"Critical Point and Onset of Deconfinement" Conference "CPOD 2018"

Corfu
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Abstracts

CONTENTS

MONDAY 24/9

MAGIC - how Matter's extreme phases can be revealed in Gravitational wave observations and in relativistic heavy Ion Collision experiments

Horst Stöcker

Abstract

This opening talk combines a survey of our recent advancements in two rather distinct fields, which reveal - on first sight as a surprise - a quite close similarity of both, namely relativistic collisions of nuclei and of neutron stars.
Recently, the group at FiAS and at Goethe University discovered that the emitted gravitational waves, as predicted from general relativistic magneto- hydrodynamics from binary neutron star merger - calculations, are extremely sensitive to the appearance of quark matter and the stiffnes of the equation of state of QCD Matter in the inner cores of the two colliding Neutron Stars, as also in their gravitational collapse to one black hole. This is a new observable messenger from outer space, which does provide direct signals for the phase structure of strongly interacting QCD matter at high baryon density and high temperature.
Those astrophysically created extremes of thermodynamics do match, to within 20%, the values of densities and temperatures which we find in relativistic hydrodynamics and transport theory of heavy ion collisions at the existing laboratories like LHC, SpS at Cern, RHIC at Brookhaven, and HaDes - SiS18 at GSi and at the NICA and FAIR accelerators under construction, if though at quite different rapidity windows, impact parameters and bombarding energies of the heavy nuclear systems.
We demonstrate how the gravitational wave signals from future advanced LIGO-Virgo - to radiowave signals from SKA- events can be combined with the analysis of high multiplicity fluctuation (Kurtosis and Skewness)- and flow measurements in heavy ion detectors in the lab to pin down the EoS and the phase structure of dense matter.

Results from Beam Energy Scan (BES) Program at RHIC and plans for the second phase of BES

Grazyna Odyniec

Abstract

The Beam Energy Scan (BES) program at RHIC was launched with the specific aim to explore the QCD Phase Diagram. Particular emphasis was given to the search for phase boundaries, the location of the Critical Point (CP) and the disappearance or modifications of the QGP signals observed at the top RHIC energies. The first run with Au+Au collisions at 7.7 GeV, 11.5 GeV and 39 GeV took place in 2010, and the next runs added data at energies of 14.5, 19.6 and 27 GeV. Additionally, the fixed target program allowed to extend energy range to 4.5 GeV. The results of the first phase of BES program obtained by the STAR (Solenoidal Tracker at RHIC) experiment will be presented and discussed, as well as plans for the second phase of the program (BES II) starting in a few month.

New results on spectra and fluctuations from NA61

Katarzyna Grebieszkow
for the NA61/SHINE Collaboration

Abstract

The NA61/SHINE experiment aims to discover the critical point of strongly interacting matter and study the properties of the onset of deconfinement. For this purpose we perform a two-dimensional scan of the (T-μ_B) phase diagram by varying the energy (5.1 < $\sqrt{s_{NN}}$ < 16.8/17.3 GeV) and the system size (p+p, p+Pb, Be+Be, Ar+Sc, Xe+La, Pb+Pb) of the collisions. In this presentation the NA61/SHINE results on particle spectra as well as fluctuations and correlations in p+p, Be+Be, Ar+Sc, and Pb+Pb collisions will be presented. In particular, the latest results on charged kaons spectra, charged pions ratios (electromagnetic effects), protons intermittency, femtoscopic radii, anisotropic flow, and higher order moments of multiplicity and net-charge fluctuations are planned to be discussed. The NA61/SHINE data will be compared to predictions of models and to the results from other experiments at the same energy range. Finally, the motivation, NA61/SHINE plans, and the first measurements of open charm production in heavy ion collisions at the Super Proton Synchrotron energies will be shown.

Searching for the QCD critical point via the rapidity dependence of cumulants

Jasmine Brewer

Abstract

The search for a possible critical point in the QCD phase diagram is ongoing in heavy ion collision experiments at RHIC which scan the phase diagram by scanning the beam energy, a coming upgrade will increase the luminosity and extend the rapidity acceptance of the STAR detector. In fireballs produced in RHIC collisions, the baryon density depends on rapidity. By employing Ising universality together with a phenomenologically motivated freezeout prescription, we show that the resulting rapidity dependence of cumulant observables sensitive to critical fluctuations is distinctive. The dependence of the kurtosis (of the event-by-event distribution of the number of protons) on rapidity near mid-rapidity will change qualitatively if a critical point is passed in the scan. Hence, measuring the rapidity dependence of cumulant observables can enhance the prospect of discovering a critical point, in particular if it lies between two energies in the beam energy scan.

Recent results from proton intermittency analysis in nucleus-nucleus collisions from NA61/SHINE at CERN SPS

Nikolaos Davis[(*)], N. Antoniou, F. Diakonos
for the NA61/SHINE Collaboration

Abstract

The search for experimental signatures of the critical point (CP) of strongly interacting matter is one of the main objectives of the NA61/SHINE experiment at CERN SPS. In the course of the experiment, an energy (beam momentum 13A – 150A GeV/c) and system size (p+p, p+Pb, Be+Be, Ar+Sc, Xe+La) scan is performed.
We investigate local proton density fluctuations connected to the critical behavior of the order parameter as a possible signature of the phase transition in the neighborhood of the CP. To this end, we perform an intermittency analysis of the proton second scaled factorial moments (SSFMs) in transverse momentum space, which we expect to scale according to a universal power-law in the vicinity of the CP.
Previous analyses of this sort [1] revealed significant power-law fluctuations in the NA49 heavy ion collision experiment for the "Si"+Si system at 158A GeV/c; no intermittency was observed in NA49 "C"+C and Pb+Pb collisions at the same energy, nor in NA61/SHINE Be+Be collisions at 150A GeV/c. The fitted power-law exponent in "Si"+Si was consistent with the theoretically expected critical value, within errors, a result suggesting a baryochemical potential for the critical point in the vicinity of ~250 MeV. We now extend the analysis to the similar-sized NA61/SHINE Ar+Sc system at 150A GeV/c.
In the calculation of scaled factorial moments, statistical techniques are employed in order to subtract non-critical background and enhance the signal in cases of low statistics. We investigate the effects of non-proton contamination as well as varying number of participant nucleons on the quality and magnitude of uncertainties of the intermittency power-law fit. Our analysis is furthermore supplemented by Monte Carlo simulations, through which we explore the possibility of non-critical effects producing an intermittency signal.

[1] T. Anticic et al, Eur. Phys. J. C 75: 587 (2015).

[(*)] *Speaker*

Benchmark values for net proton number fluctuations

Boris Tomasik

Abstract

Fluctuations of net proton number are investigated in framework of a Monte Carlo model, which takes into account i) overall baryon number conservation, ii) position of (remnants of) wounded nucleons in rapidity, iii) probabilistic assignment of a baryon to be a proton, iv) limited acceptance of the detector, v) correlation between the produced baryon and antibaryon in rapidity, vi) centrality fluctuations. We show that while the central moments of net proton multiplicity distribution do depend on the correlation distance between produced baryons and antibaryons, the kappa*sigma^2 and S*sigma do not. The composition of the baryons and antibaryons which depends on rapidity can lead to a dependence of the cumulants on the width of the rapidity window and also to an interesting rapidity dependence.

Identified Particle Fluctuations from ALICE at the CERN LHC

Anar Rustamov

Abstract

TBA

QCD matter with a crossover and a first-order phase transition

Christopher Plumberg

Abstract

In this talk, I present a phenomenological parametrization of the phase diagram of QCD as a function of temperature T and baryochemical potential μ. The parametrization is constructed by introducing a switching function which controls the nature of the transition between the Hadron-Resonance Gas (HRG) and Quark-Gluon Plasma (QGP) phases of nuclear matter, such that the equation of state (EOS) possesses a rapid crossover at large T and small μ, a critical point placed anywhere along the phase transition line, and a first-order transition at small T and large μ. This EOS offers a convenient phenomenological tool for assessing the possible effects of the conjectured QCD critical point on heavy-ion observables.

Fluid dynamical phenomena in QGP and its recent experimental signatures

Laszlo P. Csernai

Abstract

Collective relativistic fluid dynamics is the dominant description of heavy ion reactions. With a Yang-Mills flux-tube initial state and a high-resolution (3+1)D particle-in-cell relativistic (PICR) hydrodynamics simulation, we calculate the shear flow, vorticity and Lambda polarization for different energies. The origin of polarization in high energy collisions is discussed, and we find linear impact parameter dependence of the global Lambda polarization. Furthermore, the global Lambda polarization in our model decreases very quickly with time in the low energy domain, and the decline curve fits well the recent results of Beam Energy Scan (BES) program launched by the STAR Collaboration at the Relativistic Heavy Ion Collider (RHIC). The time evolution of polarization is also discussed.

Explosions of massive blue-supergiant stars triggered by the QCD phase transition

Tobias Fischer

Abstract

Motivated from the observations of yet-unexplained explosive phenomena associated with massive blue-supergiant stars with zero-age main sequence (ZAMS) masses around 50 solar masses, new light has been shed on the old idea [1] that the appearance of QCD degrees of freedom may explain such cosmic events [2]. Obeying chiral physics and taking yet-another important observation of the very existence of massive neutron stars of 2 solar masses seriously into account, puts sever constraints on the behavior of the equation of state at supersaturation density. In particular, sfficient stiffness with increasing density is required. Both aspects indicate rather high densities for the hadron-quark phase transition in excess of twice saturation density (at zero temperature). As a consequence, this excludes low- and intermediate mass stars (10-15 solar masses) - they are canonically considered in supernova studies - from the presence of 'exotic' high-density phases. On the other hand, during the evolution of very massive core-collapse supernova progenitors with ZAMS masses of about 50 solar masses, significantly higher core temperatures and densities are reached, where the appearance of the hadron-quark phase transition triggers not only the supernova explosion onset but also a millisecond neutrino burst is released. The latter observable signal provides evidence not only for the presence of a 1^{st}-order phase transition at supersaturation density but contains also details about its properties. The future observation of such a feature from the next galactic event will allow us to either confirm such scenario or, if not observed, rule out a (strong) 1^{st}-order phase transition at high densities encountered in astrophysics. In this talk I will review this scenario in the light of presently known constraints from nuclear physics as well as observations. The latter includes the first binary neutronstar merger event associated with GW170817 [3]. Furthermore, I will discuss implications for astrophysics, e.g., the remnants from such supernova explosions are massive neutron stars with quark-matter core of 2 solar masses at birth.

References

[1] I. Sagert, T. Fischer, M. Hempel, G. Pagliara, J. Schaffner-Bielich, et al., "Signals of the QCD phase transition in core-collapse supernovae" Phys.Rev.Lett., 102, 081101 (2009).

[2] T. Fischer, N.-U. F. Bastian, M.-R. Wu, S. Typel, T. Klähn, and D. B. Blaschke, "Highdensity phase transition paves the way for supernova explosions of massive blue-supergiant stars" ArXiv e-prints astro-ph.HE/1712.08788 (2017).

[3] B. P. Abbot, et al. [LIGO scientific and Virgo collaborations] "GW170817 Observation of Gravitational Waves from a Binary Neutron Star Inspiral" Phys.Rev.Lett., 119, 161101 (2017).

TUESDAY 25/9

QCD phase diagram from lattice

Swagato Mukherjee

Abstract

I will provide a brief overview of the recent lattice QCD results pertaining to the phase structure of QCD.

Lattice-based Equation of State of QCD matter with a critical point

Claudia Ratti

Abstract

I will review the state-of-the art results on the QCD equation of state at finite density from lattice simulations. I will then construct a family of equations of state for QCD in the temperature range $30<T<800$ MeV and in the chemical potential range $0<\mu_B<450$ MeV. The equations of state match available lattice QCD results up to $O(\mu_B^4)$ and in each of them we place a critical point in the 3D Ising model universality class. Our results for the pressure, entropy density, baryon density, energy density and speed of sound can be used as inputs in the hydrodynamical simulations of the fireball created in heavy ion collisions.

Critical end points in (2+1)-flavor QCD with imaginary chemical potential

Jishnu Goswami

Abstract

The QCD phase diagram at finite temperature and density has a very rich physical structure which can be explored with first principle lattice QCD calculations. The crossover transition at vanishing and small values of the chemical potential, which is expected to end in the QCD critical point, is expected to become a true second order phase transition in the chiral limit. This, however, is not yet established beyond doubt. Lattice QCD calculations performed with the standard, unimproved staggered fermion action suggest, that the chiral phase transition in QCD might be first order. In that case a critical quark mass value would exist at which the crossover transition ends on a second order phase transition and becomes first order for smaller values of the quark mass. The value of this critical mass, if it exists, may be extracted from calculations at imaginary values of the chemical potential. We will present results on a determination of the critical quark mass in simulations of (2+1)-flavor QCD with an imaginary chemical potential. We use the Highly Improved Staggered Quark (HISQ) action and perform calculations in the Roberge-Weiss plane, where the value of the critical mass is expected to be the largest. We explore a range of quark masses corresponding to pion mass values, $m_\pi \leq 90$ MeV. Contrary to calculations performed with unimproved actions we find no evidence for the occurrence of first order transitions at the small quark mass values explored so far.

News on net-charge fluctuations and correlations from lattice QCD

Frithjof Karsch

Abstract

I will present recent results from lattice QCD calculations of higher order cumulants of net-charge fluctuations, with a focus on correlations of strangeness fluctuations with net-baryon number and net-electric charge fluctuations.

Off-diagonal cumulants of net-charge, net-proton and net-kaon multiplicity distributions in Au+Au collisions at $\sqrt{s_{NN}}$ = 7.7-200 GeV from STAR

Arghya Chatterjee

Abstract

Fluctuations of conserved quantities such as net-baryon, net-charge, and net-strangeness number have generated considerable interest in the study of the thermodynamic properties of the hot and dense QCD matter. Theoretical calculations suggest that the off-diagonal cumulants of conserved charges along with the diagonal cumulants can help better constrain the freeze-out parameters and therefore help to map the QCD phase diagram. We present the 2nd-order off-diagonal cumulants of net-charge, net-proton, and net-kaon multiplicity distributions in Au+Au collisions from the RHIC BES-I program in the energy range of $\sqrt{s_{NN}}$ = 7.7-200 GeV. We also present the centrality and the acceptance (η) dependence of the cumulants. The measured cumulant ratios are compared with the predictions from both thermal (HRG) and non-thermal (UrQMD) models.

Bottomonia physics at RHIC and LHC

Georg Wolschin

Abstract

The suppression of Upsilon-mesons in the hot quark-gluon medium (QGP) versus reduced feed-down is investigated in heavy-ion collisions at energies reached at RHIC and at LHC. Our centrality- and p_T-dependent model encompasses screening, collisional damping and gluodissociation in the QGP. For Y(1S) it is in agreement with both STAR and CMS data provided the relativistic Doppler effect and the reduced feed-down from the Y(nS) and chi_b(nP) states are properly considered. At both energies, most of the Y(1S)-suppression is found to be due to reduced feed-down, whereas the main Y(2S) suppression is caused by hot-medium effects in the collectively expanding QGP. The importance of reduced feed-down increases with energy. The p_T-dependence is flat due to the relativistic Doppler effect. Possible suppression effects due to the transient electromagnetic fields in more peripheral collisions are shown to be negligible. The predicted Y(1S)-suppression in Pb-Pb at $\sqrt{s_{NN}}$ =5.02 TeV is compared with CMS data. Cold nuclear matter effects are discussed for p-Pb at the same energy.

[1] J. Hoelck, F. Nendzig, and G. Wolschin, Phys. Rev. C 95, 024905 (2017).
[2] J. Hoelck and G. Wolschin, Eur. Phys. J. A, 53 (2017).

Recent measurements of identified hadron spectra and multiplicities in Ar+Sc and Be+Be collisions at SPS energies

Maciej Lewicki

Abstract

NA61/SHINE is a fixed target experiment at the CERN Super Proton Synchrotron. The main goals of the experiment are to discover the critical point of strongly interacting matter and to study the properties of the onset of deconfinement. In order to reach these goals, a study of hadron production properties is performed in nucleus-nucleus, proton-proton and proton-nucleus interactions as a function of collision energy and size of the colliding nuclei. In this talk, the newest preliminary results on identified hadron spectra produced in Ar+Sc and Be+Be collisions at six beam momenta (13A, 19A, 30A, 40A, 75A and 150A GeV/c) will be shown. The kinematic distributions and measured multiplicities of identified hadrons will be compared with NA61/SHINE and NA49 p+p and Pb+Pb results, as well as with available world data.

Strange matter and kaon to pion ratio in SU(3) PNJL model

Alexandra Friesen

Abstract

The "horn" in the K^+/π^+ ratio firstly described by NA49 Collaboration and then by experiments at the RHIC - BES, still has not exact theoretical description. All theoretical approaches, which give the behaviour in the K^+/π^+ ratio similar to "horn" have a common idea that at the "horn" energies a phase transition has to appear. In this work the behavior of strange matter in the frame of the SU(3) Polyakov-loop extended Nambu-Jona-Lasinio model including $U_A(1)$ anomaly is considered. The PNJL model seems to be most promising as an instrument for description of the chiral phase transition, the deconfinement properties and the existence of quarks and hadron states [1,2]. Using the model, it can be shown that the splitting of kaon and anti-kaon masses appearing as a result of introduction of density [3], may explain the difference in the K^+/π^+ ratio and K^-/π^- ratio at low $\sqrt{s}$ and their tendency to the same value at high $\sqrt{s}$ (high T), where kaons become degenerate. In the model the rise in the ratio K^+/π^+ appears near CEP when the K^+/π^+ ratio is calculated along the phase transition line and it can be considered as a critical region signal.

[1] A. V. Friesen, Yu. L. Kalinovsky, V. D. Toneev, Int. J. Mod. Phys. A, 30 (2015). 1550089

[2] A. Dubinin, A. Radzhabov, D. Blaschke, A. Wergieluk, Phys. Rev. D 96, 094008 (2017)

[3] P. Costa, M. C. Ruivo, Yu. L. Kalinovsky, Phys. Lett. B560 (2003) 171 - 177.

Implications of the chiralspin symmetry for QCD at high temperatures and densities

Leonid Glozman

Abstract

At a temperature $2T_c$ at vanishing chemical potential the chiralspin symmetry emerges in QCD, as has been recently obtained on the lattice with chiral fermions. This symmetry is larger that the chiral symmetry of the QCD Lagrangian. It is a symmetry of the chromo-electric interaction while the chromo-magnetic interaction breaks it. Emergence of this symmetry implies that the elementary objects at this temperature are quarks with a definite chirality that are connected by the chromo-electric field, i.e. there are no free deconfined quarks. The chemical potential term of the QCD action is also chiralspin symmetric, which means that at $2T_c$ the chiralspin symmetry persists at any chemical potential. This implies that the existing view on the nature of high-temperature QCD should be modified.

Production of Entropy at the Chiral Phase Transition from Dissipation and Noise

Christoph Herold

Abstract

We study the mechanisms of entropy production at a chiral phase transition from the Langevin dynamics of the chiral condensate coupled to the longitudinal expansion of a quark fluid. Hereby, both damping and random noise are identified as sources of an increasing entropy per baryon number during the nonequilibrium evolution towards a chirally broken phase. We find that the initial condition of the medium as well as the expansion rate that is reached at the crossing of the phase boundary have a strong influence on both the produced entropy and a possible reheating of the fluid. Although there is no latent heat at a crossover, we are able to demonstrate that, even in this case, the finite relaxation time will cause the medium to reheat. This effect is well known for a first-order phase transition and naturally leads to an even stronger entropy increase there. Finally, we discuss the possible impact on observables related to pion multiplicities.

Chiral symmetry restoration and quark deconfinement beyond mean field in a magnetized PNJL model

Shijun Mao

Abstract

We study chiral symmetry restoration and quark deconfinement beyond mean field approximation in a magnetized PNJL model. The feedback from mesons to quarks modifies the quark coupling constant and Polyakov potential. As a result, the separate critical temperatures for the two phase transitions at mean field level coincide and the magnetic catalysis becomes inverse magnetic catalysis, when the meson contribution is included.

Directed flow and freeze-out in relativistic heavy-ion collisions at NICA and FAIR energies

Larissa Bravina

Abstract

The detailed analysis of the directed flow in ultrarelativistic heavy ion collisions has been done in UrQMD model. We found that the flow is developing for quite significant time and depends drastically on the energy. In contrast to Hydro models microscopic models can explain the changing of the slope of v1(rapidity) with increase of energy for nucleons. While for pions anti-flow is always dominating. We also found that space time evolution picture of the flow has direct connection with vorticity. The investigations confirm that around 7AGeV there is a changing of the regimes in relativistic heavy ion collisions.

QCD Critical Point and Finite size effect

Kun Xu

Abstract

We investigate the kurtosis of net baryon number fluctuation in a realistic Polyakov-NJL model with parameters fixed by lattice results at zero chemical potential. To our surprise we find the kurtosis from the PNJL model along the experimental freeze-out line agree well with the BES-I data very well. It is also observed that the dip structure of the kurtosis is sensitive to the relation between the freeze-out line and the phase boundary, and the peak structure is solely determined by the existence of the CEP mountain and can be used as a clean signature for the existence of CEP. We also investigate finite-size effects on the chiral phase transition in the NJL model. To take into account finite-size effects, momentum integrals are replaced by momentum summations. It is found that zero-mode and nonezero-mode momentum have opposite behaviors as size decreases, and two sets of critical points appear.

From first principle QCD to dynamical fluctuations

Nicolas Wink

Abstract

I will present results for Euclidean and real-time correlations functions in QCD and QCD-assisted models. In particular I discuss the systematic embedding of low energy effective theories in QCD. The real-time correlation functions of such an embedded low-energy effective theory across the phase diagram serve as an input for a QCD-assisted transport evolution of the critical mode. I will present results for the equilibration time of different cumulants of the critical mode for different equilibrium states in the phase diagram.

QCD phase diagram with a critical point from holographic black holes

Israel Portillo Vazquez

Abstract

We use the gauge/gravity duality to map thermodynamic fluctuations of black holes onto fluctuations of baryon charge in a hot and baryon dense Quark-Gluon Plasma (QGP). Our approach gives results that are in quantitative agreement with state-of-the-art lattice simulations for the QCD equation of state at finite baryon density and fluctuations of baryon charge, while simultaneously encompassing nearly-perfect fluidity. This framework provides a definite prediction for the QCD critical point, which is found to be within the reach of low collision energy experiments at RHIC and also the CBM experiment at FAIR.

WEDNESDAY 26/9

Freeze-out temperature from net-Kaon fluctuations at RHIC

Jacquelyn Noronha-Hostler

Abstract

We compare the mean-over-variance ratio of the net-kaon distribution calculated within a state of-the-art hadron resonance gas model to the latest experimental data from the Beam Energy Scan at RHIC by the STAR collaboration. Our analysis indicates that it is not possible to reproduce the experimental results using the freeze-out parameters from the existing combined fit of net-proton and net-electric charge mean-over-variance. The strange mesons need about 10-15 MeV higher temperatures than the light hadrons at the highest collision energies. In view of the future Î› fluctuation measurements, we predict the Î› variance-over-mean and skewness-times-variance at the light and strange chemical freeze-out parameters. We observe that the Î› fluctuations are sensitive to the difference in the freeze-out temperatures established in this analysis. Our results have implications for other phenomenological models in the field of relativistic heavy ion collisions.

Nuclear correlations and modifications of the nucleon-nucleon potential due to the QCD critical mode

Juan Torres-Rincon

Abstract

The scalar-isoscalar mode of QCD becomes lighter/nearly massless close to the chiral transition/second-order critical point. From nuclear physics we know that this mode is the main responsible for the attractive part of the nucleon-nucleon potential at interparticle distances of 1-2 fm. Therefore one expects that close to the critical point there is a long-range strong attraction among nucleons. Using a Walecka-Serot model for the NN potential we study the effects of the critical point in a finite system of nucleons and mesons by solving classical Molecular Dynamics+Langevin equations for the freeze-out conditions of heavy-ion collisions. Going beyond the mean-field approximation allows us to account for strong nucleon correlations in the time evolution, leading to baryon clustering. We observe that light cluster formation, together with an enhancement of higher-order cumulants of the proton distribution can signal the presence of the critical point. (Collaborators E. Shuryak)

Dynamics of net-baryon density fluctuations near the QCD critical point

Marlene Nahrgang[(*)], *Marcus Bluhm*

Abstract

Critical fluctuations in the net-baryon density play an essential role in the search for the QCD critical point. These form dynamically from intrinsic fluid dynamical fluctuations in the critical region. In this talk, we study the diffusive dynamics of the net-baryon density and show how long-range correlations develop within the framework of fluctuating fluid dynamics. We show under which conditions Gaussian and non-Gaussian fluctuations emerge from the consistent propagation of purely white noise. Real-time numerical simulations of the stochastic diffusion allow us to discuss the influence of exact baryon number conservation, of the finite size of the system and of non-equilibrium effects caused by its rapid evolution. This represents a crucial step toward a realistic modeling of critical point signals searched for at CERN-SPS and in the beam energy scan at RHIC.

[(*)] *Speaker*

Finite-size scaling, intermittency and the QCD critical point

Fotios Diakonos

Abstract

We argue that finite-size scaling (FSS) is linked to the intermittency effect of the baryon number density (order-parameter) fluctuations in transverse momentum space. Considering the 3d Ising universality class of the QCD critical endpoint (CEP) we introduce the Ising-QCD partition function for the description of the baryon-number density fluctuations within the critical region. With the help of this partition function we calculate baryon-number multiplicity moments to show that the critical region is very narrow in the chemical potential direction while the FSS-subregion is very narrow also in the temperature direction. Furthermore, we propose a systematic way to detect the CEP based on combined measurements of the intermittency index φ_2 and the freeze-out parameters μ_b (baryochemical potential), T (temperature). According to our findings the critical chemical potential lies close to the freeze-out chemical potential of the fireball, formed in central Si+Si collisions at maximum SPS energy (NA49, CERN). Based on this, we discuss the possibilities to detect the CEP in the running ion-collision experiments STAR and NA61.

Finite size effects on critical fluctuations

Taklit Sami, Moussa Agah, Marcus Bluhm[(*)], Anna Borer, Marlene Nahrgang, Nathan Thouroux

Abstract

The search for the QCD critical point is one of the top priorities in current and future heavy-ion collision experiments. Unlike thermodynamic systems, the matter created in a heavy-ion collision is not spatially infinite and a rather homogeneous temperature near the critical point can be expected only in regions of a couple of fm. Moreover, to observe fluctuations for a globally conserved order parameter such as the net-baryon density the volume of observation V must be small compared to the full system size. In this talk, we formally expand the critical cumulants in powers of the correlation length Xi over V which can be almost equal. We observe that the magnitude of the variance is reduced compared to known leading-order in Xi/V results. Moreover, depending on the values of the Ising model couplings, both skewness and kurtosis can show interesting structures around the critical point and even sign changes compared to leading-order expectations. These results are an important baseline as they show that already equilibrium results are modified when one takes realistic constraints of a heavy-ion collision experiment into account.

[(*)] *Speaker*

Chiral symmetry restoration by parity doubling and the structure of neutron stars

David Blaschke

Abstract

We investigate the equation of state for a recently developed hybrid quark-meson-nucleon model under neutron star conditions of β-equilibrium and charge neutrality. The model has the characteristic feature that at increasing baryon density chiral symmetry is restored in a first order transition within the hadronic phase by lifting the mass splitting between chiral partner states, before quark deconfinement takes place. Most important for this study are the nucleon (neutron, proton) and N(1535) states. We present three sets for the two free parameters which result in compact star mass-radius relations in accordance with modern constraints on the mass from PSR J0437-4715 and on the compactness from GW170817. We also consider the threshold for the direct URCA process for which a new relationship is given and suggest as an additional constraint on the parameter choice of the model that this process shall become operative at best for stars with masses above the range for binary radio pulsars, $M > 1.4 M_{\rm e}$.

[1] M. Marczenko, D. Blaschke, K. Redlich, C. Sasaki, arXiv 1805.06886 (2018).

Equation of state for hot QCD and compact stars from mean field approach

Anton Motornenko

Abstract

The SU(3) flavor parity-doublet quark-hadron chiral model [1-4] is used to investigate thermodynamic properties of QCD matter. The quark sector of the model is tuned to the μ_B=0 lattice QCD data on trace anomaly. The structure of the baryon number susceptibilities in the temperature/chemical potential plane is studied in some detail. The model predicts three consecutive transitions that can be addressed to nuclear first-order liquid-gas phase transition, chiral symmetry restoration, and transition to quark-dominated phase. At μ_B=0, a good agreement with the corresponding lattice data is obtained. The deviations from the free hadron gas baseline in the crossover temperature region at μ_B=0 are mainly attributed to the leftover of the liquid-gas transition in nuclear matter, the chiral phase transition determines the baryon fluctuations at much higher μ_B, and at even higher baryon densities the behavior of fluctuations is controlled by deconfinement transition. Within obtained equation of state properties of neutron stars are studied. Namely, the mass-radius relation and tidal deformabilities are calculated. The results are found in agreement with recent bounds on compact star properties from GW170817 gravitational wave signal attributed to neutron star merger.

[1] P. Papazoglou, S. Schramm, J. Schaffner-Bielich, H. Stoecker, W. Greiner, Phys. Rev. C 57, 2576 (1998).
[2] J. Steinheimer, S. Schramm and H. Stoecker, J.Phys. G38, 035001 (2011).
[3] J. Steinheimer, S. Schramm and H. Stoecker, Phys. Rev. C 84, 045208 (2011).
[4] A. Motornenko, S. Schramm, J. Steinheimer, V. Vovchenko and H. Stoecker, ongoing work.

Strangeness Neutrality, Baryon-Strangeness Correlations and the Phase Structure of QCD

Fabian Rennecke

Abstract

Since the incident nuclei in heavy-ion collisions do not carry strangeness, the global net strangeness of the detected hadrons has to vanish. We show that there is an intimate relation between strangeness neutrality and baryon-strangeness correlations. In the context of heavy-ion collisions, the former is a consequence of quark number conservation of the strong interactions while the latter are sensitive probes of the character of QCD matter. We investigate the sensitivity of baryon-strangeness correlations on the freeze-out conditions of heavy-ion collisions by studying their dependence on temperature, baryon- and strangeness chemical potential. The impact of strangeness neutrality on the QCD equation of state at finite chemical potentials will also be discussed. We model the low-energy sector of QCD by an effective Polyakov loop enhanced quark-meson model with 2+1 dynamical quark flavors and use the functional renormalization group to account for the non-perturbative quantum fluctuations of hadrons.

Composite particle production in relativistic particle collisions through quantum entanglement

Rene Bellwied

Abstract

I am discussing the possibility that a quantum entangled initial state in relativistic collisions could potentially lead to seemingly thermal particle distributions in the final state. I will develop the argument on the basis of evidence in elementary collisions, but then try to extend its applicability to heavy ion collisions on the basis of evidence from the yields of light nuclei and other composite particles.

First NA61/SHINE results on Bose-Einstein correlation function

Barnabas Porfy

Abstract

The last decades of high energy physics revealed, that in ultra-relativistic ion-ion collisions, a strongly interacting quark gluon plasma (sQGP) is created. Varying the collision energy allows for the investigation of the phase diagram of QCD matter. The nature of the quark-hadron transition can be studied via Bose-Einstein correlation functions (femtoscopy), as the investigation of the femtoscopic correlation functions in heavy ion reactions reveals the space-time structure of the hadron production of the sQGP. In our recent measurements, we utilized Levy-type sources to describe the measured correlation functions obtained by the NA61/SHINE experiment at the CERN SPS. In this presentation we report the measurement of the Levy source parameters as a function of average pair transverse mass. One of the source parameters, the Levy stability parameter alpha, describing the shape of the source, was suggested to be related to one of the critical exponents (the so-called correlation exponent eta), and thus may shed light on the location of the critical endpoint on the QCD phase diagram.

Gribov horizon, Polyakov loop and finite temperature

Pablo Pais

Abstract

We consider finite-temperature SU(2) gauge theory in the continuum formulation. Choosing the Landau gauge, the existing gauge copies are taken into account by means of the Gribov-Zwanziger quantization scheme, which entails the introduction of a dynamical mass scale (Gribov mass) directly influencing the Green functions of the theory. Here, we determine simultaneously the Polyakov loop (vacuum expectation value) and Gribov mass in terms of temperature, by minimizing the vacuum energy w.r.t. the Polyakov-loop parameter and solving the Gribov gap equation. The main result is that the Gribov mass directly feels the deconfinement transition, visible from a cusp occurring at the same temperature where the Polyakov loop becomes nonzero. We also present a first look at the critical temperature obtained from the refined Gribov-Zwanziger approach. Finally, problems for the pressure at low temperatures and the new approaches trying to bypass it are reported.

THURSDAY 27/9

Prospects for the study of baryon-rich matter at new facilities

Volker Friese

Abstract

TBA

Decoding the Phase structure of QCD at high μ_B with HADES

Tetyana Galatyuk

Abstract

TBA

Studies of baryonic matter in the BM@N and MPD experiments at Nuclotron/NICA

Mikhail Kapishin

Abstract

The NICA (Nuclotron-based Ion Collider fAcility) project is under 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 center-of-mass energies up to 11 GeV per nucleon. The physics program will be performed at two experiments, BM@N (Baryonic Matter at Nuclotron) at beams extracted from the Nuclotron, and MPD (Multi-Purpose Detector) at the NICA collider. The aim of the BM@N experiment is to study interactions of relativistic heavy ion beams with fixed targets. The scientific program comprises studies of nuclear matter in the intermediate energy range between experiments at the SIS and NICA/FAIR facilities. The BM@N experiment has recorded first experimental data in the carbon, argon and krypton beams of kinetic energy per nucleon ranging from 2.3 to 4.5 GeV per nucleon. The MPD detector is under construction to study hot and baryon rich QCD matter in heavy ion collisions at the NICA collider in the energy range $\sqrt{s_{NN}}$ = 4 - 11 GeV. Physics program includes the study of collective phenomena, Λ polarization, dilepton, hyperon and hypernuclei production under extreme conditions of highest baryonic density.

High density matter physics at J-PARC-HI

Takao Sakaguchi

Abstract

A future project at J-PARC called J-PARC-HI has been proposed. The project aims for accelerating and bombarding ions up to Uranium to fixed heavy ion targets at the cms energy of $\sqrt{s_{NN}}$ =2-6.2GeV, where 8-10 times higher density as the normal nuclear matter is expected to be created. The possible beam rate of up to 10^{11} ions per cycle, a five order of magnitude higher than AGS, enable us to measure statistics-starved rare probes ever explored. The heavy-ion acceleration scheme consists of a new linac and a booster as the injector, followed by the existing 3-GeV Rapid-Cycling Synchrotron (RCS) and 50-GeV MR. Taking advantage of the very high intensity beam, we introduce event selection quantities on top of the conventional centrality variable, which would exclusively select high-density matter events. The primary observables includes the ones not measured in the past, namely, electromagnetic probes (photons and lepton pairs), higher order flow of particles and the fluctuation of conserved charges such as net-baryons. We will also perform hypernuclei and exotic hadron spectroscopy in addition to the systematic measurement of conventional hadronic observables. We designed a multi-purpose spectrometer to measure dileptons, photons, and hadrons, and a spectrometer dedicated to hypernuclei measurement. We will discuss the physics to be explored at J-PARC-HI and then present the status on the accelerator and detectors as well as the data acquisition system.

Vorticity, hydrodynamic helicity and polarization in baryon-rich matter

Alexander Sorin[(*)] *and Oleg Teryaev*

Abstract

We study the structure and energy dependence of vorticity and hydrodynamic helicity fields in peripheral heavy ion collisions using the kinetic Quark-Gluon String and Parton-Hadron-String Dynamics models. We observe the formation of specific toroidal structures of vorticity field (vortex sheets). Their existence is mirrored in the polarization of hyperons of the percent order. Its rapid decrease with energy was predicted and recently confirmed by STAR collaboration. The energy dependence is sensitive to the temperature dependent term derived and discussed in various theoretical approaches. The antihyperon polarization is of the same sign and larger magnitude. The crucial role of strange vector mesons is also discussed.

[(*)] *Speaker*

Anisotropic flow measurements at NICA energies

Arkadiy Taranenko

Abstract

Extensive measurements of azimuthal anisotropy in relativistic A+A collisions, have provided invaluable insights on the expansion dynamics and the transport properties of the strongly interacting matter produced in such collisions. The recent results of flow measurements from the top SIS energy to the top SPS energy will discussed with emphasis on techniques, interpretation, and uncertainties in the measurements. The prospects for future measurements at NICA energies will be presented and discussed.

FRIDAY 28/9

Anisotropic flow measurement from NA61/SHINE and NA49 experiments at CERN SPS

O. Golosov, E. Kashirin, V. Klochkov, Ilya Selyuzhenkov[(*)]
for the NA61/SHINE Collaboration

Abstract

The NA61/SHINE experiment at the CERN SPS recently extended its program for the energy scan with Pb ions in the energy range of 13A-150A GeV. In the year 2016 a sample of Pb+Pb collisions at beam momentum 13A and 30A GeV/c was collected by the NA61/SHINE experiment. The NA61/SHINE measurements with Pb ions and the experimental techniques using spectators at the lowest energy available at the SPS are also relevant for the preparation of the Compressed Baryonic Matter (CBM) heavy-ion experiment at the future FAIR facility in Darmstadt. We present results on direct and elliptic flow measurement in Pb+Pb collisions at 30A GeV/c relative to the spectator plane determined with the Projectile Spectator Detector. Also a new analysis of 40A GeV/c data collected by the NA49 experiment in year 2000 using forward spectator calorimeters (VETO and RCAL) are presented. The flow coefficients are reported as a function of rapidity and transverse momentum in different classes of collision centrality. The new results are compared with existing results from previous NA49 analysis and the STAR data at RHIC.

[(*)] *Speaker*

Electromagnetic effects and the longitudinal evolution of the system at CERN SPS energies

Nikolaos Davis

Abstract

We review our studies of spectator-induced electromagnetic (EM) effectson charged pion emission in nucleus-nucleus collisions at CERN SPS and RHIC BES energies. These we discuss in the context of (1) new data on Ar+Sc collisions from the NA61/SHINE experiment (2) new findings on the role of energy-momentum conservation for the longitudinal evolution of the system at SPS energies, and (3) new work on the space-time evolution of spectator fragmentation. Although the average Ar spectator charge in intermediate Ar+Sc collisions is only about 8 elementary units, the corresponding EM field is large enough to impose a visible distortion on final state pi+/pi- ratios, and break isospin symmetry [1]. A Monte Carlo simulation of this process provides new information on the space-time evolution of the system in Ar+Sc collisions, as well as that of spectator fragmentation. We compare this information to that obtained for Au+Au and Pb+Pb collisions from STAR [2], NA49 [3], and WA98 [4] experiments. A uniform picture emerges where the distance d_E between the pion formation zone at freeze-out and the spectator system decreases with increasing pion rapidity. At central rapidity our estimates agree with pion decoupling times obtained from standard femtoscopy [5]. As a result, a specific picture of the longitudinal evolution of the system emerges. We construct a simple model of the heavy ion collision, local in the impact parameter plane, and appropriate for the SPS energy range. With some similarity to the original "fire-streak" approach, we start from local energy and momentum conservation, and nicely describe the centrality dependence of the pion rapidity distribution and total pion yields in heavy ion collisions at $\sqrt{s_{NN}}$ =17.3 GeV [6]. We also explain the broadening of this distribution when going from central to peripheral collisions. We discuss the resulting implications on the role of energy and momentum conservation in the early stage of the A+A reaction [7]. Finally, we comment on the possibility of using EM effects in relativistic heavy ion collisions to test the nuclear models of spectator break-up [8]. This includes possible new measurements in the framework of the NA61/SHINE Phase II programme recommended by the SPSC [9].

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[3] A. Marcinek et al., Acta Phys.Polon. B49 (2018) 711-718.
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[5] K. Aamodt et al. Phys. Lett. B 696 (2011) 328.
[6] T. Anticic et al., Phys. Rev. C 86, 054903 (2012).
[7] A. Szczurek, M. Kiełbowicz and A. Rybicki, Phys. Rev. C 95 (2017), 024908.
[8] K. Mazurek, A. Szczurek et al., Phys.Rev. C97 (2018) no.2, 024604.
[9] NA61/SHINE Collab., A. Aduszkiewicz et al., CERN-SPSC-2018-008.

Event averaging and event-shape sorting as seen by femtoscopy

Jakub Cimerman

Abstract

Inhomogeneities of the initial energy density distribution lead to measurable anisotropy of the two-particle correlations in relative momentum. In the first part we shall investigate how averaging over a large number of events influences the shape of the observed correlation function. We demonstrate that a correlation function characterised by Levy distribution may result from an average over Gaussian correlation functions with varying sizes and orientations. In the second part we try to avoid this averaging using events which have similar shape. We sort events according to their similarity and investigate the azimuthal dependence of the correlation radii within events classes which differ in shape. The method is explained and demonstrated on events simulated with various event generators.

Forward hadron calorimeter (PSD) of NA61/SHINE for heavy ion studies and its upgrade for experiments beyond 2020

Sergey Morozov

Abstract

The Projectile Spectator Detector (PSD) is a segmented modular hadron calorimeter currently used in the NA61/SHINE experiment at the CERN SPS. The PSD is used for collision centrality determination as well as estimation of the event plane orientation in nucleus-nucleus collisions. The main goal of the NA61/SHINE experiment includes studying the onset of deconfinement and searching for the critical point of strongly interacting matter. It is of crucial importance to have a precise event class characterization for the analysis of event-by-event observables. The PSD has been already used for centrality selection at the trigger level in measurements of Be+Be, Ar+Sc, Xe+La and Pb+Pb reactions at a wide range of beam energies (13 - 158 AGeV). The performance of the PSD in different collision systems will be shown and the proposed upgrade of the forward hadron calorimeter system for future experiments planned beyond 2020 will be presented.

QCD critical point, fluctuations and hydrodynamics

Yi Yin

Abstract

The search for the QCD critical point in heavy-ion collision experiments requires dynamical modeling of the bulk evolution of the QCD matter as well as of the fluctuations near the critical point. Critical slowing down means that fluctuations are significantly deviating from equilibrium near the critical point. We generalize hydrodynamics to quasi-equilibrium conditions where the state of the system is characterized by the off-equilibrium magnitude of fluctuations in addition to the usual hydrodynamic variables – conserved densities. We find that the key ingredient of the formalism – the extended entropy taking into account the off-equilibrium fluctuations – is remarkably similar to the 2PI action in quantum field theory. We use the new formalism to demonstrate the major effects of critical fluctuations on the bulk evolution the strong frequency dependence of the anomalously large bulk viscosity as well as the stiffening of the equation of state with increasing frequency or wave-number. Based on M. Stephanov and Yi Yin, "Hydro+ hydrodynamics with parametric slowing down and fluctuations near the critical point", arXiv 1712.10305, to appear in PRD.

Understanding the out-of-equilibrium dynamics near a critical point with “Hydro+”

Gregory Ridgway

Abstract

Upcoming experimental programs, like the Beam Energy Scan at RHIC, will look for signatures of a possible critical point in the QCD phase diagram in fluctuation observables. To understand and predict these signatures, one must account for the fact that the dynamics of any critical fluctuations must be out-of-equilibrium because of critical slowing down, the fluctuations cannot stay in equilibrium as the droplet of QGP produced in a collision expands and cools. Furthermore, their out-of-equilibrium dynamics must also influence the hydrodynamic evolution of the cooling droplet. The recently developed Hydro+ formalism allows for a consistent description of both the hydrodynamics and the out-of-equilibrium fluctuations, including the feedback between them. We shall provide the first demonstration of how this works, setting up a Hydro+ simulation in a simplified setting a rapidity-independent fireball undergoing radial flow with an equation of state in which we imagine a critical point close to the μ_B=0 axis of the phase diagram. Within this setup, we show that we can quantitatively capture non-equilibrium phenomena, including critical fluctuations over a range of scales and memory effects, as well as the backreaction of the out-of-equilibrium fluctuations on the hydrodynamic flow of the fireball.

Shear viscosity and resonance lifetimes in the hadron gas

Jean-Bernard Rose

Abstract

Previous calculations of the shear viscosity to entropy density ratio in the hadron gas have failed to reach a consensus, with η/s predictions differing by almost an order of magnitude when approaching the phase transition. This work addresses and solves this discrepancy by providing an independent extraction of this coefficient using the newly-developed SMASH (Simulating Many Accelerated Strongly interacting Hadrons) transport code and the Green-Kubo formalism. We compare the results from SMASH with numerical solutions of the Boltzmann equation for various systems using the Chapman-Enskog expansion as well as previous results in the literature. Substantial deviations of the coefficient are found between transport approaches mainly based on resonance propagation with finite lifetime (such as SMASH) and other (semi-analytical) approaches with energy-dependent cross-sections, where interactions do not introduce a timescale other than the inverse scattering rate. Our conclusion is that long-lived resonances strongly affect the transport properties of the system, resulting in significant differences in Î·/s with respect to other approaches where binary collisions dominate. We argue that the relaxation time of the system, which characterizes the shear viscosity, is determined by the interplay between the mean-free time and the lifetime of resonances. We show how an artificial shortening of the resonance lifetimes or the addition of a background elastic cross section nicely interpolate between the two discrepant results. To turn this around, we note that the temperature dependence of η/s can be used to constrain the properties of the hadron gas. Finally, this analysis of the effects of resonance lifetimes is extended to other transport coefficients such as electric conductivity and bulk viscosity in simple systems.

QCD equation of state at finite baryon density with fugacity expansion

Volodymyr Vovchenko

Abstract

QCD equation of state at finite baryon density is studied in the framework of expansion in baryonic fugacity. Recent lattice QCD data at imaginary baryochemical potential, obtained for physical quark masses, provides the four leading coefficients of the fugacity expansion of net baryon density from first-priciples. On the basis of these lattice data, we formulate the Cluster Expansion Model (CEM), which provides all higher-order coefficients on the basis of the leading two. CEM is shown to be consistent with all presently available lattice data for baryon number susceptibilities up to 8th order. Effective parameterization of the QCD equation of state at finite baryon density on the basis of CEM, which can be used in hydro simulations at finite baryon density, is presented.

Evolution of multiplicity fluctuations in heavy ion collisions expansion

Radka Sochorova

Abstract

The evolution of multiplicity distribution of a species which undergoes chemical reaction can be described with the help of master equation. Firstly, we study the master equation for the fixed temperature, because we want to know how fast different moments of the multiplicity distribution approach their equilibrium value. We particularly look at the 3rd and 4th factorial moments and their equilibrium values from which central moments and other ratios can be calculated. Then we study the situation in which the temperature of the system decreases. We found out that in the non-equilibrium state, higher factorial moments differ more from their equilibrium values than the lower moments and that the behaviour of the combination of the central moments depends on the combination we choose. If one chooses to determine the chemical freeze-out temperature from the measured values of higher moments, this effects might jeopardise the correctness of the extracted value.

PHENIX results on centrality and collision energy dependent Levy analysis of HBT correlation functions

Daniel Kincses

Abstract

The experimental investigation of the QCD phase diagram becomes possible by varying the center of mass collision energy and centrality in heavy-ion collisions. To describe the space-time structure and geometry of the particle emitting source, HBT correlations are among the best observables. In our latest analysis at the PHENIX experiment at RHIC we utilize Levy-type sources to describe the measured pion-pion correlation functions at different beam energies and centralities. The three main extracted source parameters can yield different information about the source. The lambda parameter (the strength of the correlation function) may provide an indirect measurement of in-medium mass modification, while the Levy scale parameter R is related to the physical size of the source. The index of stability alpha is related to one of the critical exponents (the correlation-exponent, eta), so it may provide information on the nature of the quark-hadron phase transition. In this talk we report the current status of our analysis of the centrality and beam energy dependence of the Levy source parameters in Au+Au collisions from $\sqrt{s_{NN}}$ = 15 GeV to $\sqrt{s_{NN}}$ = 200 GeV.

Open charm measurements at CERN SPS energies in the NA61/SHINE experiment - status and plans

Anastasia Merzlaya

Abstract

The study of open charm meson production provides an efficient tool for detailed investigations of the properties of hot and dense matter formed in nucleus-nucleus collisions. In particular, charm mesons are of particular interest in the context of the phase-transition between confined hadronic matter and the quark-gluon plasma. Recently, the experimental setup of the NA61/SHINE experiment was supplemented with a small-acceptance version of the Vertex Detector (SAVD) which was motivated by the importance and the possibility of the first direct measurements of open charm meson production in heavy ion collisions at SPS energies. First exploratory data taking in Pb+Pb collisions at 150*A* GeV/c with the SAVD was performed in 2016, and a D^0 signal was extracted in it's $D^0 \rightarrow \pi^+ + K^-$ decay channel. This was the first, direct observation of open charm in nucleus-nucleus collisions at the SPS energies. In October and November of 2017 a large statistic data set was recorded for Xe+La collisions with the SAVD at beam momenta of 150*A*, 75*A* and 40*A* GeV/c, these data are currently under intense analysis. The physics motivation behind the open charm measurements at the SPS energies will be discussed. The concept of the SAVD hardware and the status of the analysis will be shown, discussing challenges related to the reconstruction in the SAVD. Also, the future plans of open charm measurements in the NA61/SHINE experiment after 2020 related to the upgraded version of the Vertex Detector will be presented.

$K^*(892)^0$ production in p+p interactions at 158 GeV/c from NA61/SHINE

Angelika Tefelska
for the NA61/SHINE Collaboration

Abstract

The NA61/SHINE experimental physics program is focused on searching for the critical point and on the study of the properties of the onset of deconfinement in strongly interacting matter. A scan of the phase diagram of strongly interacting matter is done by changing the energy of colliding ions (from 13*A* to 150/158*A* GeV) and by changing the system size (from p+p to Pb+Pb). The main topic of this talk are preliminary results of $K^*(892)^0$ meson production in p+p interactions at beam momentum 158 GeV/c obtained by the NA61/SHINE experiment. The analysis $K^*(892)^0$ was done for the first time with the template method in the K^+ pi^- decay channel. The results include the double differential spectra $d^2n/(dydp_T)$, $d^2n/(m_T\ dm_T\ dy)$ as well as p_T integrated and extrapolated dn/dy spectra. The measured mass and width of the $K^*(892)^0$ as function of transverse momenta are also presented and compared to other published results. Finally, the multiplicity of $K^*(892)^0$ and the ratio of $<K^*(892)^0>/<K^->$ as a function of $\sqrt{s_{NN}}$ is presented together with results of other experiments.

Meson properties in magnetized quark matter

Pengfei Zhuang

Abstract

We study neutral and charged meson properties in the magnetic field. Taking the bosonization method in a two-flavor Nambu-Jona-Lasinio model, we derive effective meson Lagrangian density with minimal coupling to the magnetic field, by employing derivative expansion for both the meson fields and Schwinger phases. We extract from the effective Lagrangian density the meson curvature, pole and screening masses. As the only Goldstone mode, the neutral pion controls the thermodynamics of the system and propagates the long range quark interaction. The magnetic field breaks down the space symmetry, and the quark interaction region changes from a sphere in vacuum to a ellipsoid in magnetic field. Reference: Ziyue Wang and Pengfei Zhuang, Physical Review D97, 034026(2018).

Experimental Summary Aspects of CPOD

Seweryn Kowalski

Theoretical Summary

Larry McLerran