

Critical Point and Onset of Deconfinement 2016



Report of Contributions

Contribution ID: 1

Type: **Talk**

Existence of the critical endpoint in the vector meson extended linear sigma model

Monday, 30 May 2016 14:00 (30 minutes)

In the framework of an SU(3) (axial)vector meson extended linear sigma model with additional constituent quarks and Polyakov loops, we investigate the effects of (axial)vector mesons on the chiral phase transition. The parameters of the Lagrangian are set at zero temperature and we use a hybrid approach where in the effective potential the constituent quarks are treated at one-loop level and all the mesons at tree-level. We have four order parameters, two scalar condensates and two Polyakov loop variables and their temperature and baryochemical potential dependence are determined from the corresponding field equations. We investigate the thermodynamics of the system, and at zero temperature we compare our results with lattice calculations. We study, furthermore, the changes of the tree-level scalar meson masses in the hot and dense medium.

Primary author: WOLF, Gyorgy (Wigner FK)

Presenter: WOLF, Gyorgy (Wigner FK)

Session Classification: Parallel session 1

Contribution ID: 2

Type: **Talk**

Search for a mixed phase of QCD matter at NICA

Friday, 3 June 2016 11:30 (30 minutes)

The Nuclotron-based Ion Collider Facility (NICA) project is now under active realization at the Joint Institute for Nuclear Research (JINR, Dubna). The main goal of the project is an experimental study of hot and dense strongly interacting matter in heavy ion (up to Au) collisions at centre-of-mass energies up to 11 GeV per nucleon. Two modes of the operation are foreseen, collider mode and extracted beams, with the two detectors, MPD and BM@N. In the collider mode the average luminosity is $10E27 \text{ cm}^{-2} \text{ s}^{-1}$ for Au(79+). The fixed target experiment BM@N at the JINR superconducting synchrotron Nuclotron is in a preparation stage. Extracted beams of various nucleus species with maximum momenta 13 GeV/c (for protons) will be available. The NICA project also foresees a study of spin physics with the detector SPD with extracted and colliding beams of polarized deuterons and protons at centre-of-mass energies up to 27 GeV (for protons). The proposed program allows to search for possible signs of the phase transitions and critical phenomena as well as to shed light on the problem of nucleon spin structure. General design, construction status and physics program of the NICA complex will be presented.

Primary author: SORIN, Alexander (Joint Institute for Nuclear Research, Dubna)

Presenter: SORIN, Alexander (Joint Institute for Nuclear Research, Dubna)

Session Classification: Plenary session

Contribution ID: 4

Type: **Talk**

Chiral magnetic effect and chiral kinetic theory

Monday, 30 May 2016 15:00 (30 minutes)

A power expansion scheme is set up to determine the Wigner function that satisfies the quantum kinetic equation for spin-1/2 charged fermions in a background electromagnetic field. Vector and axial-vector current induced by magnetic field and vorticity are obtained simultaneously from the Wigner function. The chiral magnetic and vortical effect and chiral anomaly are shown as natural consequences of the quantum kinetic equation. The axial-vector current induced by vorticity is argued to lead to a local polarization effect along the vorticity direction in heavy-ion collisions.

Primary author: PU, Shi (USTC, China)

Presenter: PU, Shi (USTC, China)

Session Classification: Parallel session 2

Contribution ID: 5

Type: **Talk**

Surprises for the chemical freeze-out line from the new data in proton-proton and nucleus-nucleus collisions

Monday, 30 May 2016 14:00 (30 minutes)

New results of the NA61/SHINE and HADES collaborations, as well as the updated data from NA49, and the existing data from other collaborations are analyzed within the transport models and the hadron resonance gas (HRG) statistical model. The chemical freeze-out parameters in $p+p$ interactions and central $A+A$ collisions are found and compared with each other in the $\sqrt{s_{NN}} = 3.2\text{--}17.3$ GeV energy range.

The chemical freeze-out temperatures in $p+p$ interactions are found to be larger than the corresponding temperatures in central $A+A$ collisions. The temperature in $p+p$ slowly grows with energy from 130 to 175 MeV, in contrast to $A+A$ temperature, which increases very fast from zero and saturates at $T_{A+A} \simeq 156$ MeV. This value is lower than predicted by chemical freeze-out line in HRG previously, but is very close to the temperature found in HRG in $A+A$ at the LHC.

The largest difference $T_{p+p} - T_{A+A} \simeq 60$ MeV is at low energies. These temperatures are very close $T_{p+p} \simeq T_{A+A}$ at $\sqrt{s_{NN}} = 6.3 - 7.7$ GeV, and then the difference grows again reaching 20 MeV at the highest SPS energy. The radius R_{A+A} increases with collision energy, while R_{p+p} is approximately constant. More data at low energies are needed. The minimal requirements to the set of measured particles are obtained, see arXiv:1512.08025 for details.

Primary author: BEGUN, Viktor (Jan Kochanowski University)

Presenter: BEGUN, Viktor (Jan Kochanowski University)

Session Classification: Parallel session 2

Contribution ID: 6

Type: **Talk**

Fluctuations of the freeze-out temperature in Pb-Pb collisions at LHC

Friday, 3 June 2016 17:30 (30 minutes)

Many data in the High Energy Physics are, in fact, sample means. It is shown that when this exact meaning of the data is taken into account and the most weakly bound states are removed from the hadron resonance gas, the acceptable fit to the whole spectra of pions, kaons and protons measured at midrapidity in central Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV is obtained. The invariant distributions are predicted with the help of the Single-Freeze-Out Model (SFOM) in the chemical equilibrium framework. The new idea introduced into the SFOM in this work is to randomize one of the parameters of the model. It has turned out that the successful improvement is achieved only when the freeze-out temperature becomes a random variable and nothing is gained with the randomization of geometric parameters of the model. Low p_T pions and protons are reproduced simultaneously as well as p/π ratio. Additionally, correct predictions extend over lower parts of large p_T data. The method is applied to other centrality bins of Pb-Pb collisions and the results are also presented. Some more general, possible implications of this approach are pointed out.

Based on: D.Prorok, "Single Freeze-Out, Statistics and Pion, Kaon and Proton Production in Central Pb-Pb Collisions at $\sqrt{s_{NN}} = 2.76$ TeV", J. Phys. G: Nuclear and Particle Physics **43** (2016) 055101.

Primary author: PROROK, Dariusz (University of Wroclaw, Poland)

Presenter: PROROK, Dariusz (University of Wroclaw, Poland)

Session Classification: Parallel session 2

Contribution ID: 8

Type: **Talk**

Inverse Magnetic Catalysis in Nambu–Jona-Lasinio Model beyond Mean Field

Monday, 30 May 2016 14:30 (30 minutes)

We study inverse magnetic catalysis in the Nambu–Jona-Lasinio model beyond mean field approximation. The feed-down from mesons to quarks is embedded in an effective coupling constant at finite temperature and magnetic field. While the magnetic catalysis is still the dominant effect at low temperature, the meson dressed quark mass drops down with increasing magnetic field at high temperature due to the dimension reduction of the Goldstone mode in the Pauli-Villars regularization scheme.

Primary author: MAO, Shijun (Xian Jiaotong University)

Presenter: MAO, Shijun (Xian Jiaotong University)

Session Classification: Parallel session 2

Contribution ID: 12

Type: **Talk**

Non-perturbative production rate of photons with a lattice quark propagator –effect of vertex correction –

Thursday, 2 June 2016 15:00 (30 minutes)

We analyze the production rate of photons from the deconfined medium with a quark propagator obtained from a lattice QCD numerical simulation. We calculate the production rates non-perturbatively at two temperatures above T_c . The photon-quark vertex is determined gauge-invariantly so as to satisfy the Ward-Takahashi identity. It is found that the vertex correction modifies spectra quantitatively. The photon production rate shows a peculiar structure reflecting the dispersion relations and kinematics of quasi-particles. We discuss the origin of this structure.

Primary author: KIM, Taekwang (Osaka University)

Presenter: KIM, Taekwang (Osaka University)

Session Classification: Parallel session 2

Contribution ID: 13

Type: **Talk**

Understanding experimentally-observed fluctuations

Thursday, 2 June 2016 12:00 (30 minutes)

Fluctuation observables in relativistic heavy ion collisions measured by event-by-event analysis are important observables for the study of thermodynamics in primordial stage. In this talk, I will discuss some problems which have to be considered seriously when one compares the experimental results on fluctuations with theoretical study. In particular, I will discuss (1) non-equilibrium property of fluctuations, (2) finite-volume effects, and (3) effects of non-perfect efficiency of detectors on the measurement of fluctuations.

Approaches to resolving these problems will also be discussed.

Primary author: KITAZAWA, Masakiyo (Osaka University)

Presenter: KITAZAWA, Masakiyo (Osaka University)

Session Classification: Plenary session

Contribution ID: 14

Type: **Talk**

Thermal Model Description of Collisions of Small Nuclei.

Friday, 3 June 2016 11:00 (30 minutes)

The dependence of particle production on the size of the colliding nuclei is analysed in terms of the thermal model using the canonical ensemble.

The concept of strangeness correlation in clusters of sub-volume V_C is used to account for the suppression of strangeness.

A systematic analysis is presented of the predictions of the thermal model for particle production in collisions of small nuclei.

The pattern of the maxima in particle ratios as

a function of beam energy is quite special, as they do not occur at the same beam energy.

Also, the Λ/π^+ ratio shows a clear maximum even for the smallest systems while the maximum in the K^+/π^+ ratio disappears in small systems.

Primary author: CLEYMANS, Jean (University of Cape Town)

Presenter: CLEYMANS, Jean (University of Cape Town)

Session Classification: Plenary session

Contribution ID: 15

Type: **Talk**

Charm diffusion coefficient from nonzero momentum Euclidean correlator in temporal channel

Monday, 30 May 2016 16:00 (30 minutes)

We study a charm quark diffusion coefficient with nonzero momentum correlator on the quenched lattice. Starting from rather general requirements on the spectral function, we derive inequalities to constrain the value of the diffusion coefficient. These inequalities have quantities which can be measured on the lattice from temporal correlator with nonzero momentum. Using the inequalities and the numerical simulation on the lattice, we constrain the value of the diffusion coefficient for $1.5 < T/T_c < 4.5$.

Primary author: IKEDA, Atsuro (Osaka University)

Presenter: IKEDA, Atsuro (Osaka University)

Session Classification: Parallel session 1

Contribution ID: 16

Type: **Talk**

Cumulative production of pions by heavy baryonic resonances in proton-nucleus collisions

Monday, 30 May 2016 14:30 (30 minutes)

Pion production in the backward direction in the target rest frame is considered in proton-nucleus ($p+A$) collisions. Pions outside the kinematical boundary of proton-nucleon ($p+N$) collisions, the so called cumulative effect, is studied. Basic restrictions on the energy of pions emitted in the backward direction in $p+N$ and $p+A$ reactions are considered. These are restrictions that follow from energy-momentum conservation. It is argued that resonances with very high masses are the only source of the cumulative pions. The resonances are first created in $p+N$ reactions. Due to successive collisions with nuclear nucleons, the masses of these resonances may increase and simultaneously their longitudinal velocities decrease. It is suggested that these two effects give an explanation of the cumulative pion production. The heavy hadron-like systems with very high masses (heavy resonances, Hagedorn fireballs, quark-gluon bags, baryon and meson strings) are of primary importance for properties of strongly interacting matter at high temperatures and/or baryonic density. They may have also decisive influence on the transition between hadron matter and quark-gluon plasma, and define the type of this phase transition and existence of the QCD critical point itself. We also use the Ultra relativistic Quantum Molecular Dynamics model to describe the existing data and analyze some microscopic aspects of cumulative pion production in $p+A$ reactions.

Primary author: MOTORNENKO, Anton (Taras Shevchenko National University of Kyiv)

Presenter: MOTORNENKO, Anton (Taras Shevchenko National University of Kyiv)

Session Classification: Parallel session 1

Contribution ID: 18

Type: **Talk**

Dynamical fluctuations near the QCD critical point and their impact on the net-proton kurtosis

Friday, 3 June 2016 14:30 (30 minutes)

We investigate the kurtosis of the net-proton number and the chiral order parameter within the model of nonequilibrium chiral fluid dynamics for a crossover scenario near the critical point. Our model describes the interplay between a dynamical order parameter and a quark-gluon fluid during the expansion of the hot fireball created in a heavy-ion collision. A subsequent hadronization process allows us to study experimental observables via an event-by-event analysis. We aim at understanding the different impact of two distinct sources of fluctuations: First, initial state fluctuations and second, critical fluctuations created at the phase transition. Our results show that only the latter ones help develop a characteristic signal in the net-proton kurtosis around the crossover transition. We demonstrate that a suppression of the kurtosis is related to the equilibrium signal for criticality as seen in the net-baryon number susceptibility. Although effects of finite size and inhomogeneity are present, the signal in the net-proton kurtosis develops clearly.

Primary author: HEROLD, Christoph (Suranaree University of Technology)

Presenter: HEROLD, Christoph (Suranaree University of Technology)

Session Classification: Parallel session 2

Contribution ID: 19

Type: **Talk**

Measurement of virtual photons radiated from Au+Au collisions at $\sqrt{s}_{\text{beam}} = 1.23\text{A GeV}$ with HADES

Friday, 3 June 2016 16:00 (30 minutes)

Dileptons are a unique probe to study microscopic properties of nuclear matter under extreme conditions of temperature and density achieved in heavy-ion collisions. The low-mass excess radiation

(above cocktail) observed from SIS to top RHIC energies is well understood theoretically in terms of

strict VMD assuming strong broadening of the in-medium rho spectral function. This broadening is

linked to the coupling of vector mesons to baryons and anti-baryons and is expected to be maximal in

baryon-rich medium as formed at lowest beam energies.

This is the paramount topic of the experimental program of HADES conducted at SIS18 accelerator in GSI. Strong, non-linear system size dependence of the integrated yield above the NN reference has been extracted from former C+C and Ar+KCl runs [1].

This contribution will present results on virtual photon production from high statistics Au+Au at $\sqrt{s}_{\text{beam}} = 1.23\text{A GeV}$ data and confront them with the reference measured by HADES as well as with available model predictions. The integrated excess yield will be put in context of the dilepton excitation function measured in RHIC beam energy scan.

[1] G. Agakishiev et al. [HADES Collaboration], Phys. Rev. C **84** (2011) 014902

This work has been supported by TU Darmstadt: VH-NG-823, Helmholtz Alliance HA216/EMMI and GSI.

Primary author: HARABASZ, Szymon (TU Darmstadt / Jagiellonian University)

Presenter: HARABASZ, Szymon (TU Darmstadt / Jagiellonian University)

Session Classification: Parallel session 2

Contribution ID: 20

Type: **Talk**

PHENIX Levy analysis of Bose-Einstein correlation functions

Friday, 3 June 2016 16:30 (30 minutes)

The importance of the RHIC beam energy scan program is that comparing results at different energies (varied in the region where the transition from hadronic to quark matter is expected to occur) allows us to investigate the structure of QCD matter, and the quark-hadron transition. One of the best tools to gain information about the (soft) particle-emitting source is the measurement of Bose-Einstein or HBT correlations of identical bosons. Today, high energy physics experiments measure the scale parameter of these correlation functions (often called HBT radii) as a function of particle type, transverse momentum, azimuthal angle, collision energy, collision geometry. In this talk I present results from the RHIC PHENIX experiment, related to Bose-Einstein correlations and the search for the critical point. In our latest measurements, we utilize Levy-type sources, whose index of stability α may also yield information on the nature of the quark-hadron phase transition. I will discuss what the beam energy dependence of the pion source tells us about the critical point, then I present the latest status of the analysis of the Levy source parameters as a function of transverse momentum, and explain how the non-Gaussian shape of correlation functions is related to one of the critical exponents.

Primary author: KINCSES, Dániel (Eötvös Loránd University Budapest)

Presenter: KINCSES, Dániel (Eötvös Loránd University Budapest)

Session Classification: Parallel session 2

Contribution ID: 23

Type: **Talk**

Collective dynamics in smal sysytems

Saturday, 4 June 2016 10:00 (30 minutes)

The presence of collective expansion in small collision is discussed.
Approaches based on relativistic hydrodynamics are compared to existing data.
Possibilities to study fluctuations in the interaction region in small collision systems are described.

Primary author: BOŹEK, Piotr (AGH University of Science and Technology)

Presenter: BOŹEK, Piotr (AGH University of Science and Technology)

Session Classification: Plenary session

Contribution ID: 24

Type: **Talk**

Anisotropic hydrodynamics

Tuesday, 31 May 2016 11:30 (30 minutes)

Recent developments in anisotropic hydrodynamics will be reviewed.

Primary author: FLORKOWSKI, Wojciech (Institute of nuclear Physics, Krakow)

Presenter: FLORKOWSKI, Wojciech (Institute of nuclear Physics, Krakow)

Session Classification: Plenary session

Contribution ID: 25

Type: **Talk**

Bayesian analysis of new class of realistic hybrid EoS models based on M-R data

Tuesday, 31 May 2016 17:00 (30 minutes)

We performed a Bayesian analysis of a new class realistic models of two-phase equations of state (EoS) for hybrid stars and demonstrated that the observation of such a pair of high-mass twin stars would have a sufficient discriminating power to favor hybrid EoS with a strong first order phase transition over alternative EoS.

The new class of two-phase EoS is characterized by three main features:

- (1) stiffening of the nuclear EoS at supersaturation densities due to quark exchange effects (Pauli blocking) between hadrons, modelled by an excluded volume correction,
- (2) stiffening of the quark matter EoS at high densities due to multi-quark interactions and
- (3) possibility for a strong first order phase transition with an early onset and large density jump.

The third feature results from a Maxwell construction for the possible transition from the nuclear to a quark matter phase and its properties depend on the two parameters used for (1) and (2), respectively. Varying these two parameters one obtains a class of hybrid EoS that yields solutions of the Tolman-Oppenheimer-Volkoff (TOV) equations for sequences of hadronic and hybrid stars in the mass-radius diagram which cover the full range of patterns according to the Alford-Han-Prakash classification following which a hybrid star branch can be either absent, connected or disconnected with the hadronic one. The latter case often includes a tiny connected branch. The disconnected hybrid star branch, also called “third family”, corresponds to high-mass twin stars characterized by the same gravitational mass but different radii.

Primary author: AYRIYAN, Alexander (JINR)

Presenter: AYRIYAN, Alexander (JINR)

Session Classification: COST Action MP1304 “NewCompStar” WG2 Meeting

Contribution ID: 26

Type: **Talk**

Correlated fluctuations near the QCD critical point

Saturday, 4 June 2016 09:30 (30 minutes)

Recently, the STAR beam energy scan (BES) measured the multiplicity distributions of net protons with the maximum transverse momentum extended from 0.8 GeV to 2 GeV. The related higher cumulants (moments) present large deviations from the poisson baselines, showing the potential of discovery the QCD critical point in experiment.

In this talk, we introduce a freeze-out scheme for the dynamical models near the QCD critical point through coupling the classical particles with the correlated fluctuating sigma field [2]. For an infinite and stationary medium, such freeze-out scheme can reproduce the standard Staphanov formulas [3] for critical fluctuations. Within this framework, we calculate the correlated fluctuations of net protons emitted from the hydrodynamic freeze-out surface at various collision energies. A comparison with recent STAR BES data shows that our model could reproduce kurtosis (and C4) through tuning the related parameters, but always over-predicts the C2 and C3 data with the poisson/binomial baselines due to the positive contributions from the static critical fluctuations [2]. In the later part of this talk, we will briefly discuss the dynamical critical fluctuations, showing that the sign of C3 could be solved by the memory effects after a dynamical evolution [4].

[1] X. Luo PoS CPOD2014, 019 (2014).

[2] Lijia Jiang, Pengfei Li, Huichao Song, arXiv:1502.06164[nucl-th].

[3] M. Stephanov, Phys. Rev. Lett. 102, 032301 (2009).

[4] Lijia Jiang and Huichao Song, in preparation.

Primary author: SONG, Huichao (Peking Univ.)

Presenter: SONG, Huichao (Peking Univ.)

Session Classification: Plenary session

Contribution ID: 28

Type: **Talk**

Thermal Dileptons as Fireball Probes at SIS Energies

Thursday, 2 June 2016 14:00 (30 minutes)

Electromagnetic probes are radiated during the whole time evolution of a heavy-ion collision. They decouple from the collision zone once they are produced and carry valuable information about the properties of matter created inside the hot and dense fireball to the detector.

In particular, the yield of low-mass dileptons was identified to be sensitive to the fireball lifetime, while the slope in the intermediate-mass region of the dilepton invariant-mass spectrum can serve as a thermometer which is unaffected by blue-shift effects caused by the collective expansion of the medium [1].

Realistic thermal dilepton emission rates and an accurate description of the fireball's space-time evolution are needed to properly describe the contribution of in-medium signals to the dilepton invariant-mass spectrum.

Utilizing a coarse-graining method we extract local temperature, baryon and pion densities from hadronic transport simulations of Au+Au collisions at SIS energies. These serve as an input for the calculation of the pertinent radiation of thermal dileptons based on an in-medium ρ spectral function that describes available spectra at ultrarelativistic collision energies.

The obtained yields and slopes of the invariant-mass spectra [2] will be compared to the excitation function of the lifetime and temperatures of the fireball established at higher energies [1]. The results can serve as a baseline for future explorations by the HADES and CBM experiments at FAIR as well as the RHIC beam energy scan phase II.

[1] R. Rapp and H. van Hees, Phys. Lett. B 753 (2016) 586.

[2] T. Galatyuk, P. M. Hohler, R. Rapp, F. Seck and J. Stroth, arXiv:1512.08688 [nucl-th].

Primary author: SECK, Florian (TU Darmstadt)

Presenter: SECK, Florian (TU Darmstadt)

Session Classification: Parallel session 2

Contribution ID: 29

Type: **Talk**

Novel picture of the soft modes at the QCD critical point based on the FRG method

Monday, 30 May 2016 17:00 (30 minutes)

One of remarkable features in the expected structure of the QCD phase diagram is the existence of QCD critical point (CP), which is the end point of the phase boundary of the first-order between the hadronic phase and the QGP phase. At the CP, the phase transition becomes second order, and thus there should be gapless and long-life modes called the soft modes, which govern the low-energy dynamics. Thus revealing the precise nature of the soft modes has a decisive importance for understanding the dynamical properties of the system around the CP.

In this talk, we shall report on an intensive investigation [1] of the soft mode at the QCD CP on the basis of the functional renormalization group (FRG) method in the local potential approximation. We calculate the spectral function as a function of the energy and momentum in the scalar and pseudo-scalar channels in the quark-meson model on the basis of the recent development[2]. At finite baryon chemical potential with a finite quark mass, the baryon-number fluctuation is coupled to the scalar channel and the spectral function in the sigma channel has a support not only in the time-like and but also in the space-like regions, which correspond to the mesonic and the particle-hole phonon excitations, respectively. We find that the energy of the peak position of the latter becomes vanishingly small with the height being enhanced as the system approaches the QCD CP, which is a manifestation of the fact that the phonon mode is the soft mode associated with the second-order transition at the CP, as was suggested by some authors[3,4]. We also extract the dispersion curves of the mesonic and the phonon modes, which leads to a novel and striking finding that the dispersion curve of the would-be sigma mesonic mode crosses the light-cone into the space-like region, and then eventually merge into the phonon mode as the system approaches further close to the CP. This suggests that the sigma-mesonic mode also becomes soft at the CP, in contrast to the pionic mode. We also discuss implications of the results on the type of possible inhomogeneous phases at higher densities and experiments, and theoretical elaboration to incorporate higher-derivative effects.

[1] T. Yokota, T. Kunihiro and K. Morita, arXiv:1603.02147.

[2] R. A. Tripolt, L. von Smekal and J. Wambach, Phys. Rev. D 90, no. 7, 074031 (2014).

[3] H. Fujii and M. Ohtani, Phys. Rev. D 70, 014016 (2004).

[4] D. T. Son and M. A. Stephanov, Phys. Rev. D 70, 056001 (2004).

Primary author: YOKOTA, Takeru (Kyoto University, Japan)

Presenter: YOKOTA, Takeru (Kyoto University, Japan)

Session Classification: Parallel session 1

Contribution ID: 30

Type: **Talk**

Event-by-event multiplicity fluctuations in relativistic heavy ion collisions

Friday, 3 June 2016 17:00 (30 minutes)

Non-critical thermal fluctuations are important baselines in search of the critical point for the RHIC beam energy scan program. In this talk, we present our investigations on the non-critical baselines of cumulants of (net-conserved) charge distributions in relativistic heavy ion collisions. By deriving a general formula of multiplicity distribution in connect with the method used in experiment, we demonstrate the mismatch between experimental measurements (conditional probability distributions) and previous theoretical calculations (probability distributions in a given thermal system) on multiplicity distributions. From the general formula, we investigate how to obtain the basic statistical expectations of higher order cumulants from experiments with the help of the data of the reference multiplicity distribution and mean value distribution. We find that the improved baseline measure for multiplicity distribution mimics the negative binomial distribution instead of Poisson one, though the Poisson distribution was used as input in a specific statistical ensemble. Recently, we implement this idea to event-by-event hybrid model simulations, and calculate the higher order cumulants of charge (proton) distributions in HIC. Our results reasonably reproduce the data at $\sqrt{s_{NN}} = 200$ GeV but shows deviations at lower collisional energies.

References:

HJX, On the multiplicity distribution in statistical model: (I) negative binomial distribution, arXiv:1602.06378.

Jixin Li, HJX, Huichao Song, Event-by-event multiplicity fluctuations in VISHNU hybrid model, in prepare.

Primary author: XU, Haojie (Peking University)

Presenter: XU, Haojie (Peking University)

Session Classification: Parallel session 2

Contribution ID: 31

Type: **Talk**

Critical fluctuations in models with van der Waals interactions

Monday, 30 May 2016 16:30 (30 minutes)

Particle number fluctuations are considered within the full van der Waals (VDW) equation, which contains both attractive (mean-field) and repulsive (eigenvolume) interactions. Two steps to extend the VDW equation and make it appropriate for new physical applications are carried out:

(i) the grand canonical ensemble (GCE) formulation which allows to calculate the particle number fluctuations, and (ii) the inclusion of the quantum statistics which allows to describe the nuclear matter as a system of interacting nucleons.

The VDW equation is used to calculate the scaled variance, skewness, and kurtosis of nucleon number fluctuations in nuclear matter, and these quantities show singular behavior with rich structures around the critical point.

The strongly intensive measures Delta and Sigma of the particle number and excitation energy fluctuations are also considered, and, similarly, show singular behavior near the CP. The Delta measure is shown to be more sensitive to the

proximity of the critical point than the Sigma measure. Based on universality argument, similar behavior is expected to occur in the vicinity of the QCD critical point.

Additionally, the role of repulsive (eigenvolume) VDW interactions in the hadron resonance gas model is considered.

It is shown that the extraction of the chemical freeze-out parameters is very sensitive to the choice of eigenvolumes for different hadrons. Comparison to the lattice QCD is also explored.

Primary author: VOVCHENKO, Volodymyr

Presenter: VOVCHENKO, Volodymyr

Session Classification: Parallel session 1

Contribution ID: 32

Type: **Talk**

Vorticity in the QGP liquid and Lambda polarization at the RHIC BES energies

Tuesday, 31 May 2016 12:30 (30 minutes)

We study the formation of collective flow vorticity in non-central heavy ion collisions at RHIC Beam Energy Scan collision energy range, $\sqrt{s_{NN}} = 7.7 \dots 200$ GeV with state-of-the-art viscous hydro model, vHLE+UrQMD. With the model adjusted to approach the experimental data for rapidity, transverse momentum distributions and elliptic flow of produced hadrons, we explore the collision energy and centrality dependence of the thermal vorticity and the resulting polarization of produced Lambda baryons. We show the dependence of polarization on transverse momentum and rapidity.

Primary author: KARPENKO, Iurii (INFN Firenze)

Presenter: KARPENKO, Iurii (INFN Firenze)

Session Classification: Plenary session

Contribution ID: 33

Type: **Talk**

The Compressed Baryonic Matter (CBM) Experiment at FAIR

Wednesday, 1 June 2016 11:30 (30 minutes)

The CBM Experiment is one of the main four scientific pillars of the new Facility for Antiproton and Ion Research (FAIR). Its main objective is the study of the QCD phase diagram in the region of high baryon-densities. With nucleus-nucleus collisions at the SIS100 accelerator at beam energies up to 14 A GeV strongly interacting matter with densities about 10 times as high as normal nuclear matter can be produced. The experimental setup is designed to cope with highest interaction rates (up to 10 MHz), which for the first time will also allow to measure rare probes (open charm, light and heavy vector mesons) in the FAIR energy regime. We will report on the current status of the CBM experiment. Many detector subsystems have already completed their technical design reports, or will finalize them in 2016. The main achievements and challenges of these developments will be discussed. Also, a lot of effort is being spend on evaluating the physics performance of the experiment. An overview on the main results in the context of the CBM physics program will be given.

Primary author: BLUME, Christoph (Johann-Wolfgang-Goethe Univ. (DE))

Presenter: BLUME, Christoph (Johann-Wolfgang-Goethe Univ. (DE))

Session Classification: Plenary session

Contribution ID: 35

Type: **Talk**

Transport Theory Based on the Nambu— Jona-Lasinio Lagrangian

Saturday, 4 June 2016 09:00 (30 minutes)

Starting from the (Polyakov-) Nambu-Jona-Lasinio Lagrangian, (P)NJL, we formulate a transport theory which allows for describing the expansion of a quark-antiquark plasma and the subsequent transition to the hadronic world —without adding any new parameter to the standard (P)NJL approach, whose parameters are fixed to vacuum physics. This transport theory can be used to describe ultrarelativistic heavy-ion reaction data as well as to study the (first-order) phase transition during the expansion of the plasma. (P)NJL predicts such a phase transition for finite chemical potentials. In this contribution we give an outline of the necessary steps to obtain such a transport theory and present first results.

Primary author: AICHELIN, Joerg (Subatech)

Presenter: AICHELIN, Joerg (Subatech)

Session Classification: Plenary session

Contribution ID: 36

Type: **Talk**

Interplay between deconfinement and chiral properties

Friday, 3 June 2016 09:30 (30 minutes)

We study the relation between quark confinement and chiral symmetry breaking, and investigate interplay between confinement/deconfinement and chiral properties at finite temperatures. We analytically derive some relations of the Polyakov loop or its fluctuations with Dirac eigenmodes in temporally odd-number lattice QCD [1,2]. For these quantities related to confinement, the contribution from the low-lying Dirac eigenmodes is found to be negligibly small, while the modes are essential for chiral symmetry breaking. This result indicates that there is no direct, one-to-one correspondence between confinement/deconfinement and chiral symmetry breaking in QCD.

[1] T. M. Doi, K. Redlich, C. Sasaki and H. Suganuma, Phys. Rev. D92, 094004 (2015).

[2] T. M. Doi, H. Suganuma and T. Iritani, Phys. Rev. D90, 094505 (2014); H. Suganuma, T. M. Doi and T. Iritani, Prog. Theor. Exp. Phys. 2016, 013B06 (2016).

Primary author: SUGANUMA, Hideo (Kyoto University)

Presenter: SUGANUMA, Hideo (Kyoto University)

Session Classification: Plenary session

Contribution ID: 37

Type: **Talk**

Wounded quarks at the LHC

Saturday, 4 June 2016 12:30 (30 minutes)

We apply the wounded quark model to particle production and properties of the initial fireball in $A+A$, $p+A$, and $p+p$ collisions at the Large Hadron Collider (LHC). We find uniformity of the approach, as similar production of initial entropy per source is needed to explain particle production in all studied reactions and at all centralities. We also investigate event-by-event initial eccentricities and sizes, finding results as good or better than from the Glauber model with nucleons. In conclusion, the wounded quarks can be used as effective degrees of freedom at the LHC.

Primary author: BRONIOWSKI, Wojciech (IFJ PAN)

Presenter: BRONIOWSKI, Wojciech (IFJ PAN)

Session Classification: Plenary session

Contribution ID: 38

Type: **Talk**

Recent Results on Equation of States from NewCompStar

Tuesday, 31 May 2016 14:00 (30 minutes)

A brief summary on the recent result on compact star equation of state will be presented. I summarize the directions and activities of the NewCompStar working group on the physics of the strong interaction in cold dense nuclear and QCD medium exists in compact stars.

Primary author: BARNAFOLDI, Gergely (Wigner RCP Hungarian Academy of Sciences)

Presenter: BARNAFOLDI, Gergely (Wigner RCP Hungarian Academy of Sciences)

Session Classification: COST Action MP1304 "NewCompStar" WG2 Meeting

Contribution ID: 41

Type: **Talk**

Evaluation of the Motion of confined Particles

Thursday, 2 June 2016 14:30 (30 minutes)

We carry out numerical evaluations of the motion of classical particles in Minkowski space $calM^4$ which are confined to the inside of a bag. In particular, we analyze the structure of the paths evolving from the breaking of the dilatation symmetry, the conformal symmetry and the combination of both together. The confining forces arise directly from the corresponding nonconserved currents. We demonstrate in our evaluations that these particles under specific initial conditions move toward the interior of the bag.

Primary author: MILLER, David (Penn State)

Co-author: ROLLMANN, Dirk (Bielefeld University)

Presenters: MILLER, David (Penn State); ROLLMANN, Dirk (Bielefeld University)

Session Classification: Parallel session 1

Contribution ID: 42

Type: **Talk**

Particle production in nucleus-nucleus and pion-nucleus collisions at $E_{\text{kin}} = 0.8 - 2A \text{ GeV}$

Thursday, 2 June 2016 15:00 (30 minutes)

SMASH is a new hadronic transport model designed to describe the non-equilibrium evolution of heavy-ion collisions. After a brief introduction to the model, it will be shown that SMASH correctly reproduces the cross sections and maintains detailed balance. First comparisons to pion spectra measured by FOPI and HADES will be presented, demonstrating that the energy deposition and transverse expansion are correctly described. Predictions for the particle production in pion-nucleus collisions recently measured by HADES will be given. Understanding the hadronic interactions is the basis for the future exploration of effects of the phase transition.

Primary author: STEINBERG, Vinzent**Presenter:** STEINBERG, Vinzent**Session Classification:** Parallel session 1

Contribution ID: 43

Type: **Talk**

Transverse momentum and multiplicity fluctuations in Ar+Sc collisions at CERN SPS from NA61/SHINE

Monday, 30 May 2016 16:30 (30 minutes)

The NA61/SHINE experiment aims to discover the critical point of strongly interacting matter and study the properties of the onset of deconfinement. For these goals a scan of the two dimensional phase diagram ($T-\mu_B$) is being performed at the SPS by measurements of hadron production in proton-nucleus and nucleus-nucleus interactions as a function of collision energy and system size.

In this contribution preliminary results on transverse momentum and multiplicity fluctuations expressed in terms of strongly intensive quantities from the Ar+Sc energy scan will be presented. These fluctuations are supposed to be sensitive to the critical point existence. The NA61/SHINE results are compared with p+p and Be+Be energy scan as well as NA49 measurements and model predictions.

Primary author: ANDRONOV, Evgeny (St. Petersburg State University (RU))

Presenter: ANDRONOV, Evgeny (St. Petersburg State University (RU))

Session Classification: Parallel session 2

Contribution ID: 44

Type: **Talk**

$SU(2N_F)$ symmetry of QCD at high temperature and its implications

Friday, 3 June 2016 10:00 (30 minutes)

Given a gap in the Dirac spectrum at $T > T_c$ we show that the high-temperature QCD has a $SU(2N_F)$ symmetry. This symmetry prohibits the on-shell propagation of quarks and the only possible elementary objects in Minkowski space-time are confined $SU(2N_F)$ symmetric “hadrons”. We discuss what should be measured on the lattice in order to clarify a structure of these objects in order to understand what kind of matter we have in QCD at high temperature. An important question is also how we could experimentally distinguish it from the “quark-gluon plasma” picture.

Primary author: GLOZMAN, Leonid

Presenter: GLOZMAN, Leonid

Session Classification: Plenary session

Contribution ID: 45

Type: **Talk**

Probing the nature of phases across the phase transition at finite isospin chemical potential

Saturday, 4 June 2016 12:00 (30 minutes)

We compare the low eigenvalue spectra of the Overlap Dirac operator on two sets of configurations at $\mu_I/mu_I^c = 0.5$ and 1.5 generated with dynamical staggered fermions at these isospin chemical potential on $24^3 \times 6$ lattices. We find very small changes in the number of zero modes and low lying modes across the transition which is in stark contrast with those across the corresponding finite temperature phases where one sees a drop across the phase transition. Possible consequences are discussed.

Primary author: GAVAI, Rajiv V (Tata Institute, Mumbai, India)

Presenter: GAVAI, Rajiv V (Tata Institute, Mumbai, India)

Session Classification: Plenary session

Contribution ID: 46

Type: **Talk**

Repulsive interactions and their effects on the thermodynamics

Monday, 30 May 2016 15:00 (30 minutes)

In this talk we compare two approaches in modeling repulsive interactions among hadrons: the excluded-volume approximation and the S-matrix formalism. The latter provides a consistent treatment of broad resonances based on empirical scattering phase shifts. We shall apply these techniques to study the thermodynamics of the ($\pi N\Lambda$) system, with a particular focus on the fluctuation of Baryon charge in the thermal medium.

Primary author: LO, Pok Man (GSI)

Presenter: LO, Pok Man (GSI)

Session Classification: Parallel session 1

Contribution ID: 47

Type: **Talk**

On spectral functions and transport coefficients in QCD

Thursday, 2 June 2016 11:30 (30 minutes)

The computation of single particle spectral functions and transport coefficients with functional continuum methods is discussed. Results are presented for quark and meson, and glue ball spectral functions, as well as the temperature-dependent shear viscosity over entropy ratio.

Primary author: PAWLOWSKI, Jan M. (University of Heidelberg)

Presenter: PAWLOWSKI, Jan M. (University of Heidelberg)

Session Classification: Plenary session

Contribution ID: 48

Type: **Talk**

Across deconfinement transition

Friday, 3 June 2016 14:00 (30 minutes)

The deconfinement transition at vanishing chemical potential can be reliably studied by lattice simulations and its general features are by now well known. On the contrary, what happens at finite density is still largely unknown and in this talk I will review the results obtained in the last year regarding the dependence, for small density, of the (pseudo)critical temperature on the baryonic chemical potential.

Primary author: BONATI, Claudio (University of Pisa)

Presenter: BONATI, Claudio (University of Pisa)

Session Classification: Parallel session 1

Contribution ID: 49

Type: **Talk**

Dynamical gap generation in graphene with frequency dependent renormalization effects

Friday, 3 June 2016 16:00 (30 minutes)

In recent years there has been much interest in the study of graphene, which is a 2-dimensional crystal of carbon atoms that exhibits many interesting electronic properties and quantum effects. The dynamical generation of a gap would cause the system to undergo a phase transition to an insulating state. From a technological point of view, a finite gap would make graphene more promising as a potential material for producing novel electronic devices. A gap would also be theoretically interesting as a concrete realization of the phenomena of chiral symmetry breaking.

We consider the simplest form, mono-layer suspended graphene at half filling. The low energy dynamics are described by a continuum quantum field theory. The effective coupling is of order $c/v_F \sim 300$ times the fine structure constant of QED, where v_F is the velocity of a free electron in graphene. The system is strongly coupled and non-perturbative.

We solve a set of coupled Schwinger Dyson equations for frequency dependent fermion dressing functions. We include vertex corrections (using an ansatz which is constructed to preserve gauge invariance). We study frequency dependencies in the renormalization of the fermion Green functions and their influence on dynamical gap generation. The result is a critical coupling of ~ 3.2 . This is slightly larger than the most recent calculations in the literature and predicts (in agreement with experiment) that the insulating state does not form.

Primary author: CARRINGTON, Margaret (Brandon University)

Presenter: CARRINGTON, Margaret (Brandon University)

Session Classification: Parallel session 1

Contribution ID: 50

Type: **Talk**

PHENIX results on collective effects in small systems

Friday, 3 June 2016 15:00 (30 minutes)

Extensive measurements of azimuthal anisotropy in heavy-ion collisions, have provided invaluable insights on the expansion dynamics and the transport properties of the strongly interacting matter produced in collisions at RHIC and the LHC. However, recently a number of measurements from high-multiplicity collisions in small systems at RHIC and LHC, such as p+p, p+A, or d+Au, have found strong presence of flow-like collective effects.

A crucial open question is whether a fundamental change occurs in the reaction dynamics and the particle production mechanism, when the collision system-size is reduced from the values produced in central and mid-central heavy-ion collisions, to those obtained in small systems.

In recent experiments, the PHENIX Collaboration has made detailed differential measurements of anisotropic flow coefficients v_n of charged hadrons emerged from p+Au, d+Au and 3He+Au collisions at 200 GeV.

The results from these measurements will be presented and discussed.

Detailed comparisons to different model predictions and LHC data will be shown as appropriate.

Primary author: TARANENKO, Arkadiy (National Research Nuclear University MEPhI (RU))

Presenter: TARANENKO, Arkadiy (National Research Nuclear University MEPhI (RU))

Session Classification: Parallel session 2

Contribution ID: 51

Type: **Talk**

Field-particle dynamics for the kinetics of the chiral phase transition

Friday, 3 June 2016 16:30 (30 minutes)

We simulate the kinetics of the chiral phase transition in hot and dense strongly interacting matter within a novel kinetic-theory approach. Employing an effective linear σ model for quarks, σ mesons, and pions we treat the quarks within a test-particle ansatz for solving the Boltzmann transport equation and the mesons in terms of classical fields. The decay-recombination processes like $\sigma \leftrightarrow \bar{q} + q$ are treated using a kind of wave-particle dualism using the exact conservation of energy and momentum. After demonstrating the correct thermodynamic limit for particles and fields in a “box calculation” we apply the simulation to the dynamics of an expanding fireball similar to the medium created in ultrarelativistic heavy-ion collisions.

Primary author: VAN HEES, Hendrik (Goethe University Frankfurt)

Presenter: VAN HEES, Hendrik (Goethe University Frankfurt)

Session Classification: Parallel session 1

Contribution ID: 54

Type: **Talk**

News from strong interactions program of the NA61/SHINE experiment

Monday, 30 May 2016 11:00 (30 minutes)

The results from the analysis of fluctuations and correlations can help to discover the critical point of strongly interacting matter. In the NA61/SHINE experiment the strategy of locating the critical point relies on performing a two dimensional phase diagram ($T-\mu_B$) scan by measurements of fluctuations and correlations in proton-proton, proton-nucleus and nucleus-nucleus interactions as a function of collision energy and system size. Close to the critical point increase of fluctuations is predicted.

In this contribution the latest NA61/SHINE results on fluctuations and correlations from the p+p, Be+Be, and Ar+Sc energy scans will be presented. The NA61 experimental results will be compared with existing NA49 data and with model predictions.

Primary author: GREBIESZKOW, Katarzyna (Warsaw University of Technology (PL))

Presenter: GREBIESZKOW, Katarzyna (Warsaw University of Technology (PL))

Session Classification: Plenary session

Contribution ID: 55

Type: **Talk**

Higher order moments of net-charge multiplicity distribution in p+p interactions at SPS energies from NA61/SHINE

Friday, 3 June 2016 14:00 (30 minutes)

NA61/SHINE at the CERN SPS is a fixed-target experiment pursuing a rich physics program including measurements for heavy ion, neutrino and cosmic ray physics. The main goal of the ion program is to study the properties of the onset of deconfinement and to search for the signatures of the critical point. Specific property of the critical point – increase in the correlation length – makes fluctuations its basic signal. Recently, special interest is paid towards fluctuations of higher order moments as they are more sensitive to the correlation length than typically studied second order moments.

In this contribution preliminary results on higher order fluctuations of negatively charged hadrons and net-charge distribution in p+p interactions will be shown. The new data will be compared with model predictions.

Primary author: MAĆKOWIAK-PAWŁOWSKA, Maja Katarzyna (Warsaw University of Technology (PL))

Presenter: MAĆKOWIAK-PAWŁOWSKA, Maja Katarzyna (Warsaw University of Technology (PL))

Session Classification: Parallel session 2

Contribution ID: 56

Type: **Talk**

Symmetry breaking effect on the inhomogeneous chiral phase in the external magnetic field

Friday, 3 June 2016 17:00 (30 minutes)

The existence of the inhomogeneous chiral phase, where the chiral condensate is spatially modulated has been discussed from some effective model analysis.

The phase seems to emerge in compact stars because it appears around the conventional chiral phase transition line in the QCD phase diagram.

Assuming an inhomogeneous configuration called “dual chiral density wave (DCDW)”, where both scalar and pseudoscalar condensates are spatially modulated, the external magnetic field extends the DCDW phase over the low chemical potential (μ) region except for $\mu = 0$ in the chiral limit [1].

It seems the spread DCDW phase can be explored by the lattice QCD simulation.

Therefore we constitute the thermodynamic potential including the finite current quark mass around the critical point by the generalized Ginzburg-Landau expansion [2] to consider the effect of the explicit chiral symmetry breaking on the inhomogeneous chiral phase transition.

Consequently, we can see that the strong magnetic field extends the DCDW phase over the low μ region even if the current quark mass is finite [3].

The possibility of the exploration by the lattice QCD is phenomenologically discussed based on the result.

Besides, the inverse magnetic catalysis is also argued in the present model.

Reference

[1] T. Tatsumi, K. Nishiyama and S. Karasawa, Phys. Lett. B743, 66 (2015)

[2] D. Nickel, Phys. Rev. Lett. 103, 072301 (2009)

[3] R. Yoshiike and T. Tatsumi, Phys. Rev. D92, 116009 (2015)

Primary author: YOSHIIKE, Ryo (Kyoto university)

Presenter: YOSHIIKE, Ryo (Kyoto university)

Session Classification: Parallel session 1

Contribution ID: 58

Type: **Talk**

Status of Lattice QCD Simulations

Monday, 30 May 2016 09:00 (30 minutes)

Primary author: KARSCH, Frithjof (Bielefeld University)

Presenter: KARSCH, Frithjof (Bielefeld University)

Session Classification: Plenary session

Contribution ID: 59

Type: **Talk**

Limits on the experimental search for the CEP

Monday, 30 May 2016 09:30 (30 minutes)

Primary author: XU, Nu (LBNL)

Presenter: XU, Nu (LBNL)

Session Classification: Plenary session

Contribution ID: **60**

Type: **Talk**

Energy scan programs in HIC

Friday, 3 June 2016 09:00 (30 minutes)

Primary author: RUSTAMOV, Anar (National Nuclear Research Center (AZ))

Presenter: RUSTAMOV, Anar (National Nuclear Research Center (AZ))

Session Classification: Plenary session

Contribution ID: **66**

Type: **Talk**

Horizons, causality and information transfer

Tuesday, 31 May 2016 09:00 (30 minutes)

Primary author: SATZ, Helmut (Univ. Bielefeld)

Presenter: SATZ, Helmut (Univ. Bielefeld)

Session Classification: Plenary session

Contribution ID: 67

Type: **Talk**

Chiral criticality: confronting models with data

Tuesday, 31 May 2016 09:30 (30 minutes)

Primary author: FRIMAN, Bengt (GSI)

Presenter: FRIMAN, Bengt (GSI)

Session Classification: Plenary session

Contribution ID: 68

Type: **Talk**

Observation of the Critical Point in the Phase Diagram for Hot and Dense Nuclear Matter

Tuesday, 31 May 2016 11:00 (30 minutes)

Primary author: LACEY, Roy (State University of New York (US))

Presenter: LACEY, Roy (State University of New York (US))

Session Classification: Plenary session

Contribution ID: 71

Type: **Talk**

Inhomogeneous chiral condensates in the QCD phase diagram

Tuesday, 31 May 2016 16:00 (30 minutes)

Primary author: BUBALLA, Michael (T)

Presenter: BUBALLA, Michael (T)

Session Classification: COST Action MP1304 "NewCompStar" WG2 Meeting

Contribution ID: 72

Type: **Talk**

Consequences of simultaneous chiral symmetry restoration and deconfinement for the QCD phase diagram

Tuesday, 31 May 2016 16:30 (30 minutes)

Primary author: KLAEHN, Thomas (University of Wroclaw)

Presenter: KLAEHN, Thomas (University of Wroclaw)

Session Classification: COST Action MP1304 "NewCompStar" WG2 Meeting

Contribution ID: 73

Type: **Talk**

Cooling of neutron stars with stiff stellar matter

Tuesday, 31 May 2016 17:30 (30 minutes)

Primary author: GRIGORIAN, Hovik (Joint Institute for Nuclear Research)

Presenter: GRIGORIAN, Hovik (Joint Institute for Nuclear Research)

Session Classification: COST Action MP1304 "NewCompStar" WG2 Meeting

Contribution ID: 75

Type: **Talk**

Fluctuations in a finite volume

Tuesday, 31 May 2016 10:00 (30 minutes)

Primary author: SCHAEFER, Bernd-Jochen

Presenter: SCHAEFER, Bernd-Jochen

Session Classification: Plenary session

Contribution ID: 76

Type: **not specified**

From Glasma to QCD phase boundary

Monday, 30 May 2016 10:00 (30 minutes)

Primary author: MCLERRAN, Larry (BNL)

Presenter: MCLERRAN, Larry (BNL)

Session Classification: Plenary session

Contribution ID: **80**

Type: **Talk**

Searching for the QCD critical point through power-law fluctuations of the proton density in heavy ion collisions

Friday, 3 June 2016 14:30 (30 minutes)

Primary author: DAVIS, Nikolaos (Polish Academy of Sciences (PL))

Presenter: DAVIS, Nikolaos (Polish Academy of Sciences (PL))

Session Classification: Parallel session 1

Contribution ID: 83

Type: **Talk**

How to use Lattice and Experimental data for QCD Critical Point Search

Thursday, 2 June 2016 14:00 (30 minutes)

Primary author: NAKAMURA, Atsushi (Hiroshima Univ)

Presenter: NAKAMURA, Atsushi (Hiroshima Univ)

Session Classification: Parallel session 1

Contribution ID: 85

Type: **Talk**

Evolution of the QCD phase diagram

Thursday, 2 June 2016 16:15 (30 minutes)

Primary author: BAYM, Gordon (University of Illinois)

Presenter: BAYM, Gordon (University of Illinois)

Session Classification: Colloquium for Marek Gaździcki

Contribution ID: 86

Type: **Talk**

Energy scan programs in HIC

Thursday, 2 June 2016 16:00 (15 minutes)

Primary author: SEYBOTH, Peter (Jan Kochanowski University (PL))

Presenter: SEYBOTH, Peter (Jan Kochanowski University (PL))

Session Classification: Colloquium for Marek Gaździcki

Contribution ID: 87

Type: **Talk**

Critical Point of Nuclear Matter

Thursday, 2 June 2016 16:45 (30 minutes)

Primary author: GORENSTEIN, Mark (Bogolyubov Institute for Theoretical Physics)

Presenter: GORENSTEIN, Mark (Bogolyubov Institute for Theoretical Physics)

Session Classification: Colloquium for Marek Gaździcki

Contribution ID: **88**

Type: **Talk**

Marek & Event-by-Event Fluctuations

Thursday, 2 June 2016 17:15 (30 minutes)

Primary author: MRÓWCZYNSKI, Stanisław (Jan Kochanowski University)

Presenter: MRÓWCZYNSKI, Stanisław (Jan Kochanowski University)

Session Classification: Colloquium for Marek Gaździcki

Contribution ID: **90**

Type: **Talk**

Particle production at QCD phase boundary

Wednesday, 1 June 2016 09:00 (30 minutes)

Primary author: BRAUN-MUNZINGER, Peter (GSI - Helmholtzzentrum für Schwerionenforschung GmbH (DE))

Presenter: BRAUN-MUNZINGER, Peter (GSI - Helmholtzzentrum für Schwerionenforschung GmbH (DE))

Session Classification: Plenary session

Contribution ID: 91

Type: **Talk**

Production of light flavor hadrons in pp, p-Pb and Pb-Pb collisions with ALICE

Wednesday, 1 June 2016 09:30 (30 minutes)

Primary author: OESCHLER, Helmut (Technische Universitaet Darmstadt (DE))

Presenter: OESCHLER, Helmut (Technische Universitaet Darmstadt (DE))

Session Classification: Plenary session

Contribution ID: 92

Type: **Talk**

Chiral symmetry restoration versus deconfinement in heavy-ion collisions at high baryon density

Wednesday, 1 June 2016 10:00 (30 minutes)

Primary author: BRATKOVSKAYA, Elena (FIAS)

Presenter: BRATKOVSKAYA, Elena (FIAS)

Session Classification: Plenary session

Contribution ID: 94

Type: **Talk**

Future facilities for HIC

Monday, 30 May 2016 11:30 (30 minutes)

Primary author: FRIESE, Volker (GSI Darmstadt)

Presenter: FRIESE, Volker (GSI Darmstadt)

Session Classification: Plenary session

Contribution ID: 96

Type: **Talk**

Heavy flavor production at the QCD phase boundary

Thursday, 2 June 2016 09:00 (30 minutes)

Primary author: STACHEL, Johanna (Ruprecht-Karls-Universitaet Heidelberg (DE))

Presenter: STACHEL, Johanna (Ruprecht-Karls-Universitaet Heidelberg (DE))

Session Classification: Plenary session

Contribution ID: 97

Type: **Talk**

Fluctuation observables in heavy ion collisions

Thursday, 2 June 2016 09:30 (30 minutes)

Primary author: KOCH, Volker (LBNL)

Presenter: KOCH, Volker (LBNL)

Session Classification: Plenary session

Contribution ID: 98

Type: **Talk**

QCD transition and chemical freezeout in the presence of magnetic field

Thursday, 2 June 2016 10:00 (30 minutes)

Primary author: FUKUSHIMA, Kenji (The University of Tokyo)

Presenter: FUKUSHIMA, Kenji (The University of Tokyo)

Session Classification: Plenary session

Contribution ID: 99

Type: **Talk**

Effective dynamical models for fluctuations at the QCD transition

Thursday, 2 June 2016 11:00 (30 minutes)

Primary author: NAHRGANG, Marlene

Presenter: NAHRGANG, Marlene

Session Classification: Plenary session

Contribution ID: **100**

Type: **Talk**

From cold Fermi fluids to the hot QGP

Thursday, 2 June 2016 12:30 (30 minutes)

Primary author: BLUHM, Marcus (North Carolina State University)

Presenter: BLUHM, Marcus (North Carolina State University)

Session Classification: Plenary session

Contribution ID: **101**Type: **Talk**

Hadron production at SIS energies: an update from HADES

Wednesday, 1 June 2016 12:30 (30 minutes)

Data on particle production in heavy ion collisions in the energy regime of 1-2 A GeV have been collected over almost three decades now. As most of the newly created hadrons are produced below or slightly above their free NN-thresholds, data are usually interpreted with the help of phenomenological models, rather than comparing to elementary reference measurements. Driven by advance in detector technology, more and more rare and penetrating probes have become accessible, and still keep challenging our knowledge about the properties of the created system and its dynamical evolution. In this contribution we give an overview of the recent findings on strangeness production from HADES, with a special emphasis on the data from Au+Au collisions at 1.23 A GeV. We discuss particle yields with respect to several transport and a statistical model fit and put a special emphasis on the rise of the ϕ/K^- ratio towards lower energies and its implication for the interpretation of sequential kaon freeze-out.

Primary author: LORENZ, Manuel (University Frankfurt)

Presenter: LORENZ, Manuel (University Frankfurt)

Session Classification: Plenary session

Contribution ID: 102

Type: **Talk**

Centrality determination and multiplicity fluctuations in Ar+Sc collisions at CERN SPS from NA61/SHINE

Monday, 30 May 2016 16:00 (30 minutes)

The preliminary centrality determination procedure and charge hadron multiplicity fluctuations are investigated in the new Ar+Sc data at 13A, 19A, 30A, 40A, 75A, 150A GeV/c with NA61/SHINE at the SPS. The centrality analysis is based on nucleon-spectator energy in the forward hemisphere from the Projectile spectator detector. The scaled variance for all, negatively and positively charged hadrons is presented for different centrality classes. Results are discussed and compared with p+p and Be+Be NA61/SHINE data and the EPOS 1.99 simulations.

Primary author: SERYAKOV, Andrey (St. Petersburg State University (RU))

Presenter: SERYAKOV, Andrey (St. Petersburg State University (RU))

Session Classification: Parallel session 2

Contribution ID: **103**Type: **Poster**

Composite particles - effects of substructure

The concept to classify particles as bosons and fermions and to assume certain properties is very successful in physics. One should keep in mind that for composite particles this classification is an approximation. In that case the investigated particles are not primitive particles and truly are composed by several bosons or fermions.

The authors try to get estimates on the errors made, by the assumption of primitive particle properties. Also we look for effects that could be missed by such a treatment. One easy example is the interaction of deuterons, which is influenced by the properties of the forming protons. This could be extended to baryons and other composite fermions.

Primary author: Mr LEIBING, Simon (TU Freiberg)

Co-author: BLASCHKE, David (University of Wroclaw)

Presenter: Mr LEIBING, Simon (TU Freiberg)

Session Classification: Poster session

Contribution ID: 106

Type: **Talk**

Off-equilibrium Non-Gaussian Cumulants: criticality, complexity, and universality

Saturday, 4 June 2016 11:30 (30 minutes)

Non-equilibrium evolution of cumulants of critical fluctuations for space-time trajectories on the cross-over side of the QCD phase diagram will be discussed in detail. Memory effects are important. Utilizing a simple model of the space-time evolution of a heavy-ion collision, we demonstrate that, depending on the relaxation rate of critical fluctuations, Skewness and Kurtosis can differ significantly in magnitude as well as in sign from equilibrium expectations. Furthermore, we demonstrate that key features of the Kibble-Zurek framework of non-equilibrium phase transitions can be employed to extract the dynamics of critical cumulants for differing protocols—trajectories in the space of parameters in the vicinity of the QCD critical point. For a broad classification of crossover protocols, universal scaling functions are obtained for the cumulants that are insensitive to the parameters governing the protocols. As a consequence of this non-equilibrium universality, a map of the details of critical dynamics in heavy-ion collisions to the relevant Kibble-Zurek parameters is feasible and provides powerful model independent guidance in searches for the QCD critical point.

Primary author: MUKHERJEE, Swagato (Brookhaven National Laboratory)

Presenter: MUKHERJEE, Swagato (Brookhaven National Laboratory)

Session Classification: Plenary session

Contribution ID: **107**

Type: **Talk**

STAR BES-I highlights and RHIC BES-II program

Wednesday, 1 June 2016 12:00 (30 minutes)

Primary author: XU, Zhangbu (Brookhaven National Laboratory)

Presenter: XU, Zhangbu (Brookhaven National Laboratory)

Session Classification: Plenary session

Contribution ID: **108**Type: **Talk**

Quark matter in neutron stars

Tuesday, 31 May 2016 14:30 (30 minutes)

This talk will describe the continuing development of a consistent picture of the liquid interiors of neutron stars, driven by three recent advances: observations of heavy neutron stars with masses ~ 2.0 solar masses; determinations of masses and radii simultaneously for an increasing number of neutron stars; and an emerging understanding in QCD of how nuclear matter can turn into deconfined quark matter in the interior.

Primary author: BAYM, Gordon (University of Illinois)

Presenter: BAYM, Gordon (University of Illinois)

Session Classification: COST Action MP1304 "NewCompStar" WG2 Meeting

Contribution ID: **109**Type: **Talk**

Systematic Extraction of QGP Properties

Monday, 30 May 2016 12:00 (30 minutes)

One of the motivations for the RHIC beam energy scan program was its capability of providing data for the determination of the temperature- and baryon-density dependence of QGP transport coefficients, such as the specific shear viscosity. This task is complicated by the rich set phenomena that computational models commonly used for the determination of the transport coefficients need to address, ranging from pre-equilibrium evolution to fluctuations around the QCD critical point.

In my talk I will demonstrate an new method for determining the physics parameters that drive the dynamics of computational models, utilizing Bayesian statistics and a multi-parameter model to data comparison. We shall use a state-of-the-art hybrid model for calculating the time-evolution of a heavy-ion collision, including that of the QGP phase and its subsequent decay into the hadronic final state. RHIC-BES data will be utilized to extract first hints for a possible baryo-chemical potential dependence of the QGP specific shear viscosity.

Primary author: BASS, Steffen (Duke University)

Presenter: BASS, Steffen (Duke University)

Session Classification: Plenary session

Contribution ID: **110**Type: **Talk**

Chiral symmetry breaking in continuum QCD

Monday, 30 May 2016 17:30 (30 minutes)

Model parameter free investigations of Yang-Mills theory and quenched QCD in the vacuum are presented as a necessary prerequisite for corresponding investigations of the QCD phase structure with the functional renormalisation group equation. Preliminary results for Yang-Mills theory at finite temperature are discussed. Finally, a phenomenological application of the vacuum results to the eta-prime-meson mass at the chiral crossover is presented.

Primary author: MITTER, Mario (Univ. Heidelberg)

Presenter: MITTER, Mario (Univ. Heidelberg)

Session Classification: Parallel session 1

Contribution ID: 111

Type: **Talk**

Fluctuations of charges at the phase boundary

Monday, 30 May 2016 12:30 (30 minutes)

In this talk, I will first summarize the critical behavior of fluctuations of conserved charges expected in the vicinity of the chiral phase boundary. Then, I will show how the finite quark mass or finite volume modifies the divergent cumulants in QCD-like model calculations. Particular emphasis will be put on the importance of the regular contribution to the fluctuations when the singular part contribution is smeared. I will show that the electric charge fluctuations can have non-trivial effects by imposing momentum cuts even in the absence of the criticality.

Primary author: MORITA, Kenji (Kyoto University)

Presenter: MORITA, Kenji (Kyoto University)

Session Classification: Plenary session

Contribution ID: 112

Type: **Talk**

Electromagnetic probes from SIS18 to LHC energies in coarse-grained transport simulations

Thursday, 2 June 2016 14:30 (30 minutes)

Electromagnetic radiation in heavy-ion collisions at SIS18, FAIR, SPS, RHIC and LHC energies is studied within an approach which uses coarse-grained transport simulations to calculate thermal dilepton and photon emission applying in-medium spectral functions from hadronic many-body theory and partonic production rates based on lattice calculations. The microscopic output from the Ultra-relativistic Quantum Molecular Dynamics (UrQMD) model is hereby put on a grid of space-time cells which allows to extract the local temperature and chemical potential in each cell via an equation of state. The comparison of data and model outcome shows that the invariant mass and transverse momentum spectra can be described by a cocktail of hadronic decay contributions together with thermal emission from broadened vector-meson spectral functions and (for higher collision energies) from the Quark-Gluon Plasma phase. Besides a comparison to existing experimental data, predictions for LHC energies are presented and it is analysed under which conditions one might observe signals of a phase transition at FAIR energies. We argue that the high luminosities available at the future Facility for Antiproton and Ion Research enable systematic studies of - e.g. - system size, energy and momentum dependence, which would allow for better constraints on existing models and a deeper insight into the structure of the QGP phase diagram.

Primary author: ENDRES, Stephan (Frankfurt University / Frankfurt Institute for Advanced Studies)

Presenter: ENDRES, Stephan (Frankfurt University / Frankfurt Institute for Advanced Studies)

Session Classification: Parallel session 2

Contribution ID: 113

Type: **Talk**

Recent progress in understanding deconfinement and chiral symmetry breaking transitions

Saturday, 4 June 2016 11:00 (30 minutes)

While the crucial role of gauge topology was recognized from 1970's, confinement was associated with monopoles and chiral symmetry breaking with instantons. Recognizing presence of non-zero holonomy, van Baal and others discovered splitting of the instantons into their constituents —the instanton-dyons. Several groups now work out properties of their ensembles, which generate both the deconfinement and chiral phase transitions in QCD-like theories. Introducing variable phases for quark periodicity conditions —known as flavor holonomies —one can switch fermion coupling to different dyons, and thus dramatically change both the order and temperature of both transitions. First lattice studies of modified —so called Z_N -symmetric QCD —have also found these effects.

Primary author: SHURYAK, Edward (Stony Brook University)

Presenter: SHURYAK, Edward (Stony Brook University)

Session Classification: Plenary session

Contribution ID: 114

Type: **Poster**

Centrality determination in heavy-ion collisions with CBM experiment

The size and evolution of the medium created in a heavy-ion collision depends on collision geometry. Experimentally collisions are characterized by the measured particles multiplicities around midrapidity or energy measured in the forward rapidity region, which is sensitive to the spectator fragments. In the CBM experiment the multiplicity of produced particles is measured with the silicon tracking system (STS). The projectile spectator detector (PSD) is sensitive to spectator fragments. We present the procedure of collision centrality determination in CBM and its performance using the PSD and the STS information.

Primary authors: SELYUZHENKOV, Ilya (GSI - Helmholtzzentrum für Schwerionenforschung GmbH (DE)); KLOCHKOV, Viktor (GSI)

Presenters: SELYUZHENKOV, Ilya (GSI - Helmholtzzentrum für Schwerionenforschung GmbH (DE)); KLOCHKOV, Viktor (GSI)

Session Classification: Poster session

Contribution ID: 115

Type: **Talk**

Mean pion multiplicities in Ar+Sc collisions

Monday, 30 May 2016 17:30 (30 minutes)

The investigation of preliminary results for mean negatively charged pion multiplicities $\langle\pi^{-}\rangle$ from Ar+Sc collisions is the main topic of the talk.

The data has been taken recently by the NA61/SHINE collaboration for a wide range of momenta - 13, 19, 30, 40, 75 and 150 A GeV/c. Starting with rapidity distribution of differential spectra $\frac{dn}{dy}$ extrapolated to unmeasured regions, the procedure of obtaining the final multiplicities is presented. The mean number of wounded nucleons

$\langle W \rangle$ extracted from Glissando MC model is used to obtain the $\langle\pi^{-}\rangle/\langle W \rangle$ ratio. Using data from other experiments,

the comparison of $\langle\pi^{-}\rangle/\langle W \rangle$ for different collisions and momenta is discussed.

Primary author: NASKREŃ, Michał (University of Wrocław (PL))

Presenter: NASKREŃ, Michał (University of Wrocław (PL))

Session Classification: Parallel session 2

Contribution ID: 117

Type: **Poster**

Quasi-Particle Quark-Nuclear Hybrid EoS with Excluded Volume Effects

In this poster, we outline a two-phase description of the quark-nuclear matter hybrid equation of state that takes into account effects of phase space occupation (excluded volume) in both, the hadronic and the quark matter phases. For the nuclear matter phase, the reduction of the available volume at increasing density leads to a stiffening, while for the quark matter phase a reduction of the effective string tension in the confining density functional is obtained. The deconfinement phase transition in the resulting hybrid equation of state is sensitive to both excluded volume effects. As an application, we consider matter under compact star constraints of electric neutrality and β -equilibrium. We obtain mass-radius relations for hybrid stars that fulfill the $2M_{\odot}$ constraint and exhibit the high-mass twin phenomenon. Both features depend sensitively on the excluded volume.

Primary author: KALTENBORN, Mark (University of Wrocław)

Presenter: KALTENBORN, Mark (University of Wrocław)

Session Classification: Poster session

Contribution ID: **118**

Type: **Talk**

QCD in stars

Tuesday, 31 May 2016 15:00 (30 minutes)

We delineate properties of cold, dense QCD matter through equations of state supposed from observational constraints on neutron stars.

Primary author: KOJO, Toru (University of Illinois, Urbana-Champaign)

Presenter: KOJO, Toru (University of Illinois, Urbana-Champaign)

Session Classification: COST Action MP1304 "NewCompStar" WG2 Meeting

Contribution ID: 119

Type: **Talk**

Directed flow in heavy-ion collisions and softening of equation of state

Tuesday, 31 May 2016 12:00 (30 minutes)

We analyze the directed flow (v_1) of protons and pions in high-energy heavy-ion collisions in the incident energy range from $\sqrt{s_{NN}} = 7.7$ GeV to 27 GeV within a microscopic transport model [1].

Standard hadronic transport approaches do not explain the collapse of directed flow below $\sqrt{s_{NN}} \simeq 20$ GeV.

By contrast, when we take account of a softening of the equation of state via the attractive orbit scattering [2],

we can well describe the behavior of directed flow data recently obtained by the STAR collaboration [3].

We argue that the observed collapse of directed flow at midrapidity at $9 \text{ GeV} \leq \sqrt{s_{NN}} \leq 20 \text{ GeV}$ is the evidence for the softening of the QCD equation of state.

We also discuss the possible density region where the softening takes place.

[1] Y. Nara, A. Ohnishi, H. Stöcker, arXiv:1601.07692 [hep-ph].

[2] H. Sorge, Phys. Rev. Lett. 82 (1999), 2048;

P. Danielewicz and S. Pratt, Phys. Rev. C 53 (1996), 249.

[3] L. Adamczyk et al. [STAR Collaboration], Phys. Rev. Lett. 112 (2014), 162301.

Primary author: OHNISHI, Akira (Kyoto University)

Presenter: OHNISHI, Akira (Kyoto University)

Session Classification: Plenary session

Contribution ID: 120

Type: **Talk**

Polyakov loop fluctuations in terms of Dirac eigenmodes

Friday, 3 June 2016 12:00 (30 minutes)

We investigate the relation between quark confinement and chiral symmetry breaking in the finite-temperature lattice QCD. First of all, we derive analytical formulae to express the Polyakov loop and its fluctuations in terms of the Dirac eigenmodes[1-3]. Based on the analytical formulae, it is shown that the low-lying Dirac modes have little contribution to the quantities such as the Polyakov loop and its fluctuations while these modes are important for chiral symmetry breaking. In other words, the result means no direct one-to-one correspondence between confinement and chiral symmetry breaking in QCD. In our talk, we present our results including the numerical results and the recent developments.

[1] T. M. Doi, K. Redlich, C. Sasaki and H. Suganuma, Phys. Rev. D92, 094004 (2015).

[2] T. M. Doi, H. Suganuma and T. Iritani, Phys. Rev. D90, 094505 (2014).

[3] H. Suganuma, T. M. Doi and T. Iritani, Prog. Theor. Exp. Phys. 2016, 013B06 (2016).

Primary author: DOI, Takahiro (Japan/Kyoto University)

Presenter: DOI, Takahiro (Japan/Kyoto University)

Session Classification: Plenary session

Contribution ID: **121**Type: **Talk**

Photon emission in the vicinity of a critical point

Wednesday, 1 June 2016 11:00 (30 minutes)

We address holographically (i) an emulation of deconfinement upon temperature increase as sequential or instantaneous melting (disappearance) of normalizable eigenmodes of hadron states with a Regge type spectrum in vacuum, and (ii) the phase diagram within the updated DeWolfe-Gubser-Rosen model. Photon emission rates are calculated and found to map out the peculiarities (CEP and first-order phase transition) of the phase diagram emerging from a quark-meson model with linearized fluctuations.

Primary author: KAMPFER, Burkhard (HZDR & TU Dresden)

Presenter: KAMPFER, Burkhard (HZDR & TU Dresden)

Session Classification: Plenary session

Contribution ID: 122

Type: **Talk**

Critical Phenomena in the Nonextensive Nambu Jona-Lasinio Model

Friday, 3 June 2016 15:00 (30 minutes)

We present a thermodynamical analysis of the nonextensive, QCD-based, Nambu - Jona-Lasinio model (NJL) of strongly interacting matter in the critical region. It is based on the nonextensive generalization of the Boltzmann-Gibbs (BG) statistical mechanics, used in the NJL model, to its nonextensive version. This can be introduced in different ways, depending on different possible choices of the form of the corresponding nonextensive entropies, which are all presented and discussed in detail. Unlike previous attempts the present approach fulfils the basic requirements of thermodynamical consistency. Detailed calculations of entropy and specific heat are presented. Phase diagram in the critical region, in the in the (T,μ) plane, is shown for different values of non-extensivity.

Primary author: ROŻYNEK, Jacek (NCBJ Warsaw Poland)

Presenter: ROŻYNEK, Jacek (NCBJ Warsaw Poland)

Session Classification: Parallel session 1

Contribution ID: 123

Type: **Poster**

Phase diagram of the three-flavor PNJL model

The QCD phase diagram and transitions between quark and hadron phases are in the focus of recent investigations in both theoretical and experimental fields of heavy energy physics. For a description of matter at high temperature and density effective models of Nambu-Jona-Lasinio-type have proven most useful. On the basis of NJL-type models it is possible to describe the chiral restoration transition and to describe the quark-gluon coupling and confinement transition, when the Polyakov loop is included. The Polyakov loop extended NJL (PNJL) model can reproduce results of lattice QCD at zero and imaginary chemical potential, where LQCD has no sign problem. In this poster contribution we present the dependence of the first-order phase transition line and its critical endpoint in the PNJL model phase diagram when the following aspects are taken into account:

- different parametrizations of the effective potential $U(\Phi, \bar{\Phi}; T)$
- including the coupling of quarks to a repulsive vector mean field,
- modification of the quark interaction by “entanglement” with the Polyakov loop.

Primary author: FRIESEN, Alexandra (Joint Institute for Nuclear Research, Dubna)

Presenter: FRIESEN, Alexandra (Joint Institute for Nuclear Research, Dubna)

Session Classification: Poster session

Contribution ID: 124

Type: **Poster**

Physical properties of Polyakov loop geometrical clusters in SU(2) gluodynamics

A novel approach to identify the geometrical (anti)clusters formed by the Polyakov loops of the same sign and to study their properties in the lattice SU(2) gluodynamics is developed. The (anti)cluster size distributions are analyzed for the lattice coupling constant β

$\beta = [2.3115; 3]$. The found distributions are similar to the ones existing in 2- and 3-dimensional Ising systems. 2.52 as a transition between two liquids during which one of the liquid droplets (the largest cluster of a certain Polyakov loop sign) experiences a condensation, while another droplet (the next to the largest cluster of opposite Polyakov loop sign) evaporates. The clusters of smaller sizes form two accompanying gases, which behave oppositely to their liquids. The liquid drop formula is used to analyze the distributions of the gas (anti)clusters and to determine their bulk, surface and topological parts of free energy. Surprisingly, even the monomer multiplicities are reproduced with high quality within such an approach. The behavior of surface tension of gaseous (anti)clusters is studied. It is shown that this quantity can serve as an order parameter of the deconfinement phase transition in SU(2) gluodynamics. Moreover, the critical exponent of surface tension coefficient of gaseous clusters is found in the upper vicinity of critical temperature. Its value coincides with the one found for 3 dimensional Ising model within error bars. The Fisher topological exponent of (anti)clusters is found to have the same value 1.806 ± 0.008 , which agrees with an exactly solvable model of the nuclear liquid-gas phase transition [2] and disagrees with the Fisher droplet model [3], which may evidence for the fact that the SU(2) gluodynamics and the model [2] are in the same universality class.

[1] L. Moretto et al., Phys. Rev. Lett. 94, 202701 (2005).

[2] V. Sagun, A. Ivanytskyi, K. Bugaev and I. Mishustin, Nucl. Phys. A 924, 24 (2014).

[3] M. E. Fisher, Physics 3, 255 (1967).

Primary author: IVANYTSKYI, Oleksii (National Academy of Sciences of Ukraine (UA))

Co-authors: OLIINYCHENKO, Dmytro (CERN); NIKONOV, Eduard (Joint Institute for Nuclear Research (JINR)); ILGENFRITZ, Ernst-Michael (Joint Institute for Nuclear Research Dubna, Russia); ZINOVJEV, Gennady (National Academy of Sciences of Ukraine (UA)); MISHUSTIN, Igor (Goethe University); Prof. BUGAEV, Kyrill (Bogolyubov Institute for Theoretical Physics of NAS of Ukraine); SAGUN, Violetta

Presenter: IVANYTSKYI, Oleksii (National Academy of Sciences of Ukraine (UA))

Session Classification: Poster session

Contribution ID: 125

Type: **Talk**

Pion spectra in Ar+Sc interactions at SPS energies

Monday, 30 May 2016 17:00 (30 minutes)

The aim of the NA61/SHINE ion programme is to explore the QCD phase diagram within the range of thermodynamical variables accessible by the SPS. In addition the experiment provides precision hadron production measurements for description of the neutrino beam of the T2K experiment at J-PARC and for simulation of cosmic-ray showers for the Pierre Auger Observatory and KASCADE experiments. The main physics goals of the NA61/SHINE ion programme are the study of the properties of the onset of deconfinement and the search for signatures of the critical point of strongly interacting matter. These goals are pursued by performing an energy (beam momentum 13A-158A GeV/c) and system size (p+p, p+Pb, Be+Be, Ar+Ca, Xe+La, Pb+Pb) scan. In this talk I will discuss recent analysis results of Ar+Sc interactions at six beam momenta: 13A, 19A, 30A, 40A, 75A, 150A GeV/c. I will present the rapidity and transverse mass spectra of pions obtained with the “h-” analysis method. The newly obtained data will be compared with different collision systems, namely: p+p, Be+Be and Pb+Pb.

Primary author: LEWICKI, Maciej (University of Wroclaw)

Presenter: LEWICKI, Maciej (University of Wroclaw)

Session Classification: Parallel session 2

Contribution ID: 126

Type: **Poster**

Mott-hadron resonance gas and lattice QCD thermodynamics

We present an effective model for low-energy QCD thermodynamics which provides a microscopic interpretation of the transition from a gas of hadron resonances to the quark-gluon plasma by Mott dissociation of hadrons and compare results with data from lattice QCD simulations. We consider the thermodynamics of the Polyakov-loop extended Nambu–Jona-Lasinio (PNJL) model within the self consistent approximation scheme of the ϕ -derivable approach. This allows us to obtain the Generalized Beth-Uhlenbeck (GBU) equation of state. Our approach goes beyond the mean-field description of quark matter by taking into account hadronic correlations (bound and scattering states) as well as their backreaction on the propagator of constituents. The next step in our work is to include more hadronic degrees of freedom than just the low-lying pseudoscalar mesons. For that purpose we discuss a model for the generic behavior of hadron masses and phase shifts at finite temperature which shares basic features with recent developments within the PNJL model for correlations in quark matter.

Primary author: ALEKSANDR, Dubinin (University of Wrocław)

Presenter: ALEKSANDR, Dubinin (University of Wrocław)

Session Classification: Poster session

Contribution ID: 127

Type: **Poster**

CBM performance for anisotropic flow measurements

Compressed Baryonic Matter experiment (CBM) at FAIR has a potential of discoveries in the area of QCD phase diagram with high net baryon densities and moderate temperatures. Anisotropic transverse flow is one of the key observables to study the properties of matter created in a heavy-ion collisions.

CBM performance for anisotropic flow measurements is studied with Monte-Carlo simulations of gold ions at SIS-100 energies using heavy-ion event generators. Different combinations of the CBM detector subsystems are used to investigate the possible systematic biases in flow measurement and to study effects of detector azimuthal non-uniformity. Resulting performance of the CBM for flow measurements is demonstrated for directed flow as a function of pseudorapidity and transverse momentum in different centrality classes.

Primary author: BLINOV, Vitalii (Frankfurt University / GSI)

Presenter: BLINOV, Vitalii (Frankfurt University / GSI)

Session Classification: Poster session

Contribution ID: 128

Type: **Poster**

Non-local Quark Model for modelling the composite Higgs particle

In this poster, we propose an approach for the Higgs boson as top-quark condensate within non-local Nambu–Jona-Lasinio (NJL) model. The advantage of non-local models over local ones is the spectrum of composed particle masses, which has a lower value than the sum of masses of particles of which it consists. By adjusting two parameters in the non-local NJL, the interaction range and the coupling, we can simultaneously describe the top quark mass and the Higgs boson mass.

Primary author: KACHANOVICH, Aliaksei (University of Wrocław)

Presenter: KACHANOVICH, Aliaksei (University of Wrocław)

Session Classification: Poster session

Contribution ID: 129

Type: **Talk**

The Mar(e)k of QGP: Strangeness and Entropy

Thursday, 2 June 2016 17:45 (30 minutes)

I look back at the early results of S+S collisions at 200 A GeV and related theoretical data analysis of more than 20 years ago, and compare these results with those we have since obtained in Pb-Pb reactions at SPS and LHC. The key signatures, strangeness and multistrange antibaryons, as well as entropy content of this small system do indicate development of conditions that are today associated with the formation of quark-gluon deconfined phase of matter. The forthcoming experimental effort to characterize the threshold of QGP formation as a function of collisions energy and reaction volume will be placed into strangeness and entropy context.

Primary author: RAFELSKI, Johann (University of Arizona)

Presenter: RAFELSKI, Johann (University of Arizona)

Session Classification: Colloquium for Marek Gaździcki

Contribution ID: 130

Type: **Poster**

Hybrid Equation of State for Heavy-Ion Collisions and Astrophysics

The aim of our work is to develop a unified equation of state (EoS) for nuclear and quark matter for a wide range in temperature, density and isospin so that it becomes applicable for heavy-ion collisions as well as for the astrophysics of neutron stars, their mergers and supernova explosions. As a first step, we use improved EoS for the hadronic and quark matter phases and join them via Maxwell construction. For this we work with a generalized density functional approach for the self energies in a quasi particle picture, which gives us the possibility to start with a reasonable physical basis and apply improvements to fit constraints from lattice QCD and neutron star measurements.

Primary author: BASTIAN, Niels-Uwe (University of Wrocław)

Presenter: BASTIAN, Niels-Uwe (University of Wrocław)

Session Classification: Poster session

Contribution ID: 131

Type: **Poster**

Dynamical freeze-out in event-by-event hydrodynamics

We employ a dynamical freeze-out criterion, which requires the hydrodynamical expansion rate to be equal to the pion scattering rate, in an ideal fluid hydrodynamical calculation of spectra at RHIC (EoS s95p-PCE-v1, $T_{chem} = 150$ MeV). We find that the p_T spectra are very similar to those evaluated using freeze-out in constant temperature, but pion $v_2(p_T)$ is reduced by $\sim 10\%$.

Primary author: HUOVINEN, Pasi (Goethe-Universität)

Presenter: HUOVINEN, Pasi (Goethe-Universität)

Session Classification: Poster session

Contribution ID: 132

Type: **Poster**

Temperature effects on superfluid phase transition in Bose-Hubbard model with three-body interaction

We study the combined effects of two and three-body local interactions as well as the finite temperature on the phase diagram of simple lattice bosons model. In order to handle system with strong local interactions we use the resolvent expansion technique, based on the contour integral representation of a partition function, and to find the phase diagram we derive Landau-type expansion for free energy in terms of the superfluid order parameter. Since superfluidity is expected to appear in the QCD phase diagram at large density, presented model and computational techniques may be helpful in development of effective models of dense quark matter.

Primary author: SZYMAŃSKI, Michał (University of Wrocław)

Presenter: SZYMAŃSKI, Michał (University of Wrocław)

Session Classification: Poster session

Contribution ID: 133

Type: **Talk**

Generalized Beth-Uhlenbeck approach to quark-hadron matter

Friday, 3 June 2016 12:30 (30 minutes)

An effective model for low-energy QCD thermodynamics is presented which provides a microscopic interpretation of the transition from a gas of hadron resonances to the quark-gluon plasma by Mott dissociation of hadrons. The self consistent approximation scheme of the Φ -derivable approach is applied to describe the thermodynamics of the Polyakov loop extended Nambu–Jona-Lasinio (PNJL) model which is shown to take the form of a Generalized Beth-Uhlenbeck (GBU) equation of state. This approach goes beyond the mean-field description of quark matter by taking into account hadronic correlations (bound and scattering states) as well as their backreaction on the quasiparticle properties of the constituents. The approach is straightforwardly extended to include more hadronic degrees of freedom than just the low-lying pseudoscalar mesons. To this end a model for the generic behavior of hadron masses and phase shifts at finite temperature is employed which shares the basic features with the PNJL model for correlations in quark matter. The results compare well with data from lattice QCD simulations [1].

[1] D. Blaschke, A. Dubinin, L. Turko, in preparation (2016)

Primary author: BLASCHKE, David (University of Wroclaw)

Presenter: BLASCHKE, David (University of Wroclaw)

Session Classification: Plenary session

Contribution ID: 134

Type: **Talk**

Relaxation rates and phase transitions

Friday, 3 June 2016 17:30 (30 minutes)

Using a bottom-up gauge gravity constructions, relaxation rates of strongly coupled field theories are computed. A variety of phase structures are considered, from a crossover up to a first order phase transition. It is established that near the transition the applicability of a hydrodynamic description breaks down at lower momenta than in the conformal case. In the case of the first order phase transition, a spinodal region appears at temperatures for which the speed of sound squared is negative. An estimate of the preferential scale attained by the unstable modes is also given. Additionally we observe a novel diffusive regime for sound modes over a range of wavelengths. Additionally, for a range of wavelengths we observe a novel diffusive regime for sound modes.

Primary author: JANKOWSKI, Jakub (Jagiellonian University)

Presenter: JANKOWSKI, Jakub (Jagiellonian University)

Session Classification: Parallel session 1

Contribution ID: 135

Type: **Poster**

vHLLE, a code for hydrodynamic modelling of relativistic heavy ion collisions

vHLLE solves the equations of relativistic viscous hydrodynamics in 3+1 dimensions using Israel-Stewart framework. In addition to energy and momentum, charge densities are explicitly propagated and included in the equation of state, making the code suitable for simulations of matter expansion with finite baryon density. With the help of ideal-viscous splitting, we keep the ability to solve the equations of ideal hydrodynamics in the limit of zero viscosities using a Godunov-type algorithm. Milne coordinates are used to treat the predominant expansion in longitudinal (beam) direction effectively.

Primary author: KARPENKO, Iurii (Frankfurt Institute for Advanced Studies)

Presenter: KARPENKO, Iurii (Frankfurt Institute for Advanced Studies)

Session Classification: Poster session

Contribution ID: 136

Type: **Poster**

The Physics of core-collapse supernovae - Towards 3-dimensional models

Presenter: Dr FISCHER, Tobias (Institute of Theoretical Physics, University of Wroclaw)

Session Classification: Poster session

Contribution ID: 137

Type: **Poster**

In-medium quark mass-gap equation solutions

Presenter: CIERNIAK, Mateusz (University of Wrocław)

Session Classification: Poster session