse momentum in pp, p-Pb, and Pb-Pb collisions at the LHC," *Phys. Lett. B* **727** (2013) 371–380, arXiv:1307.1094 [nucl-ex].

B. Conference reports and preprints

[1] B. Abelev and others (ALICE collaboration), "Centrality, rapidity and transverse momentum dependence of J/Ψ suppression in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV." 2013. arXiv:1311.0214 [nucl-ex].

[2] B. Abelev and others (ALICE collaboration), "J/Ψ production and nuclear effects in p-Pb collisions at $\sqrt{s_{NN}} = 5.02$TeV." 2013. arXiv:1308.6726 [nucl-ex].

[3] B. Abelev and others (ALICE collaboration), "Measurement of charged jet suppression in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV." 2013. arXiv:1311.0633 [nucl-ex].

[4] B. Abelev and others (ALICE collaboration), "Multiplicity Dependence of Pion, Kaon, Proton and Lambda Production in p-Pb Collisions at $\sqrt{s_{NN}} = 5.02$ TeV." 2013. arXiv:1307.6796 [nucl-ex].

[5] B. Abelev and others (ALICE collaboration), "Multi-strange baryon production at mid-rapidity in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV." 2013. arXiv:1307.5543 [nucl-ex].

[6] B. Abelev and others (ALICE collaboration), "Two and Three-Pion Quantum Statistics Correlations in Pb-Pb Collisions at $\sqrt{s_{NN}} = 2.76$ TeV at the LHC." 2013. arXiv:1310.7808 [nucl-ex].

[7] L. Adamczyk and others (STAR collaboration), "Dielectron Mass Spectra from Au+Au Collisions at $\sqrt{s_{NN}} = 200$ GeV." 2013. arXiv:1312.7397 [hep-ex].

[8] L. Adamczyk and others (STAR collaboration), "Energy Dependence of Moments of Net-proton Multiplicity Distributions at RHIC." 2013. arXiv:1309.5681 [nucl-ex].

[9] L. Adamczyk and others (STAR collaboration), "J/ψ polarization in p+p collisions at $\sqrt{s}$ =200 GeV in STAR." 2013. arXiv:1311.1621 [nucl-ex].

[10] L. Adamczyk and others (STAR collaboration), "J/ψ production at low p_T in Au+Au and Cu+Cu collisions at $\sqrt{s_{NN}} = 200$ GeV at STAR." 2013. arXiv:1310.3563 [nucl-ex].

[11] L. Adamczyk and others (STAR collaboration), "Neutral pion cross section and spin asymmetries at intermediate pseudorapidity in polarized proton collisions at $\sqrt{s}$ =200 GeV." 2013. arXiv:1309.1800 [nucl-ex].

[12] L. Adamczyk and others (STAR collaboration), "Suppression of Upsilon Production in d+Au and Au+Au Collisions $\sqrt{s_{NN}} = 200$ GeV." 2013. arXiv:1312.3675 [nucl-ex].

[13] A. Adare, M. Luzum, and H. Petersen, "Initial state fluctuations and final state correlations: Status and open questions," in *ECT∗ Workshop Initial State Fluctuations and Final State Correlations*, Trento, Italy, 2 - 6 July 2012, vol. 87 of *Physica Scripta*, p. 048001. 2013. arXiv:1212.5388 [nucl-th].

[14] V. Akishina and I. Kisel, "J/Ψ reconstruction in the di-muon decay channel with the CBM experiment for p+Au collisions at 30 GeV laboratory beam energy," in *FAIRNESS 2012: FAIR NExt Generation of ScientistS*, Hersonissos, Greece, 3 - 8 Sept. 2012, vol. 426 of *J. Phys. Conf. Ser.*, p. 012024. 2013.

[15] P. Amaro, S. Schlesser, M. Guerra, E. L. Bigot, J. P. Santos, C. I. Szabo, A. Gumberidze, and P. Indelicato, "Absolute measurements and simulations of x-ray line energies of highly charged ions with a double-crystal spectrometer," in *16th International Conference on the Physics of Highly Charged Ions (HCI2012)*, Heidelberg, 2-7 Sept. 2012, vol. T156 of *Physica Scripta*, p. 014104. 2013.

[16] G. B. Andresen, A. A. Søndergaard, R. A. Rodriguez, S. Becker, and M. Greiner, "Weather-Driven Modeling of Future Renewable Power Systems," in *8th Conference on Sustainable Development of Energy, Water and Environment Systems (SDEWES)*, Dubrovnik, Croatia, 22 - 27 Sept. 2013. 2013.

[17] A. Andronic, P. Braun-Munzinger, K. Redlich, and J. Stachel, "The statistical model in Pb-Pb collisions at the LHC," in *Quark Matter 2012 International Conference*, Washington DC, USA, 13 - 18 August 2012, vol. 904–905 of *Nucl. Phys. A*, pp. 535c–538c. 2013. arXiv:1210.7724 [nucl-th].

[18] M. Attems, A. Rebhan, and M. Strickland, "The chromo-Weibel instability in an expanding background," in *International Symposium on Multiparticle Dynamics (ISMD2012)*, Kielce, Poland, 17 - 21 Sept. 2012, vol. 6 of *Acta Phys. Polon. B Proc. Suppl.*, pp. 393–402. 2013. arXiv:1302.5098 [hep-ph].

[19] M. Attems, A. Rebhan, and M. Strickland, "Longitudinal thermalization via the chromo-Weibel instability," in *10th Conference on Quark Confinement and the Hadron Spectrum (Confinement X)*, Munich, Germany, 8 - 12 October 2012, vol. ConfinementX (2012) of *Proceedings of Science*, p. 176. 2013. arXiv:1301.7749 [hep-ph].

[20] J. Auvinen and H. Petersen, "Collision Energy Evolution of Elliptic and Triangular Flow in a Hybrid Model," in *8th International Workshop on Critical Point and Onset of Deconfinement (CPOD 2013)*, Napa, CA, USA, 11 - 15 March 2013, vol. PoS(CPOD 2013) of *Proceedings of Science*, p. 034. 2013. arXiv:1310.7751 [nucl-th].

[21] J. Auvinen and H. Petersen, "Evolution of elliptic and triangular flow as a function of beam energy in a hybrid model," in *FAIRNESS 2013: Workshop for young scientists with research interests focused on physics at FAIR*, Berlin, Germany, 15 - 21 Sept. 2013. 2013. arXiv:1301.5225 [nucl-th].

[22] M. Bach, J. de Cuveland, H. Ebermann, D. Eschweiler, J. Gerhard, S. Kalcher, M. Kretz, V. Lindenstruth, H. Lüdde, M. Pollok, and D. Rohr, "A Comprehensive Approach for a Power Efficient General Purpose Supercomputer," in *21st Euromicro International Conference on Parallel, Distributed and Network-Based Processing*, Belfast, UK, 27 Feb. - 1 March 2013, pp. 336–342. 2013.

[23] D. Banaś, M. Pajek, A. Gumberidze, A. Surzhykov, and T. Stöhlker, "Differential L-shell radiative recombination rate coefficients for bare uranium ions interacting with low-energy electrons," in *7th workshop on Atomic and Molecular Physics*, Jurata, Poland, 10 - 14 Sept. 2012, vol. 222 of *Eur. Phys. J. Special Topics*, pp. 2317–2322. 2013.

[24] D. Banaś, M. Pajek, A. Gumberidze, A. Surzhykov, and T. Stöhlker, "K-shell differential radiative recombination rates for bare uranium ions interacting with low-energy electrons," in *16th International Conference on the Physics of Highly Charged Ions (HCI2012)*, Heidelberg, 2-7 Sept. 2012, vol. T156 of *Physica Scripta*, p. 014045. 2013.

[25] F. Bauer and R. Memisevic, "Feature grouping from spatially constrained multiplicative interaction," in *International Conference on Learning Representations 2013*, Scottsdale, AZ, USA, 2-4 May 2013. 2013. arXiv:1301.3391 [cs.LG].

[26] F. Becattini, M. Bleicher, J. Steinheimer, and R. Stock, "Hadronization, Chemical Equilibrium and Chemical Freeze-Out," in *8th International Workshop on Critical Point and Onset of Deconfinement (CPOD 2013)*, Napa, CA, USA, 11 - 15 March 2013, vol. CPOD2013 of *Proceedings of Science*, p. 010. 2013.

[27] S. Becker, R. Rodriguez, G. B. Andresen, M. Greiner, and S. Schramm, "Potential of Electricity Transmission for Sharing Renewables Across Europe," in *8th Conference on Sustainable Development of Energy, Water and Environment Systems (SDEWES)*, Dubrovnik, Croatia, 22 - 27 Sept. 2013. 2013.

[28] S. Becker, R. A. Rodriguez, G. B. Andresen, S. Schramm, and M. Greiner, "Transmission grid extensions during the build-up of a fully renewable pan-European electricity supply." 2013. arXiv:1307.1723 [physics.soc-ph].

[29] H. Berrehrah, E. Bratkovskaya, W. Cassing, P. B. Gossiaux, J. Aichelin, and M. Bleicher, "Collisional processes of on-shell and off-shell heavy quarks in vacuum and in the Quark-Gluon-Plasma." 2013. arXiv:1308.5148 [hep-ph].

[30] H. Berrehrah, E. Bratkovskaya, W. Cassing, P. B. Gossiaux, and J. Aichelin, "Towards the dynamical study of heavy-flavor quarks in the Quark-Gluon-Plasma," in *Strangeness in Quark Matter SQM2013*, Birmingham, UK, 22 - 27 July 2013. 2013. arXiv:1311.0736 [hep-ph].

[31] J. J. Bjerrum-Bohr, I. N. Mishustin, and T. Døssing, "Hydrodynamics of a quark droplet II: Implications of a non-zero baryon chemical potential." 2013. arXiv:1310.2818 [nucl-th].

[32] M. Bleicher and G. Graef, "Recent HBT Results from a Hybrid Transport Approach to Heavy Ion Reactions," in *International Symposium on 'Exciting Physics'*, Makutsi, South Africa, 13 - 20 Nov. 2011, FIAS Interdisciplinary Science Series, pp. 237–242. Springer, 2013.

[33] M. Bleicher and C. Herold, "Fluid dynamics near the QCD critical point," in *10th Conference on Quark Confinement and the Hadron Spectrum (Confinement X)*, Munich, Germany, 8 - 12 October 2012, vol. ConfinementX (2012) of *Proceedings of Science*, p. 217. 2013. arXiv:1301.3686 [nucl-th].

[34] P. Bozek, W. Broniowski, and G. Torrieri, "Hydrodynamic models of particle production," in *Strangeness in Quark Matter SQM2013*, Birmingham, UK, 22 - 27 July 2013. 2013. arXiv:1309.7782 [nucl-th].

[35] E. Bratkovskaya, W. Cassing, J. Aichelin, C. Hartnack, Y. Leifels, H. Oeschler, and L. Tolos, "In-medium effects on strangeness production," in *XI International Conference on Hypernuclear and Strange Particle Physics (HYP2012)*, Barcelona, Spain, 1 - 5 Oct. 2012, vol. 914, pp. 387–391. 2013.

[36] E. L.Bratkovskaya, W. Cassing, V. P. Konchakovski, O. Linnyk, V. Ozvenchuk, V. D. Toneev, and V. Voronyuk, "The QGP dynamics in relativistic heavy-ion collisions," in *Workshop on Discovery Physics at the LHC (Kruger 2012)*, Kruger National Park, Mpumalanga, South Africa, 3 - 9 Dec. 2012, vol. 455 of *J. Phys: Conf. Ser.*, p. 012048. 2013. arXiv:1304.4115 [nucl-th].

[37] E. L. Bratkovskaya, V. P. Konchakovski, O. Linnyk, W. Cassing, V. Voronyuk, and V. D. Toneev, "The QGP phase in relativistic heavy-ion collisions," in *International Symposium on 'Exciting Physics'*, Makutsi, South Africa, 13 - 20 Nov. 2011, FIAS Interdisciplinary Science Series, pp. 225–235. Springer, 2013.

[38] E. L. Bratkovskaya, V. Ozvenchuk, W. Cassing, V. P. Konchakovski, O. Linnyk, R. Marty, and H. Berrehrah, "Parton-hadron dynamics in heavy-ion collisions," in *2nd Caribbean Symposium on Cosmology, Graviation, Nucler and Astroparticle Physics (STARS2013)*, Havana, Cuba, 4 - 10 May 2013. 2013. arXiv:1312.7578 [nucl-th].

[39] E. L. Bratkovskaya, V. Ozvenchuk, W. Cassing, V. P. Konchakovski, and O. Linnyk, "Parton-hadron matter in- and out-off equilibrium," in *29th Winter Workshop on Nuclear Dynamics (WWND 2013)*, Squaw Valley CA, USA, 3 - 10 Feb. 2013, vol. 458 of *J. Phys.: Conf. Ser.*, p. 012019. 2013. arXiv:1304.7154 [nucl-th].

[40] K. A. Bugaev, A. I. Ivanytskyi, D. R. Oliinychenko, E. G. Nikonov, V. V. Sagun, and G. M. Zinovjev, "Non-smooth Chemical Freeze-out and Apparent Width of Wide Resonances and Quark Gluon Bags in a Thermal Environment." 2013. arXiv:1312.4367 [nucl-th].

[41] K. A. Bugaev, D. R. Oliinychenko, V. V. Sagun, A. I. Ivanytskyi, J. Cleymans, E. G. Nikonov, and G. M. Zinovjev, "Chemical freeze-outs of strange and non-strange particles and residual chemical non-equilibrium." 2014. arXiv:1312.5149 [hep-ph].

[42] T. Burch and G. Torrieri, "Quantum ideal hydrodynamics on the lattice," in *31st international symposium on Lattice Field Theory (Lattice 2013)*, Mainz, Germany, 29 July - 3 Aug. 2013. 2013. arXiv:1311.3333 [hep-lat].

[43] L. Burigo, I. Pshenichnov, I. Mishustin, and M. Bleicher, "Microdosimetry spectra and RBE of H-1, He-4, Li-7 and C-12 nuclei in water studied with Geant4." 2013. arXiv:1307.2174 [physics.med-ph].

[44] L. Burigo, I. Pshenichnov, I. Mishustin, and M. Bleicher, "Monte Carlo simulations of Microdosimetry for Space Research at FAIR," in *FAIRNESS 2012: FAIR NExt Generation of ScientistS*, Hersonissos, Greece, 3 - 8 Sept. 2012, vol. 426 of *J. Phys. Conf. Ser.*, p. 012006. 2013.

[45] N. Buyukcizmeci, A. S. Botvina, and I. N. Mishustin, "Tabulated equation of state for supernova matter including full nuclear ensemble." 2013. arXiv:1304.6741 [nucl-th].

[46] D. Cabrera, L. M. Abreu, F. J. Llanes-Estrada, and J. M. Torres-Rincon, "Heavy flavor relaxation in a hadronic medium," in *XI International Conference on Hypernuclear and Strange Particle Physics (HYP2012)*, Barcelona, Spain, 1 - 5 Oct. 2012, vol. 914 of *Nucl. Phys. A*, pp. 505–511. 2013. arXiv:1303.1303 [hep-ph].

[47] D. Cabrera, L. M. Abreu, E. Bratkovskaya, A. Ilner, F. J. Llanes-Estrada, A. Ramos, L. Tolos, and J. M. Torres-Rincon, "Strange and heavy mesons in hadronic matter," in *FAIRNESS 2013: Workshop for young scientists with research interests focused on physics at FAIR*, Berlin, Germany, 15 - 21 Sept. 2013. 2013. arXiv:1312.4343 [hep-ph].

[48] D. Cabrera and R. Rapp, "The $\pi\rho$ Cloud Contribution to the ω Width in Nuclear Matter." 2013. arXiv:1307.4001 [nucl-th].

[49] G. Calcagni, L. Modesto, and P. Nicolini, "Super-accelerating bouncing cosmology in asymptotically-free non-local gravity." 2013. arXiv:1306.5332 [gr-qc].

[50] P. Chandrashekhariah, G. Spina, and J. Triesch, "Let it Learn – A Curious Vision System for Autonomous Object Learning," in *8th International Conference on Computer Vision Theory and Applications (VISAPP)*, Barcelona, Spain, 21 - Feb 24, 2013. 2013.

[51] R. Chatterjee, H. Holopainen, T. Renk, and K. J. Eskola, "Centrality and initial formation time dependence of the emission of thermal photons from fluctuating initial conditions at RHIC and LHC," in *5th International Conference on Hard and Electromagnetic Probes of High Energy nuclear Collisions (Hard Probes 2012)*, Cagliari, Italy, 27 May - 1 June 2012, vol. 910 of *Nucl. Phys. A*, pp. 207–208. 2013. arXiv:1207.6917 [nucl-th].

[52] R. Chatterjee, H. Holopainen, T. Renk, and K. J. Eskola, "Influence of initial state fluctuations on the production of thermal photons," in *Quark Matter 2012 International Conference*, Washington DC, USA, 13 - 18 August 2012, vol. 904–905 of *Nucl. Phys. A*, pp. 849c–852c. 2013. arXiv:1210.3517 [hep-ph].

[53] Z. Dai, G. Exarchakis, and J. Lücke, "What are the invariant occlusive components of image patches? A probabilistic generative approach," in *Proceedings NIPS2013*, Lake Tahoe, Nevada, USA, 5 - 8 December 2013, vol. 26 of *Advances in Neural Information Processing Systems*, pp. 243–251. 2013.

[54] S. Denifi, G. Garcia, B. A. Huber, B. P. Marinković, N. Mason, J. Postler, H. Rabus, G. Rixon, A. V. Solov'yov, E. Suraud, and A. V. Yakubovich, "Radiation damage of biomolecules (RADAM) database development: current status," in *International Conference "Dynamics of Systems on the Nanoscale" (DySoN 2012)*, Sankt Petersburg, Russia, 30 Sept. - 4 Oct. 2012, vol. 438 of *J. Phys. Conf. Ser.*, p. 012016. 2013.

[55] V. Dexheimer, R. Negreiros, S. Schramm, and M. Hempel, "Deconfinement to Quark Matter in Neutron Stars – The Influence of Strong Magnetic Fields," in *XII HADRON PHYSICS*, Bento Goncalves, Brazil, 22 - 27 April 2012, vol. 1520 of *AIP Conf. Proc.*, pp. 264–269. 2013. arXiv:1208.1320 [astro-ph].

[56] V. Dexheimer, R. Negreiros, and S. Schramm, "Deconfinement to Quark Matter in Magnetars," in *Quark Matter 2012 Satellite Meeting on Extreme QCD*, Washington, DC, USA, 21 - 23 August 2012, vol. 432 of *J. Phys.: Conf. Ser.*, p. 012005. 2013. arXiv:1210.8160 [astro-ph].

[57] A. R. P. Dirkes, M. Maziashvili, and Z. K. Silagadze, "Black hole remnants due to Planck-length deformed QFT." 2013. arXiv:1309.7427 [gr-qc].

[58] S. Endres and M. Bleicher, "Dilepton production at SIS energies with the UrQMD model," in *FAIRNESS 2012: FAIR NExt Generation of ScientistS*, Hersonissos, Greece, 3 - 8 Sept. 2012, vol. 426 of *J. Phys. Conf. Ser.*, p. 012033. 2013.

[59] S. Endres, H. van Hees, J. Weil, and M. Bleicher, "Dilepton Production in Transport Calculations and Coarse-Grained Dynamics," in *FAIRNESS 2013: Workshop for young scientists with research interests focused on physics at FAIR*, Berlin, Germany, 15 - 21 Sept. 2013. 2013. arXiv:1312.5606 [nucl-th].

[60] S. Endres, H. van Hees, and M. Bleicher, "Studies of Dilepton Production in Coarse-Grained Transport Dynamics," in *8th International Workshop on Critical Point and Onset of Deconfinement (CPOD 2013)*, Napa, CA, USA, 11-15 March 2013, vol. PoS(CPOD 2013) of *Proceedings of Science*, p. 052. 2013.

[61] W. Florkowski, M. Martinez, R. Ryblewski, and M. Strickland, "Anisotropic hydrodynamics – basic concepts," in *10th Conference on Quark Confinement and the Hadron Spectrum (Confinement X)*, Munich, Germany, 8 - 12 October 2012, vol. ConfinementX (2012) of *Proceedings of Science*, p. 221. 2013. arXiv:1301.7539 [nucl-th].

[62] W. Florkowski, M. Martinez, R. Ryblewski, and M. Strickland, "Anisotropic hydrodynamics," in *Quark Matter 2012 International Conference*, Washington DC, USA, 13 - 18 August 2012, vol. 904–905 of *Nucl. Phys. A*, pp. 803c–806c. 2013. 10.1016/j.nuclphysa.2013.02.138.

[63] E. S. Fraga, "QCD under extreme conditions: an informal discussion," in *The 2013 CERN – Latin-American School of High-Energy Physics*, Arequipa, Peru, 6 - 19 March 2013. 2013. arXiv:1310.6656 [nucl-th].

[64] E. S. Fraga, A. Kurkela, and A. Vuorinen, "Interacting quark matter equation of state for compact stars." 2013. arXiv:1311.5154 [nucl-th].

[65] E. S. Fraga, B. W. Mintz, and J. Schaffner-Bielich, "A search for inverse magnetic catalysis in thermal quark-meson models." 2013. arXiv:1311.3964 [hep-ph].

[66] A. M. Frassino, P. Nicolini, and O. Panella, "Un-Casimir effect." 2014. arXiv:1311.7173 [hep-ph].

[67] T. Gaitanos, A. B. Larionov, H. Lenske, U. Mosel, and A. Obermann, "In-medium effects on hypernuclear formation," in *XI International Conference on Hypernuclear and Strange Particle Physics (HYP2012)*, Barcelona, Spain, 1 - 5 Oct. 2012, vol. 914 of *Nucl. Phys. A*, pp. 405–409. 2013. arXiv:1211.5464 [nucl-th].

[68] C. Garcia-Recio, L. L. Salcedo, D. Gamermann, J. Nieves, O. Romanets, and L. Tolos, "Charming Baryons," in *9th international workshop on the physics of excited nucleons (NSTAR 2013)*, Peniscola, Spain, 27 - 30 May 2013. 2013. arXiv:1310.0348 [hep-ph].

[69] S. Gavin and G. Moschelli, "Probing early-time correlations in heavy ion collisions," in *FAIRNESS 2012: FAIR NExt Generation of ScientistS*, Hersonissos, Greece, 3 - 8 Sept. 2012, vol. 426 of *J. Phys. Conf. Ser.*, p. 012028. 2013.

[70] R. A. Gherghescu, D. N. Poenaru, and W. Greiner, "Pairing Influence in Binary Nuclear Systems," in *International Symposium on 'Exciting Physics'*, Makutsi, South Africa, 13 - 20 Nov. 2011, FIAS Interdisciplinary Science Series, pp. 129–137. Springer, 2013.

[71] M. I. Gorenstein, W. Greiner, and A. Rustamov, "Strangeness Production in Light and Intermediate size Nucleus-Nucleus Collisions." 2013. arXiv:1307.1293 [nucl-th].

[72] M. I. Gorenstein and K. Grebieszkow, "Strongly Intensive Measures for Transverse Momentum and Particle Number Fluctuations." 2013. arXiv:1309.7878 [nucl-th].

[73] M. I. Gorenstein and M. Rybczynski, "Energy and transverse momentum fluctuations in the equilibrium quantum systems." 2013. arXiv:1308.0752 [nucl-th].

[74] G. Graef, M. Lisa, and M. Bleicher, "A twisted emission geometry in non-central Pb+Pb collisions measurable via azimuthally sensitive HBT." 2013. arXiv:1302.3408 [hep-ph].

[75] W. Greiner, "Nuclei: superheavy – superneutronic -strange – and of antimatter," in *International Summer School for Advanced Studies 'Dynamics of open nuclear systems' (PREDEAL12)*, Predeal, Romania, 9 - 20 July 2012, vol. 413 of *J. Phys. Conf. Ser.*, p. 012002. 2013.

[76] W. Greiner, "Exciting Physics: Superheavy, Superneutronic, Superstrange Nuclear Clusters," in *International Symposium on 'Exciting Physics'*, Makutsi, South Africa, 13 - 20 Nov. 2011, FIAS Interdisciplinary Science Series, pp. 3–21. Springer, 2013.

[77] D. K. Gridnev, S. Schramm, W. Greiner, and K. Gridnev, "Argonne V18 Pair Interaction Plus Modern Versions of Urbana or Illinois Three-Body Forces Make Neutron Matter Unstable." 2013. arXiv:1306.5573 [nucl-th].

[78] D. Gridnev, V. N. Tarasov, K. A. Gridnev, S. Schramm, D. V. Tarasov, and W. Greiner, "Stability Peninsulas at the Neutron Drip Line," in *International Symposium on 'Exciting Physics'*, Makutsi, South Africa, 13 - 20 Nov. 2011, FIAS Interdisciplinary Science Series, pp. 81–90. Springer, 2013.

[79] K. A. Gridnev, V. N. Tarasov, D. K. Gridnev, S. Schramm, D. V. Tarasov, X. Vinas, and W. Greiner, "The peninsulas of neutron stability of nuclei on nuclear chart," in *International Symposium on Exotic Nuclei (EXON 2012)*, Y. E. Penionzhkevich and Y. G. Sobolev, eds., Vladivostok, Russia, 1 - 6 Oct. 2012, pp. 181–186. World Scientific, 2013.

[80] K. A. Gridnev, V. N. Tarasov, D. V. Tarasov, D. K. Gridnev, S. Schramm, and W. Greiner, "Extreme neutron rich sector of the nuclear chart," in *International Conference on Fission and properties of neutron-rich nuclei (ICFN5)*, J. H. Hamilton and A. V. Ramayya, eds., Sanibel Island, Florida, USA, 4 - 10 Nov. 2012, pp. 311–320. World Scientific, 2013.

[81] A. Grimm and B. Bäuchle, "Soft Photons from transport and hydrodynamics at FAIR energies," in *FAIRNESS 2012: FAIR NExt Generation of ScientistS*, Hersonissos, Greece, 3 - 8 Sept. 2012, vol. 426 of *J. Phys. Conf. Ser.*, p. 012013. 2013. arXiv:1211.2401 [nucl-th].

[82] A. Gumberidze, "Atomic physics at the future facility for antiproton and ion research: a status report," in *16th International Conference on the Physics of Highly Charged Ions (HCI2012)*, Heidelberg, 2-7 Sept. 2012, vol. T156 of *Physica Scripta*, p. 014084. 2013.

[83] C. Hartnack, H. Oeschler, Y. Leifels, E. Bratkovskaya, and J. Aichelin, "What heavy ion can teach us about strange particles and what strange particles can teach us about heavy ions?," in *XI International Conference on Hypernuclear and Strange Particle Physics (HYP2012)*, Barcelona, Spain, 1 - 5 Oct. 2012, vol. 914, pp. 392–395. 2013.

[84] H. van Hees, C. Wesp, A. Meistrenko, and C. Greiner, "Dynamics of the chiral phase transition," in *XXXI Max Born Symposium and HIC for FAIR Workshop*, Wroclaw, Poland, 14 - 16 June 2013. 2013. arXiv:1311.6825 [hep-ph].

[85] C. Herold, M. Nahrgang, I. Mishustin, and M. Bleicher, "Dynamical formation of domains in net-baryon density at the QCD phase transition." 2013. arXiv:1304.5372 [nucl-th].

[86] C. Herold, M. Nahrgang, I. Mishustin, and M. Bleicher, "Dynamic Enhancement of Fluctuation Signals at the QCD Phase Transition," in *8th International Workshop on Critical Point and Onset of Deconfinement (CPOD 2013)*, Napa, CA, USA, 11 - 15 March 2013, vol. PoS(CPOD 2013) of *Proceedings of Science*, p. 021. 2013.

[87] C. Herold, Y.-P. Yan, and M. Bleicher, "Signals for the QCD phase transition and critical point in a Langevin dynamical model," in *FAIRNESS 2012: FAIR NExt Generation of ScientistS*, Hersonissos, Greece, 3 - 8 Sept. 2012, vol. 426 of *J. Phys. Conf. Ser.*, p. 012008. 2013.

[88] P. O. Hess, W. Greiner, T. Schönenbach, and G. Caspar, "Black Holes or Gray Stars? That's the Question: Pseudo-Complex General Relativity," in *International Symposium on 'Exciting Physics'*, Makutsi, South Africa, 13 - 20 Nov. 2011, FIAS Interdisciplinary Science Series, pp. 313–321. Springer, 2013.

[89] B. Hippolyte and D. H. Rischke, "Global variables and correlations: Summary of the results presented at the Quark Matter 2012 conference," in *Quark Matter 2012 International Conference*, Washington DC, USA, 13 - 18 August 2012, vol. 904–905 of *Nucl. Phys. A*, pp. 318c–325c. 2013.

[90] H. Holopainen and P. Huovinen, "Dynamical freeze-out criterion in event-by-event hydrodynamics," in *Strangeness in Quark Matter SQM2013*, Birmingham, UK, 22 - 27 July 2013. 2013. arXiv:1310.0347 [nucl-th].

[91] P. Huovinen, "Decade of hydrodynamics: What have we learnt?," in *10th Conference on Quark Confinement and the Hadron Spectrum (Confinement X)*, Munich, Germany, 8 - 12 Oct. 2012, vol. ConfinementX (2012) of *Proceedings of Science*, p. 165. 2012.

[92] A. Ilner, D. Cabrera, P. Srisawad, and E. Bratkovskaya, "Properties of strange vector mesons in dense and hot matter." 2013. arXiv:1312.5215 [hep-ph].

[93] I. A. Karpenko, M. Bleicher, P. Huovinen, and H. Petersen, "Beam energy scan using a viscous hydro+cascade model," in *Strangeness in Quark Matter SQM2013*, Birmingham, UK, 22 - 27 July 2013. 2013. arXiv:1310.0702 [nucl-th].

[94] I. Karpenko, M. Bleicher, P. Huovinen, and H. Petersen, "3+1 dimensional viscous hydrodynamics at high baryon densities," in *FAIRNESS 2013: Workshop for young scientists with research interests focused on physics at FAIR*, Berlin, Germany, 15 - 21 Sept. 2013. 2013. arXiv:1311.0133 [nucl-th].

[95] I. Karpenko, P. Huovinen, and M. Bleicher, "A 3+1 dimensional viscous hydrodynamic code for relativistic heavy ion collisions." 2013. arXiv:1312.4160 [nucl-th].

[96] A. V. Karpov, V. I. Zagrebaev, Y. M. Palenzuela, and W. Greiner, "Superheavy Nuclei: Decay and Stability," in *International Symposium on 'Exciting Physics'*, Makutsi, South Africa, 13 - 20 Nov. 2011, FIAS Interdisciplinary Science Series, pp. 69–79. Springer, 2013.

[97] I. Kisel, I. Kulakov, and M. Zyzak, "Standalone First Level Event Selection Package for the CBM Experiment," in *18th Real Time Conference (RT2012)*, Berkeley, CA, USA, 11 - 15 June 2012, vol. 60 of *IEEE Transactions on Nuclear Science*, pp. 3703–3708. 2013.

[98] A. K. Kohara, E. Ferreira, and T. Kodama, "Analytical representation for pp elastic scattering at 7 TeV," in *7th International Workshop on Diffraction in High Energy Physics (Diffraction 2012)*, Puerto del Carmen, Lanzarote, Canary Islands, Spain, 10 - 15 Sept. 2012, vol. 1523 of *AIP Conf. Proc.*, pp. 119–122. 2013.

[99] T. Kollegger and R. Stock, "Antinuclei Produced in Relativistic Collisions: Results and Expectations," in *International Symposium on 'Exciting Physics'*, Makutsi, South Africa, 13 - 20 Nov. 2011, FIAS Interdisciplinary Science Series, pp. 199–209. Springer, 2013.

[100] A. V. Korol and A. V. Solov'yov, "Atomic Cluster Collisions (Editorial)," in *Fifth International Symposium "Atomic Cluster Collisions" (ISACC2011)*, Berlin, Germany, 20 - 25 June 2011, vol. 67 of *Eur. Phys. J. D*, p. 291. 2013.

[101] A. Kostyuk, A. Korol, A. Solov'yov, and W. Greiner, "Crystalline Undulator: Current Status and Perspectives," in *International Symposium on 'Exciting Physics'*, Makutsi, South Africa, 13 - 20 Nov. 2011, FIAS Interdisciplinary Science Series, pp. 399–409. Springer, 2013.

[102] D. Kroff, A. Bessa, C. A. A. de Carvalho, E. S. Fraga, and S. E. Jorás, "Semiclassical partition function for the double-well potential." 2013. arXiv:1311.1182 [hep-ph].

[103] J. Kwisthout, I. van Rooij, M. Colombo, C. Zednik, and W. A. Phillips, "Constraints on Bayesian Explanation," in *Proceedings of the 35th Annual Meeting of the Cognitive Science Society*, Berlin, Germany, 31 July - 3 Aug. 2013, pp. 87–88. 2013.

[104] T. Lang, H. van Hees, J. Steinheimer, Y.-P. Yan, and M. Bleicher, "Heavy quark transport at RHIC and LHC," in *FAIRNESS 2012: FAIR NExt Generation of ScientistS*, Hersonissos, Greece, 3 - 8 Sept. 2012, vol. 426 of *J. Phys. Conf. Ser.*, p. 012032. 2013. arXiv:1212.0696 [hep-ph].

[105] T. Lang, H. van Hees, J. Steinheimer, and M. Bleicher, "Correlated D-meson decays competing against thermal QGP dilepton radiation," in *8th International Workshop on Critical Point and Onset of Deconfinement (CPOD 2013)*, Napa, CA, USA, 11 - 15 March 2013, vol. PoS(CPOD 2013) of *Proceedings of Science*, p. 051. 2013. arXiv:1306.2798 [hep-ph].

[106] T. Lang, H. van Hees, J. Steinheimer, and M. Bleicher, "Dileptons from correlated D- and $\bar{D}$-meson decays in the invariant mass range of the QGP thermal radiation using the UrQMD hybrid model." 2013. arXiv:1305.7377 [hep-ph].

[107] T. Lang, H. van Hees, J. Steinheimer, and M. Bleicher, "Elliptic flow and nuclear modification factors of D-mesons at FAIR in a Hybrid-Langevin approach." 2013. arXiv:1305.1797 [hep-ph].

[108] K. Langanke and H. Schatz, "The role of radioactive ion beams in nuclear astrophysics," in *Nobel Symposium 152 "Physics with Radioactive Beams"*, Gothenburg, Sweden, 10 - 15 June 2012, vol. T152 of *Physica Scripta*, p. 014011. 2013.

[109] A. B. Larionov, M. Strikman, and M. Bleicher, "Polarized χ_{c2}-charmonium production in antiproton-nucleus interactions." 2013. arXiv:1312.2150 [nucl-th].

[110] J. Leitner, S. Harding, P. Chandrashekhariah, M. Frank, A. Förster, J. Triesch, and J. Schmidhuber, "Learning visual object detection and localisation using icVision," in *International Conference on Biologically Inspired Cognitive Architectures BICA2012*, Palermo, Sicily, 31 Oct. - 3 Nov. 2012, vol. 5 of *Biologically Inspired Cognitive Architectures*, pp. 29–41. 2013.

[111] Q. Li, G. Graef, and M. Bleicher, "UrQMD calculations of two-pion HBT correlations in p+p and Pb+Pb collisions at LHC energies," in *11th International Conference on Nucleus-Nucleus Collisions (NN2012)*, San Antonio, Texas, USA, 27 May - 1 June 2012, vol. 420 of *J. Phys.: Conf. Ser.*, p. 012039. 2013. arXiv:1209.0042 [hep-ph].

[112] O. Linnyk, E. L. Bratkovskaya, W. Cassing, V. P. Konchakovski, and V. Ozvenchuk, "Emissivity and conductivity of parton-hadron matter," in *International Conference on Nuclear Physics (INPC2013)*, Firence, Italy, 2 - 7 June 2013. 2013. arXiv:1308.6259 [nucl-th].

[113] O. Linnyk, W. Cassing, and E. Bratkovskaya, "Centrality dependence of the direct photon yield and elliptic flow in heavy-ion collisions at $\sqrt{s} = 200$ GeV." 2013. arXiv:1311.0279 [nucl-th].

[114] L. Lonini, Y. Zhao, P. Chandrashekhariah, B. E. Shi, and J. Triesch, "Autonomous learning of active multi-scale binocular vision," in *Third Joint IEEE International Conference on Development and Learning and Epigenetic Robotics (ICDL)*, Osaka, Japan, 18 - 22 August 2013. 2013.

[115] M. Luzum and H. Petersen, "Initial State Fluctuations and Final State Correlations in Relativistic Heavy-Ion Collisions." 2013. arXiv:1312.5503 [nucl-th].

[116] R. Mallick and S. Schramm, "Deformation of a magnetized neutron star." 2013. arXiv:1307.5185 [astro-ph.HE].

[117] R. Mallick and S. Schramm, "Oblique MHD shocks: space-like and time-like characteristics." 2013. arXiv:1309.0397 [astro-ph.HE].

[118] Y. Malyshkin, I. Pshenichnov, I. Mishustin, and W. Greiner, "Monte Carlo modeling of spallation targets containing uranium and americium." 2013. arXiv:1311.6620 [physics.ins-det].

[119] R. Marty, E. Bratkovskaya, W. Cassing, J. Aichelin, and H. Berrehrah, "Transport coefficients from the Nambu-Jona-Lasinio model for $SU(3)_f$," in *Strangeness in Quark Matter SQM2013*, Birmingham, UK, 22 - 27 July 2013. 2013. arXiv:1311.3159 [hep-ph].

[120] O. Matula, S. Fritzsche, and A. Surzhykov, "Polarization correlations between photons emitted in dielectronic recombination of high-Z ions," in *16th International Conference on the Physics of Highly Charged Ions (HCI2012)*, Heidelberg, 2-7 Sept. 2012, vol. T156 of *Physica Scripta*, p. 014051. 2013.

[121] A. Meistrenko, C. Wesp, H. van Hees, and C. Greiner, "Nonequilibrium dynamics and transport near the chiral phase transition of a quark-meson model," in *FAIRNESS 2013: Workshop for young scientists with research interests focused on physics at FAIR*, Berlin, Germany, 15 - 21 Sept. 2013. 2013. arXiv:1311.7444 [hep-ph].

[122] F. Michler, H. van Hees, D. D. Dietrich, and C. Greiner, "Asymptotic description of finite lifetime effects on the photon emission from a quark-gluon plasma." 2013. arXiv:1310.5019 [hep-ph].

[123] F. Michler, H. van Hees, D. D. Dietrich, S. Leupold, and C. Greiner, "Non-equilibrium photon production arising from the chiral mass shift," in *Proceedings of the 51st International Winter Meeting on Nuclear Physics*, Bormio, Italy, 21 - 25 January 2013. 2013. arXiv:1304.4093 [nucl-th].

[124] S. Misicu and W. Greiner, "New investigations on fragment rotational states in spontaneous fission of ^{252}Cf," in *International Conference on Fission and properties of neutron-rich nuclei (ICFN5)*, J. H. Hamilton and A. V. Ramayya, eds., Sanibel Island, Florida, USA, 4 - 10 Nov. 2012, pp. 369–380. World Scientific, 2013.

[125] E. Molnár, H. Niemi, G. S. Denicol, and D. H. Rischke, "On the relative importance of second-order terms in relativistic dissipative fluid dynamics." 2013. arXiv:1308.0785 [nucl-th].

[126] M. Nahrgang, J. Aichelin, P. B. Gossiaux, and K. Werner, "Azimuthal correlations of heavy quarks in Pb+Pb collisions at LHC ($\sqrt{s} = 2.76$ TeV)." 2013. arXiv:1305.3823 [hep-ph].

[127] M. Nahrgang, J. Aichelin, P. B. Gossiaux, and K. Werner, "Heavy-flavor azimuthal correlations of D mesons," in *Strangeness in Quark Matter SQM2013*, Birmingham, UK, 22 - 27 July 2013. 2013. arXiv:1310.2218 [hep-ph].

[128] M. Nahrgang, J. Aichelin, P. B. Gossiaux, and K. Werner, "Influence of hadronic bound states above T_c on heavy-quark observables in Pb+Pb collisions at LHC." 2013. arXiv:1305.6544 [hep-ph].

[129] M. Nahrgang, M. Bluhm, P. B. Gossiaux, and J. Aichelin, "Impact of gluon damping on heavy-quark quenching," in *Heavy Ion Collisions in the LHC Era*, Quy Nhon, Vietnam, 16 - 20 July 2012, vol. 422 of *J. Phys. Conf. Ser.*, p. 012016. 2013. arXiv:1302.2934 [hep-ph].

[130] M. Nahrgang, C. Herold, and M. Bleicher, "Influence of an inhomogeneous and expanding medium on signals of the QCD phase transition," in *Quark Matter 2012 International Conference*, Washington DC, USA, 13 - 18 August 2012, vol. 904–905 of *Nucl. Phys. A*, pp. 899c–902c. 2013. arXiv:1301.2577 [nucl-th].

[131] S. Nahrwold, R. Berger, and P. Schwerdtfeger, "Parity violation in nuclear magnetic resonance frequencies of chiral tetrahedral tungsten complexes NWXYZ (X, Y, Z = H, F, Cl, Br or I)." 2013. arXiv:1305.3963 [physics.chem-ph].

[132] K. Nakada, Y. D. Sato, and K. Matsuoka, "Theoretical Analysis of Phase Resetting on Matsuoka Oscillators," in *Proceedings of the Third International Conference on Cognitive Neurodynamics*, Hilton Niseko Village, Hokkaido, Japan, 9 - 13 June 2011, Advances in Cognitive Neurodynamics, pp. 531–536. 2013.

[133] R. Negreiros, S. Schramm, and F. Weber, "Proton superconductivity and the masses of neutron stars." 2013. arXiv:1305.0845 [astro-ph.HE].

[134] R. Negreiros, S. Schramm, and F. Weber, "Thermal Evolution of Rotating Neutron Stars," in *Compact Stars in the QCD Phase Diagram III (CSQCD III)*, Guarujá, Brazil, 12 - 15 Dec. 2012. 2013. arXiv:1307.7692 [astro-ph].

[135] J. Nemchik, I. A. Karpenko, B. Z. Kopeliovich, I. K. Potashnikova, and Y. M. Sinyukov, "High-p_T hadrons from nuclear collisions: Unifying pQCD with hydrodynamics," in *15th conference on Elastic and Diffractive scattering, EDS Blois 2013*, Saariselka, Finland, 9 - 13 Sept. 2013. 2013. arXiv:1310.3455 [hep-ph].

[136] P. Nicolini, J. Mureika, E. Spallucci, E. Winstanley, and M. Bleicher, "Production and evaporation of Planck scale black holes at the LHC," in *13th Marcel Grossmann Meeting*, Stockholm, Sweden, 1 - 17 July 2012. 2013. arXiv:1302.2640 [hep-th].

[137] S. Pal and M. Bleicher, "Medium information from anisotropic flow and jet quenching in relativistic heavy ion collisions," in *11th International Conference on Nucleus-Nucleus Collisions (NN2012)*, San Antonio, Texas, USA, 27 May - 1 June 2012, vol. 420 of *J. Phys.: Conf. Ser.*, p. 012027. 2013.

[138] N. C. Pampu, R. Vicente, R. C. Muresan, V. Priesemann, F. Siebenhühner, and M. Wibral, "Transfer entropy as a tool for reconstructing interaction delays in neural signals," in *International Symposium on Signals, Circuits and Systems (ISSCS 2013)*, Iasi, Romania, 11-12 July 2013, p. 63. 2013.

[139] D. Parganlija, P. Kovacs, G. Wolf, F. Giacosa, and D. H. Rischke, "Eta, Eta' and eLSM," in *10th Conference on Quark Confinement and the Hadron Spectrum (Confinement X)*, Munich, Germany, 8 - 12 October 2012, vol. ConfinementX (2012) of *Proceedings of Science*, p. 117. 2013. arXiv:1301.3478 [hep-ph].

[140] H. Petersen, "Event-by-Event Observables and Fluctuations," in *Quark Matter 2012 International Conference*, Washington DC, USA, 13 - 18 August 2012, vol. 904–905 of *Nucl. Phys. A*, pp. 278c–285c. 2013. arXiv:1211.5526 [nucl-th].

[141] H. Petersen, C. E. Coleman-Smith, and R. L. Wolpert, "Quantifying Initial State Fluctuations in Heavy Ion Collisions," in *Workshop "Excited QCD 2013"*, Bjelasnica Mountain, Sarajevo, 3 - 9 Feb. 2013, vol. 6 of *Acta Phys. Polon. B Proc. Suppl.*, pp. 797–802. 2013.

[142] M. Petran, J. Letessier, J. Rafelski, and G. Torrieri, "SHARE with CHARM." 2013. arXiv:1310.5108 [hep-ph].

[143] T. Petrovic, M. Vencelj, M. Lipoglavsek, R. Novak, and D. Savran, "Pile-up reconstruction algorithm for high count rate gamma-ray spectrometry," in *International Conference on Recent Trends in Nuclear Physics (ICRTNP-2012)*, Barotiwala, India, 19 - 21 Nov. 2012, vol. 1524 of *AIP Conf. Proc.*, pp. 279–282. 2013.

[144] D. N. Poenaru, R. A. Gherghescu, and W. Greiner, "Cluster radioactivity and alpha decay of superheavy nuclei," in *4th Intl. Conf. on Current Problems in Nuclear Physics and Atomic Energy*, I. M. Vyshnevskyi, ed., Kiev, Ukraine, 3 - 7 Sept. 2012, pp. 57–61. 2013.

[145] D. N. Poenaru, R. A. Gherghescu, and W. Greiner, "Heavy-particle radioactivity," in *10th International Conference on Clustering Aspects of Nuclear Structure and Dynamics (CLUSTER'12)*, Debrecen, Hungary, 24-28 Sept. 2012, vol. 436 of *J. Phys. Conf. Ser*, p. 012056. 2013.

[146] D. N. Poenaru, R. A. Gherghescu, and W. Greiner, "Unexpected Strong Decay Mode of Superheavy Nuclei," in *International Symposium on 'Exciting Physics'*, Makutsi, South Africa, 13 - 20 Nov. 2011, FIAS Interdisciplinary Science Series, pp. 91–101. Springer, 2013.

[147] D. N. Poenaru, R. A. Gherghescu, and W. Greiner, "Cluster decay of the heaviest superheavy nuclei," in *International Conference on Fission and properties of neutron-rich nuclei (ICFN5)*, J. H. Hamilton and A. V. Ramayya, eds., Sanibel Island, Florida, USA, 4 - 10 Nov. 2012, pp. 152–159. World Scientific, 2013.

[148] D. N. Poenaru and W. Greiner, "Theory and experiments on heavy-ion radioactivities," in *International Symposium Nucleus-100 "The Centenary of Atomic Nucleus"*, Y. Oganessian and A. Vdovin, eds., Dubna, Russia, March 2011, pp. 126–143. Fizmatlit Moscow, 2013.

[149] R. Pokharel, S. Gavin, and G. Moschelli, "Fluctuating Hydrodynamics Confronts the Rapidity Dependence of Transverse Momentum Fluctuations," in *Hot Quarks 2012*, Copamarina, Puerto Rico, 14 - 20 Oct. 2012, vol. 446 of *J. Phys.: Conf. Ser.*, p. 012029. 2013.

[150] R. Pokharel, S. Gavin, and G. Moschelli, "Rapidity Dependence of Transverse Momentum Correlations from Fluctuating Hydrodynamics," in *29th Winter Workshop on Nuclear Dynamics (WWND 2013)*, Squaw Valley CA, USA, 3 - 10 Feb. 2013, vol. 458 of *J. Phys.: Conf. Ser.*, p. 012005. 2013.

[151] R. G. Polozkov, V. K. Ivanov, A. V. Verkhovtsev, A. V. Korol, and A. V. Solov'yov, "New applications of the jellium model for the study of atomic clusters," in *International Conference "Dynamics of Systems on the Nanoscale" (DySoN 2012)*, Sankt Petersburg, Russia, 30 Sept. - 4 Oct. 2012, vol. 438 of *J. Phys. Conf. Ser.*, p. 012009. 2013.

[152] W.-L. Qian, P. Mota, R. Andrade, F. Gardim, F. Grassi, Y. Hama, and T. Kodama, "Decomposition of fluctuating initial conditions and flow harmonics." 2013. arXiv:1305.4673 [hep-ph].

[153] P. Rau, J. Steinheimer, S. Schramm, and H. Stöcker, "Conserved Charge Fluctuations in a Chiral Hadronic Model including Hadrons and Quarks." 2013. arXiv:1308.4319 [hep-ph].

[154] P. Rau, J. Steinheimer, and S. Schramm, "Phase Structure of QCD Matter in a Chiral Effective Model with Quarks." 2013. arXiv:1308.4518 [hep-ph].

[155] P. Rau, J. Steinheimer, S. Schramm, and H. Stöcker, "QCD Equation of State From a Chiral Hadronic Model Including Quark Degrees of Freedom," in *8th International Workshop on Critical Point and Onset of Deconfinement (CPOD 2013)*, Napa, CA, USA, 11-15 March 2013, vol. PoS(CPOD 2013 of *Proceedings of Science*, p. 059. 2012. arXiv:1306.3352 [hep-ph].

[156] J. Reinhardt and W. Greiner, "Supercritical QED and Time-Delayed Heavy Ion Collisions," in *International Symposium on 'Exciting Physics'*, Makutsi, South Africa, 13 - 20 Nov. 2011, FIAS Interdisciplinary Science Series, pp. 439–451. Springer, 2013.

[157] R. Reuschl, T. Gassner, U. Spillmann, A. Brauning-Demian, A. Ananyeva, H. Beyer, K.-H. Blumenhagen, W. Chen, S. Hagmann, M. Hegewald, P. Indelicato, M. Schwemlein, S. Toleikis, M. Trassinelli, S. Trotsenko, D. Winters, N. Winters, and T. Stöhlker, "Lifetime measurement of the 2 P-3(0) state in He-like uranium," in *16th International Conference on the Physics of Highly Charged Ions (HCI2012)*, Heidelberg, 2-7 Sept. 2012, vol. T156 of *Physica Scripta*, p. 014024. 2013.

[158] R. A. Rodriguez, S. Becker, G. B. Andresen, D. Heide, and M. Greiner, "Transmission needs across a fully renewable European power system." 2014. arXiv:1306.1079 [math.OC].

[159] O. Romanets, C. Garcia-Recio, J. N. L. L. Salcedo, and L. Tolos, "Odd-parity Dynamically Generated Baryon Resonances with Beauty Flavor," in *Workshop "Excited QCD 2013"*, Bjelasnica Mountain, Sarajevo, Bosnia and Herzogovina, 3 - 9 Feb. 2013, vol. 6 of *Acta Phys. Polon. B Proc. Suppl.*, pp. 973–978. 2013. arXiv:1304.4747 [hep-ph].

[160] O. Romanets, L. Tolos, C. Garcia-Recio, J. Nieves, L. L. Salcedo, and R. Timmermans, "Heavy-quark spin symmetry for charmed and strange baryon resonances," in *XI International Conference on Hypernuclear and Strange Particle Physics (HYP2012)*, Barcelona, Spain, 1 - 5 Oct. 2012, vol. 914 of *Nucl. Phys. A*, pp. 488–493. 2013. arXiv:1212.3943 [hep-ph].

[161] C. A. Rothkopf, "Motorik und Handlungssteuerung," in *Handbuch Kognitionswissenschaft*, A. Stephan and S. Walter, eds., pp. 374–385. J. B. Metzler, 2013.

[162] C. A. Rothkopf, "Kognitive Neurowissenschaft," in *Handbuch Kognitionswissenschaft*, A. Stephan and S. Walter, eds., pp. 78–84. J. B. Metzler, 2013.

[163] V. V. Sagun, A. I. Ivanytskyi, K. A. Bugaev, and D. R. Oliinychenko, "Bimodality Phenomenon in Finite and Infinite Systems Within an Exactly Solvable Statistical Model," in *Helmholtz International Summer School "Physics of Heavy Quarks and Hadrons"*, Dubna, Russia, 15 - 28 July 2013. 2013. arXiv:1311.7042 [nucl-th].

[164] V. V. Sagun, A. I. Ivanytskyi, K. A. Bugaev, and I. N. Mishustin, "The statistical multifragmentation model for liquid-gas phase transition with a compressible nuclear liquid." 2013. arXiv:1306.2372 [nucl-th].

[165] B. Sancristóbal, R. Vicente, A. J. Pons, G. Pipa, and J. Garcia-Ojalvo, "Modulating the Phase Coherence of Neuronal Population Oscillations in the Gamma Band," in *Proceedings of the Third International Conference on Cognitive Neurodynamics*, Hilton Niseko Village, Hokkaido, Japan, 9 - 13 June 2011, vol. III of *Advances in Cognitive Neurodynamics (III)*, pp. 475–481. 2013.

[166] C. Sasaki, "Effective theory of Yang-Mills thermodynamics," in *8th International Workshop on Critical Point and Onset of Deconfinement (CPOD 2013)*, Napa, CA, USA, 11 - 15 March 2013, vol. PoS(CPOD2013) of *Proceedings of Science*, p. 030. 2013.

[167] C. Sasaki, "Yang-Mills Thermodynamics: an Effective Theory Approach," in *XXXI Max Born Symposium and HIC for FAIR Workshop*, Wroclaw, Poland, 14 - 16 June 2013. 2013. arXiv:1312.3818 [hep-ph].

[168] C. Sasaki, "Interplay between chromoelectric and chromomagnetic gluons in Yang-Mills thermodynamics," in *International Conference on new Frontiers in Physics (ICNFP 2013)*, Kolymbari, Crete, Greece, 28 Aug. - 5 Sept. 2013. 2013. arXiv:1312.5245 [hep-ph].

[169] C. Sasaki, I. Mishustin, and K. Redlich, "Implementation of chromomagnetic gluons in Yang-Mills thermodynamics." 2013. arXiv:1308.3635 [hep-ph].

[170] C. Sasaki and K. Redlich, "Effective gluon potential and Yang-Mills thermodynamics," in *10th Conference on Quark Confinement and the Hadron Spectrum (Confinement X)*, Munich, Germany, 8 - 12 October 2012, vol. ConfinementX (2012) of *Proceedings of Science*, p. 179. 2013. arXiv:1301.7645 [hep-ph].

[171] T. Schönenbach, G. Caspar, P. O. Hess, T. Boller, A. Müller, M. Schäfer, and W. Greiner, "Ray-tracing in pseudo-complex General Relativity." 2013. arXiv:1312.1170 [astro-ph].

[172] S. Schramm, V. Dexheimer, R. Negreiros, T. Schürhoff, and J. Steinheimer, "Structure and Cooling of Neutron and Hybrid Stars," in *International Symposium on 'Exciting Physics'*, Makutsi, South Africa, 13 - 20 Nov. 2011, FIAS Interdisciplinary Science Series, pp. 323–332. Springer, 2013.

[173] S. Schramm, V. Dexheimer, R. Negreiros, J. Steinheimer, and T. Schürhoff, "Compact Stars - How Exotic Can They Be?," in *"Nuclear Physics: Present and Future*, Boppard, Germany, 29 May - 5 June 2013. 2013. arXiv:1310.5804 [astro-ph].

[174] S. Schramm, V. Dexheimer, R. Negreiros, T. Schürhoff, and J. Steinheimer, "Modeling Hybrid Stars in Quark-Hadron Approaches," in *Compact Stars in the QCD Phase Diagram III (CSQCD III)*, Guaruja, SP, Brazil, 12 - 15 Dec. 2012. 2013. arXiv:1306.0989 [astro-ph].

[175] I. A. Solov'yov and W. Greiner, "Light-Activated Magnetic Compass in Birds," in *International Symposium on 'Exciting Physics'*, Makutsi, South Africa, 13 - 20 Nov. 2011, FIAS Interdisciplinary Science Series, pp. 481–492. Springer, 2013.

[176] I. A. Solov'yov and A. V. Solov'yov, "Simulation of nanofractal dynamics with MBN Explorer," in *International Conference "Dynamics of Systems on the Nanoscale" (DySoN 2012)*, Sankt Petersburg, Russia, 30 Sept. - 4 Oct. 2012, vol. 438 of *J. Phys. Conf. Ser.*, p. 012006. 2013.

[177] J. Stachel, A. Andronic, P. Braun-Munzinger, and K. Redlich, "Confronting LHC data with the statistical hadronization model," in *Strangeness in Quark Matter SQM2013*, Birmingham, UK, 22 - 27 July 2013. 2013. arXiv:1311.4662 [nucl-th].

[178] J. Steinheimer, J. Randrup, and V. Koch, "Non-equilibrium phase transition in relativistic nuclear collisions: Importance of the equation of state." 2013. arXiv:1311.0999 [nucl-th].

[179] J. Steinheimer, Z. Xu, P. Rau, C. Sturm, and H. Stöcker, "From d-Bars to Antimatter- and Hyperclusters," in *International Symposium on 'Exciting Physics'*, Makutsi, South Africa, 13 - 20 Nov. 2011, FIAS Interdisciplinary Science Series, pp. 275–289. Springer, 2013.

[180] R. Stock, F. Becattini, M. Bleicher, T. Kollegger, T. Schuster, and J. Steinheimer, "Hadronic Freeze-Out in A+A Collisions meets the Lattice QCD Parton-Hadron Transition Line," in *8th International Workshop on Critical Point and Onset of Deconfinement (CPOD 2013)*, Napa, CA, USA, 11 - 15 March 2013, vol. CPOD2013 of *Proceedings of Science*, p. 011. 2013. arXiv:1306.4201 [nucl-th].

[181] J. Struckmeier and H. Reichau, "General $U(N)$ gauge transformations in the realm of covariant Hamiltonian field theory," in *International Symposium on 'Exciting Physics'*, Makutsi, South Africa, 13 - 20 Nov. 2011, FIAS Interdisciplinary Science Series, pp. 367–395. Springer, 2013.

[182] E. Surdutovich and A. V. Solov'yov, "Multiscale approach to the physics of radiation damage with ions." 2013. arXiv:1312.0897 [physics.bio-ph]].

[183] E. Surdutovich and A. V. Solov'yov, "Multiscale approach to the physics of radiation damage with ions," in *22nd International Conference on Application of Accelerators in Research and Industry*, Fort Worth, TX, USA, 5 - 10 Aug. 2012, vol. 1525 of *AIP Conf. Proc.*, pp. 672–679. 2013.

[184] E. Surdutovich and A. V. Solov'yov, "Multiscale physics of ion-induced radiation damage," in *International Conference "Dynamics of Systems on the Nanoscale" (DySoN 2012)*, Sankt Petersburg, Russia, 30 Sept. - 4 Oct. 2012, vol. 438 of *J. Phys. Conf. Ser.*, p. 012014. 2013.

[185] E. Surdutovich, A. V. Yakubovich, and A. V. Solov'yov, "DNA damage due to thermomechanical effects caused by heavy ions propagating in tissue," in *Eighth International Symposium on Swift Heavy Ions in Matter (SHIM 2012)*, Kyoto, Japan, 24-27 Oct. 2012, vol. 314 of *Nucl. Inst. Meth. B*, pp. 63–65. 2013.

[186] G. B. Sushko, V. G. Bezchastnov, A. V. Korol, W. Greiner, A. V. Solov'yov, R. G. Polozkov, and V. K. Ivanov, "Simulations of electron channeling in bent silicon crystal," in *International Conference "Dynamics of Systems on the Nanoscale" (DySoN 2012)*, Sankt Petersburg, Russia, 30 Sept. - 4 Oct. 2012, vol. 438 of *J. Phys. Conf. Ser.*, p. 012019. 2013.

[187] G. B. Sushko, A. V. Korol, W. Greiner, and A. V. Solov'yov, "Sub-GeV Electron and Positron Channeling in Straight, Bent and Periodically Bent Silicon Crystals," in *International Conference "Dynamics of Systems on the Nanoscale" (DySoN 2012)*, Sankt Petersburg, Russia, 30 Sept. - 4 Oct. 2012, vol. 438 of *J. Phys. Conf. Ser.*, p. 012018. 2013.

[188] G. B. Sushko, A. V. Verkhovtsev, A. V. Yakubovich, and A. V. Solov'yov, "Molecular dynamics simulation of nanoindentation of nickel-titanium crystal," in *International Conference "Dynamics of Systems on the Nanoscale" (DySoN 2012)*, Sankt Petersburg, Russia, 30 Sept. - 4 Oct. 2012, vol. 438 of *J. Phys. Conf. Ser.*, p. 012021. 2013.

[189] C. I. Szabo, P. Amaro, M. Guerra, J. P. Santos, A. Gumberidze, J. Attard, and P. Indelicato, "Ion temperature and x-ray line width measurements of highly charged argon ions in an ECR ion source," in *16th International Conference on the Physics of Highly Charged Ions (HCI2012)*, Heidelberg, 2-7 Sept. 2012, vol. T156 of *Physica Scripta*, p. 014077. 2013.

[190] C. I. Szabo, P. Amaro, M. Guerra, S. Schlesser, A. Gumberidze, J. P. Santos, and P. Indelicato, "Reference free, high-precision measurements of transition energies in few electron argon ions," in *22nd International Conference on Application of Accelerators in Research and Industry*, Fort Worth, TX, USA, 5 - 10 Aug. 2012, vol. 1525 of *AIP Conf. Proc.*, pp. 68–72. 2013.

[191] L. Tolos, D. Cabrera, C. Garcia-Recio, R. Molina, J. Nieves, E. Oset, A. Ramos, O. Romanets, and L. L. Salcedo, "Strangeness and Charm in Nuclear Matter," in *XI International Conference on*

Hypernuclear and Strange Particle Physics (HYP2012), Barcelona, Spain, 1 - 5 Oct. 2012, vol. 914 of *Nucl. Phys. A*, pp. 461–471. 2013. arXiv:1211.7286 [nucl-th].

[192] L. Tolos, C. Garcia-Recio, J. Nieves, O. Romanets, and L. L. Salcedo, "Charmed mesons in nuclei with heavy-quark spin symmetry," in *20th International IUPAP Conference on Few-Body Problems in Physics (FB20)*, Fukuoka, Japan,, 20 - 25 August 2012, vol. 54 of *Few-Body Systems*, pp. 923–929. 2013. arXiv:1210.1007 [nucl-th].

[193] L. Tolos, C. Garcia-Recio, R. Molina, J. Nieves, E. Oset, A. Ramos, and L. L. Salcedo, "Review of low-energy interaction of strange and charm hadrons with nucleons and nuclei," in *Quark Confinement and the Hadron Spectrum X, October 8-12 2012, Munich, Germany*, Munich, Germany, 8 - 12 October 2012, vol. ConfinementX (2012) of *Proceedings of Science*, p. 015. 2013. arXiv:1301.2616 [nucl-th].

[194] J. M. Torres-Rincon, L. M. Abreu, D. Cabrera, F. J. Llanes-Estrada, and L. Tolos, "D-meson diffusion in hadronic matter," in *FAIRNESS 2013: Workshop for young scientists with research interests focused on physics at FAIR*, Berlin, Germany, 15 - 21 Sept. 2013. 2013. arXiv:1312.3536 [hep-ph].

[195] G. Torrieri, "Some considerations on multi-particle correlations, many particle systems, and entropy in effective field theories." 2013. arXiv:1306.5719 [hep-th].

[196] G. Torrieri, "On the origin of long-range azimuthal correlations in hadronic collisions." 2013. arXiv:1310.3529 [nucl-th].

[197] G. Torrieri and S. Lottini, "Phenomenology of quarkyonic percolation at FAIR," in *FAIRNESS 2012: FAIR NExt Generation of ScientistS*, Hersonissos, Greece, 3 - 8 Sept. 2012, vol. 426 of *J. Phys. Conf. Ser.*, p. 012003. 2013. arXiv:1211.2433 [nucl-th].

[198] P. de Vera, I. Abril, R. Garcia-Molina, and A. V. Solov'yov, "Ionization of biomolecular targets by ion impact: input data for radiobiological applications," in *International Conference "Dynamics of Systems on the Nanoscale" (DySoN 2012)*, Sankt Petersburg, Russia, 30 Sept. - 4 Oct. 2012, vol. 438 of *J. Phys. Conf. Ser.*, p. 012015. 2013.

[199] A. V. Verkhovtsev, A. V. Korol, and A. V. Solov'yov, "Plasmon excitations in photo- and electron impact ionization of fullerenes," in *International Conference "Dynamics of Systems on the Nanoscale" (DySoN 2012)*, Sankt Petersburg, Russia, 30 Sept. - 4 Oct. 2012, vol. 438 of *J. Phys. Conf. Ser.*, p. 012011. 2013.

[200] A. V. Verkhovtsev, A. V. Korol, and A. V. Solov'yov, "Quantum and classical features of the photoionization spectrum of C_{60}." 2013. arXiv:1307.3514 [physics.atm-clus].

[201] S. Vogel, "Hadronic resonances at FAIR energies," in *FAIRNESS 2012: FAIR NExt Generation of ScientistS*, Hersonissos, Greece, 3 - 8 Sept. 2012, vol. 426 of *J. Phys.: Conf. Ser.*, p. 012012. 2013.

[202] S. Vogel, P. B. Gossiaux, K. Werner, and J. Aichelin, "Charm quark energy loss in proton-proton collisions at LHC energies," in *11th International Conference on Nucleus-Nucleus Collisions (NN2012)*, San Antonio, Texas, USA, 27 May - 1 June 2012, vol. 420 of *J. Phys.: Conf. Ser.*, p. 012034. 2013.

[203] S. Weissenborn, D. Chatterjee, and J. Schaffner-Bielich, "Hyperons and massive neutron stars: Vector repulsion and strangeness," in *XI International Conference on Hypernuclear and Strange Particle Physics (HYP2012)*, Barcelona, Spain, 1 - 5 Oct. 2012, vol. 914, pp. 421–426. 2013.

[204] K. Werner, M. Bleicher, B. Guiot, I. Karpenko, and T. Pierog, "Evidence for flow in pPb collisions at 5 TeV from v2 mass splitting." 2013. arXiv:1307.4379 [nucl-th].

[205] V. Werner, N. M. Cooper, P. M. Goddard, M. K. Smith, D. Savran, S. W. Yates, B. P. Crider, E. E. Peters, A. Chakraborty, A. P. Tonchev, G. Rusev, W. Tornow, J. H. Kelley, E. Kwan, R. Raut, F. Reichel, N. Pietralla, C. Romig, M. Scheck, M. F. anJ. Beller, M. Zweidinger, and K. Sonnabend, "Dipole Response of ^{76}Se up to 9 MeV," in *14th Intl. Symposium on Capture Gamma-Ray Spectroscopy and*

Related Topics, P. E. Garrett *et al.*, eds., Guelph, Canada, 28 Aug. - 2 Sept. 2011, pp. 421–426. World Scientific, 2013.

[206] K. Werner, B. Guiot, I. Karpenko, and T. Pierog, "Analysing radial flow features in p-Pb and p-p collisions at several TeV by studying identified particle production in EPOS3." 2013. arXiv:1312.1233 [nucl-th].

[207] K. Werner, B. Guiot, I. Karpenko, and T. Pierog, "New developments in EPOS: Parton saturation," in *29th Winter Workshop on Nuclear Dynamics (WWND 2013)*, Squaw Valley CA, USA, 3 - 10 Feb. 2013, vol. 458 of *J. Phys.: Conf. Ser.*, p. 012020. 2013.

[208] K. Werner, B. Guiot, I. Karpenko, M. Bleicher, T. Pierog, and S.Porteboeuf-Houssais, "Jets, Bulk Matter, and their Interaction in Heavy Ion Collisions at the LHC," in *International Conference on Heavy Ion Collisions in the LHC Era*, Quy Nhon, Vietnam, 16 - 20 July 2012, vol. 422 of *J. Phys. Conf. Ser.*, p. 012001. 2013.

[209] K. Werner, I. Karpenko, M. Bleicher, and T. Pierog, "The Physics of EPOS," in *XVII International Symposium on Very High Energy Cosmic Ray Interactions (ISVHECRI 2012)*, Berlin, Germany, 10 - 15 Aug. 2012, vol. 52 of *EPJ Web of Conferences*, p. 05001. 2013.

[210] N. Winters, A. Warczak, J. A. Tanis, T. Gassner, A. Gumberidze, S. Hagmann, P. M. Hillenbrand, C. Kozhuharov, N. Petridis, R. Reuschl, M. Schwemlein, D. Sierpowski, U. Spillmann, R. Strzalka, S. Trotsenko, G. Weber, D. F. A. Winters, Z. Yin, and T. Stöhlker, "A study of radiative double electron capture in bare chromium ions at the ESR," in *16th International Conference on the Physics of Highly Charged Ions (HCI2012)*, Heidelberg, 2-7 Sept. 2012, vol. T156 of *Physica Scripta*, p. 014048. 2013.

[211] R. Xu, W.-T. Deng, and X.-N. Wang, "Suppression of high p_T hadron spectra in $p + A$ collisions," in *5th International Conference on Hard and Electromagnetic Probes of High Energy nuclear Collisions (Hard Probes 2012)*, Cagliari, Italy, 27 May - 1 June 2012, vol. 910 of *Nucl. Phys. A*, pp. 514–517. 2013. arXiv:1207.6836 [nucl-th].

[212] A. V. Yakubovich, A. V. Solov'yov, and W. Greiner, "Statistical Mechanical Theory of Protein Folding in Water Environment," in *International Symposium on 'Exciting Physics'*, Makutsi, South Africa, 13 - 20 Nov. 2011, FIAS Interdisciplinary Science Series, pp. 493–508. Springer, 2013.

[213] A. V. Yakubovich, I. A. Solov'yov, and A. V. Solov'yov, "Molecular dynamics simulations of bio-nano systems with MBN Explorer," in *European Conference on Nano Films (ECNF2012)*, Ancona, Italy, 17 - 22 June 2012, vol. 40 of *Physics Procedia*, pp. 93–99. 2013.

[214] H. Yépez-Martínez, P. O. Hess, and G. Lévai, "The geometric interpretation of the semimicroscopic algebraic cluster model and the role of the Pauli principle," in *10th International Conference on Clustering Aspects of Nuclear Structure and Dynamics (CLUSTER'12)*, 24 - 28 Sept. 2012, vol. 436 of *J. Phys. Conf. Ser.*, p. 012033. 2013.

[215] V. Zagrebaev, A. Karpov, and W. Greiner, "Future of superheavy element research: Which nuclei could be synthesized within the next few years?," in *11th International Conference on Nucleus-Nucleus Collisions (NN2012)*, San Antonio, Texas, USA, 27 May - 1 June 2012, vol. 420 of *J. Phys.: Conf. Ser.*, p. 012001. 2013. arXiv:1207.5700 [nucl-th].

[216] V. I. Zagrebaev, A. V. Karpov, I. N. Mishustin, and W. Greiner, "Superheavies: Short-Term Experiments and Far-Reaching Designs," in *International Symposium on 'Exciting Physics'*, Makutsi, SouthAfrica, 13 - 20 Nov. 2011, FIAS Interdisciplinary Science Series, pp. 55–67. Springer, 2013.

[217] V. I. Zagrebaev, A. V. Karpov, and W. Greiner, "Synthesis of neutron enriched heavy and superheavy nuclei," in *International Conference on Fission and properties of neutron-rich nuclei (ICFN5)*, J. H. Hamilton and A. V. Ramayya, eds., Sanibel Island, Florida, USA, 4 - 10 Nov. 2012, pp. 127–134. World Scientific, 2013.

C. Books

[1] S. M. Silverstein, B. Moghaddam, and T. Wykes, eds., *Schizophrenia – Evolution and Synthesis*. Strüngmann Forum Reports. MIT Press, 2013.

[2] P. J. Richerson and M. H. Christiansen, eds., *Cultural Evolution – Society, Technology, Language, and Religion*. Strüngmann Forum Reports. MIT Press, 2013.

[3] W. Greiner, ed., *Exciting Interdisciplinary Physics*, vol. 1 of *FIAS Interdisciplinary Science Series*. Springer Verlag, 2013.

[4] A. V. Korol, A. V. Solov'yov, and W. Greiner, *Channeling and Radiation in Periodically Bent Crystals*, vol. 69 of *Springer Series on Atomic, Optical, and Plasma Physics*. Springer Verlag, 2013.

[5] A. V. Solov'yov, ed., *Proceedings of the Second International Conference on "Dynamics of Systems on the Nanoscale" (DySoN 2012)*, vol. 438 of *Journal of Physics: Conference Series*. 2013.

FIAS Journal Publications 2013

Sorted according to frequency

Journal	Impact	2013
		214
Phys. Rev. C	3.31	39
Phys. Rev. Lett.	7.37	17
Phys. Rev. D	4.56	17
Phys. Lett. B	3.96	13
J. Phys. G: Nucl. Part. Phys.	4.18	6
Phys. Rev. A	2.88	6
Eur. Phys. J. C	3.63	6
J. of Biomolecular NMR	3.61	5
Int. J. Mod. Phys. E	0.60	5
Nucl. Phys. A	1.54	4
Ann. Phys. (NY)	2.86	4
Front. Psychology	1.59	4
PLOS Computational Biology	5.22	3
Advances in High Energy Physics	4.52	3
PLOS ONE	4.09	3
Progress in Particle and Nuclear Physics	2.61	3
Computational Materials Science	1.88	3
Neuron	14.74	2
Trends in Cognitive Sciences	12.59	2
Nucleic Acids Research	8.03	2
Journal of Neuroscience	7.12	2
Cerebral Cortex	6.54	2
JHEP	5.62	2
Journal of Vision	3.38	2
Computer Physics Communications	3.27	2
Vision Research	2.41	2
Phys. Rev. E	2.26	2
Europhys. Lett.	2.17	2
Physics of Plasmas	2.15	2
Journal of Instrumentation	1.87	2
Nucl. Inst. Meth. A	1.21	2
Chinese Physics Letters	0.73	2
Romanian Journal of Physics	0.53	2
Behavioral and Brain Sciences	9.40	1
Nature Communications	7.40	1
Structure	6.35	1
J. Cosmol. Astropart. Phys.	5.72	1
Neuro-Oncology	5.72	1
Mon. Not. R. Astron. Soc.	4.90	1
Schizophrenia Research	4.75	1
Astronomy and Astrophysics	4.59	1
IEEE Trans. on Neural Networks and Learning	3.77	1
Phys. Rev. B	3.69	1
European Journal of Neuroscience	3.63	1

Sorted according to impact factor

Journal	Impact	2013
		214
Neuron	14.74	2
Trends in Cognitive Sciences	12.59	2
Behavioral and Brain Sciences	9.40	1
Nucleic Acids Research	8.03	2
Nature Communications	7.40	1
Phys. Rev. Lett.	7.37	17
Journal of Neuroscience	7.12	2
Cerebral Cortex	6.54	2
Structure	6.35	1
J. Cosmol. Astropart. Phys.	5.72	1
Neuro-Oncology	5.72	1
JHEP	5.62	2
PLOS Computational Biology	5.22	3
Mon. Not. R. Astron. Soc.	4.90	1
Schizophrenia Research	4.75	1
Astronomy and Astrophysics	4.59	1
Phys. Rev. D	4.56	17
Advances in High Energy Physics	4.52	3
J. Phys. G: Nucl. Part. Phys.	4.18	6
PLOS ONE	4.09	3
Phys. Lett. B	3.96	13
IEEE Trans. on Neural Networks and Learning	3.77	1
Phys. Rev. B	3.69	1
Eur. Phys. J. C	3.63	6
European Journal of Neuroscience	3.63	1
J. of Biomolecular NMR	3.61	5
Journal of Vision	3.38	2
Phys. Rev. C	3.31	39
Computer Physics Communications	3.27	2
Journal of Geophysical Research: Space Phys	3.02	1
Phys. Rev. A	2.88	6
Ann. Phys. (NY)	2.86	4
Progress in Particle and Nuclear Physics	2.61	3
Consciousness and Cognition	2.56	1
Int. J. Mass Spectrom.	2.55	1
Scientific Reports	2.43	1
Vision Research	2.41	2
Molecules	2.39	1
Frontiers in Human Neuroscience	2.34	1
Journal of Computational Physics	2.31	1
Phys. Rev. E	2.26	2
Eur. Phys. J. A	2.19	1
Europhys. Lett.	2.17	2
Physics of Plasmas	2.15	2

Journal of Geophysical Research: Space Phys	3.02	1
Consciousness and Cognition	2.56	1
Int. J. Mass Spectrom.	2.55	1
Scientific Reports	2.43	1
Molecules	2.39	1
Frontiers in Human Neuroscience	2.34	1
Journal of Computational Physics	2.31	1
Eur. Phys. J. A	2.19	1
Front. Comput. Neurosci.	2.15	1
J. American Soc. for Information Science and	2.08	1
Neural Computation	1.88	1
J. Phys. B: At. Mol. Opt. Phys.	1.88	1
Molecular Physics	1.82	1
Biological Cybernetics	1.59	1
J. Phys. A: Math. Theor.	1.56	1
Computational Biology and Chemistry	1.55	1
Eur. Phys. J. D	1.48	1
physica status solidi (b)	1.32	1
Journal of Mathematical Physics	1.29	1
Eur. Phys. J. Plus	1.30	1
Computational and Theoretical Chemistry	1.23	1
Nucl. Inst. Meth. B	1.21	1
Multisensory Research	1.18	1
Physica Medica	1.07	1
Int. J. Mod. Phys. A	1.05	1
Cent. Eur. J. Phys.	0.91	1
EURASIP J. on Advances in Signal Processing	0.81	1
Biomolecular NMR Assignments	0.72	1
Front. Neurorobotics		1
Physics of Particles and Nuclei Letters		1

Front. Comput. Neurosci.	2.15	1
J. American Soc. for Information Science and	2.08	1
Neural Computation	1.88	1
Computational Materials Science	1.88	3
J. Phys. B: At. Mol. Opt. Phys.	1.88	1
Journal of Instrumentation	1.87	2
Molecular Physics	1.82	1
Front. Psychology	1.59	4
Biological Cybernetics	1.59	1
J. Phys. A: Math. Theor.	1.56	1
Computational Biology and Chemistry	1.55	1
Nucl. Phys. A	1.54	4
Eur. Phys. J. D	1.48	1
physica status solidi (b)	1.32	1
Eur. Phys. J. Plus	1.30	1
Journal of Mathematical Physics	1.29	1
Computational and Theoretical Chemistry	1.23	1
Nucl. Inst. Meth. B	1.21	1
Nucl. Inst. Meth. A	1.21	2
Multisensory Research	1.18	1
Physica Medica	1.07	1
Int. J. Mod. Phys. A	1.05	1
Cent. Eur. J. Phys.	0.91	1
EURASIP J. on Advances in Signal Processing	0.81	1
Chinese Physics Letters	0.73	2
Biomolecular NMR Assignments	0.72	1
Int. J. Mod. Phys. E	0.60	5
Romanian Journal of Physics	0.53	2
Front. Neurorobotics		1
Physics of Particles and Nuclei Letters		1

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