ICTP-SAIFR/FAIR Workshop on Mass Generation in QCD

ICTP-SAIFR, Sao Paulo, Brazil

December 17-21, 2018

List of Abstracts

Status and progress of FAIR

Klaus Peters

(GSI Darmstadt)

Currently the international accelerator facility FAIR, one of the largest research projects worldwide, is being built in Darmstadt, Germany. At FAIR, matter that usually only exists in the depth of space will be produced in a lab for research. Scientists from all over the world will be able to gain new insights into the structure of matter and the evolution of the universe from the Big Bang to the present. FAIR is under construction at GSI Helmholtzzentrum für Schwerionenforschung. Its existing accelerator facilities will become part of FAIR and will serve as first acceleration stage. For the realization of FAIR, accelerator experts, scientists and engineers of FAIR and GSI are working closely together in teams all over the world.

The scientific goals and the status of construction will be presented.

The National Institute for Nuclear Physics and Applications

Takeshi Kodama

(UFF/INCT-FNA)

The National Insitute for Nuclear Physics and Applications, INCT-FNA, is a part of the largest scientific research projects (INCT´s) promoted by the National Council for Scientific Research (CNPq) of the Ministry of Science, Technology, Innovation and Communications (MCTI), in partnership with the CAPES of the Ministry of Education and State Agencies of the head- quarter of each INCT. Our INCT-FNA (the state of Rio de Janeiro) is composed of more than 130 researchers and 70 students from the 35 institutions scattered in the whole Brazilian territory. In this presentation, we report the present status of the project, in particular, those topics directly related to this workshop and discuss their perspectives.

RIBRAS - Radiactive Beam in Brazil

Alinka Lépine Szily

(University of São Paulo)

A short description of the research on nuclei out of the stability valley, which is one of the forefronts of nuclear physics, with very large investments for new accelerator facilities (FAIR (Germany),FRIB (USA), SPIRAL (France), RIKEN (Japan), RAON (South Korea), HIAF (China) etc. Short discussion on the production methods of radioactive beams, available at different energies and their comparison. The scientific programs attainable at different facilities, with different energies, with different beam intensities. Description of RIBRAS, which produces low energy, light radioactive beams and its main scientific results.

Hadronic molecules from effective field theory

Evgeny Epelbaum

(Ruhr-Universität Bochum, Fakultät für Physik und Astronomie, Institut für Theoretische Physik II)

Effective field theory provides a natural and efficient tool to analyze hadronic molecular states by systematically exploiting the separation between soft and hardscales. I will discuss our recent and ongoing efforts along this line focusing on theX(3872), Zb(10610) and Zb(10650) states and the corresponding spin partners.

Glueballs - fundamental, exciting and elusive

Ulrich Wiedner

(Institute f. Experimentalphysik I, Ruhr-University Bochum)

Quantum Chromodynamics is the accepted theory of the strong interaction. The gauge bosons transmitting the force are gluons. However, the non-perturbative part of QCD is far from being understood on a fundamental level.Non-perturbative aspects of QCD can be especially well studied when the gauge fields play a prominent role. Therefore, glueballs, particles composed solely of gluons, are an excellent case to proof our understanding of non-perturbative QCD. The only problem that remains is the unambiguous identification bluebells. The talk reviews the current status.

Nucleon structure studies with the PANDA experiment

Frank Maas

(Helmholtz Institute Mainz)

The time like nucleon structure as accessible in annihilation reactions is not very well known, but represents a substantial element in the understanding the non-perturbative part of nucleon structure as a whole. The PANDA experiment offers unique opportunities for nucleon structure studies in the time like region.

Prospects for hyperon physics with PANDA

Tord Johansson

(Uppsala University)

Antiproton-proton collisions are excellent tools to study the production excellent tools to study the production hyperons. This allows to study spin degrees of freedom in the production of antistrange-strange quark pairs, perform symmetry test and search for excited multistrange hyperons. The prospect to carry out such studies with PANDA@FAIR will be reviewed.

In-medium properties of the low-lying bottom baryons in the QMC model

Kazuo Tsushima

(Cruzeiro do Sul University)

In-medium properties of the low-lying strange, charm, and bottom baryons in symmetric nuclear matter are studied in the quark-meson coupling (QMC) model. Results for the effective masses, mean filed potentials felt by the light quarks in the baryons, in-medium bag radii, and the lowest mode bag eigenvalues are presented for those calculated using the updated data. This study completes the in-medium properties of the low-lying baryons in symmetric nuclear matter in the QMC model, for the strange, charm and bottom baryons which contain one or two strange, one charm or one bottom quarks, as well as at least one light quark. Highlight is the prediction of the bottom baryon effective masses, namely, the effective mass of Σ_b becomes smaller than that of Ξ_b at moderate nuclear matter density, $m^*_{\Sigma_b} < m^*_{\Xi_b}$, although in vacuum $m_{\Sigma_b} > m_{\Xi_b}$. We study further the effects of the repulsive Lorentz-vector potentials on the excitation (total) energies of these bottom baryons.

Extraction of the Electromagnetic Form Factors for Spin-1 Particles on the Light-Front

João Pacheco Bicudo Cabral de Melo

(Cruzeiro do Sul University)

The electromagnetic form factors of a composite vector particle within the light-front formulation of the Mandelstam formula is investigated. In order to extract the form factors from the matrix elements of the plus component of the current in the Drell-Yan frame, where the momentum transfer is chosen such that $q^+=q^0+q^3=0$, one has in principle the freedom to choose between different linear combinations of matrix elements of the current operator. The different prescriptions to calculate the electromagnetic form factors, G_0,G_1 and G_2, i.e.; charge form factor, magnetic and quadrupole respectively. With some relations between the electromagnetic matrix elements of the electromagnetic current J^+_{ji}, as demonstrated analytical here, it was possible to calculate the electromagnetic form factors for spin-1 particles without zero-modes or non-valence contributions.

Interplay of dynamical and explicit chiral symmetry breaking effects on a quark

Fernando Enrique Serna Algarín

(Cruzeiro do Sul University)

The relative contributions of explicit and dynamical chiral symmetry breaking in QCD models of the quark-gap equation are studied in dependence of frequently employed ansatze for the dressed interaction and quark-gluon vertex. The explicit symmetry breaking contributions are defined by a constituent-quark sigma term whereas the combined effects of explicit and dynamical symmetry breaking are described by a Euclidean constituent-mass solution. We extend this study of the gap equation to a quark-gluon vertex beyond the Abelian approximation complemented with numerical gluon- and ghost-dressing functions from lattice QCD. We find that the ratio of the sigma term over the Euclidean mass is largely independent of nonperturbative interaction and vertex models for current-quark masses, $m_{u,d}(\mu) \leq m(\mu) \leq m_b(\mu)$, and equal contributions of explicit and dynamical chiral symmetry breaking occur at $m(\mu) \approx 400$ MeV. For massive solutions of the gap equation with lattice propagators this value decreases to about 220 MeV.

Pion and constituent quark effective interactions and constituent quark mass

Fabio L. Braghin

(Univ. of Goiás)

A one loop background field method is applied to a quark-quark interaction mediated by a non perturbative one gluon exchange by considering the quark field is decomposed into a component that gives rise to light quark-antiquark mesons and the scalar chiral condensate and the background component correspond to (baryon) constituent quarks. A gap equation for the scalar quark-antiquark state yields the usual mechanism for Dynamical Chiral Symmetry Breaking whereas large quark and gluon effective masses expansions for the quark determinant yields a different constituent quark running effective mass. The constituent quark mass reproduces very nicely running effective mass from SDE with improvements. The method also provides several leading light quark-antiquark mesons effective interactions with constituent quarks. From these couplings, different constituent quark quadratic radia are also calculated. \\ F.L. Braghin, Phys. Rev. D 99, 014001 (2019), arXiv:hep-ph:1809.07608v2. \\ F.L. Braghin, Eur. Phys. J. A 52, 134 (2016), arXiv:1601.04916.

The PANDA Detector

Anastasios Belias

(GSI Helmholtzzentrum für Schwerionenforschung)

PANDA is the central experiment to investigate antiproton–proton annihilations at the forthcoming Facility for Ion and Antiproton Research (FAIR).

The PANDA experiment features a modern multipurpose detector with excellent tracking, calorimetry and particle-identification capabilities, to exploit fully the physics potential of the high-quality antiproton beam at the High Energy Storage Ring (HESR) impinging on fixed hydrogen or other nuclear targets.

Here we present all aspects of the PANDA detector, the main objectives of the design, and the entirety of detector systems foreseen, as well their current status and we highlight opportunities for significant contributions.

Instrumentation Lab of HEPIC@IFUSP

Marco Bregant

(University of São Paulo)

The High Energy Physics and Instrumentation Center at Instituto de Física da Universidade de São Paulo (HEPIC at USP) has as scope to carrier research in the field of High Energy Physics, spanning across phenomenology, experimental data analysis, and detector development. The instrumentation activities of the Center are presently focused on the study of Multi Pattern Gaseous Detector (MPGD), mainly Gas Electron Multiplier (GEM), and on development of readout electronics, with the project, in joint-venture with the USP Polytechnic School, of the SAMPA chip. In this talk we will present the instrumentation lab, the local expertise, and the infrastructure available, highlighting the presently ongoing development and studies of new configurations and applications for GEM detectors, and the current status of the SAMPA chip, an ASIC devoted to readout of gaseous detectors. An outlook on possible new research lines will close the talk.

PandaRoot - the simulation and reconstruction framework of PANDA

Tobias Stockmanns

(Forschungzentrum Jülich)

One essential part for the success of an experiment is the capability to simulate the expected physical interactions and the response of the detector, the efficient selection of the reactions of interest and the detailed analysis of the collected data.

All these points are covered in the simulation and reconstruction framework of the PANDA experiment called PandaRoot. This software is based on the more general framework called FairRoot, which was developed as a common tool for the FAIR experiments but is also used by other experiments outside the FAIR community.

PandaRoot offers interfaces to several different event generators, particle propagation through the detector based on Geant3 and Geant4, a realistic simulation of the detector response, sophisticated tools for the reconstruction and selection of the events as well as an analysis framework to combine and fit different particle types to decay chains. In this presentation the various different stages of a simulation and reconstruction chain will be presented, including some unique features of the software like time-based simulation.

Selected ongoing projects at RIBRAS

Rubens Lichtenthãler

(University of São Paulo)

Light exotic nuclei such as 11Li and 6He present unusual features such as very low breakup energies and a neutron halo which are not found in stable nuclei. In this talk I will describe some experiments that evidenced the existence of the halo in 11Li and 6He and how it affects the measurements of their radii.

I will also present results from recent experiments performed in RIBRAS on 6He and the proton halo candidate 8B.

Simulation for high energy physics detectors

Mario Cosentino

(Federal U. of ABC São Paulo)

In nature hadronic interactions play a central role for the understanding of matter and its constituents. To investigate these interactions theoretical and experimental tools need to be developed and with an increasing level of accuracy. On the experimental side detectors need to have higher resolution in energy, time and position and, in the case of accelerator based facilities, they must be able to cope with increasing collision rates. To ensure these capabilities the construction and operation of such detectors rely on computational simulations, which are instrumental for the design of the detectors and understanding of their acquired data. In this talk I will present an overview of detector simulations for gaseous detectors and their applications in high energy physics.

Quarkyonic matter. **What is it and how to (maybe) detect it**.

Giorgio Torrieri

(State University of Campinas)

We show that the ideal fluid limit, defined as the existance of a flow frame uμ with respect to which the fluid is homogeneus and isotropic, and the consequent independence of the equation of state on uμ, is incompatible with non-Abelian gauge theory. Instead, the equation of state becomes dependent on uμ via modes which are roughly equivalent to ghost modes in the hydrodynamic limit. These modes can be physically imagined as a field of ”purcell swimmers” whose ”arms and legs” are outstretched in Gauge space. Also, vorticity should couple to the Wilson loop via the chromo-electro-magnetic field tensor, which in this limit is not a ”force” but instead represents the polarization tensor of the gluons. We show that because of this coupling vorticity also aquires swirling non-hydrodynamic modes. We then argue that these swirling and swimming non-hydodynamic modes are the manifestation of gauge redunancy within local equilibrium, and speculate on their role in quark-gluon plasma thermalization.

Recent developments on the X, Y and Z states

Marina Nielsen

(University of São Paulo)

Since their discovery the X, Y and Z states are considered as good candidates of either tetraquark or molecular states, and their observation motivated a vigorous theoretical activity. This is a rapidly evolving field with enormous amount of new experimental information. I will review the current experimental progress and investigate some theoretical interpretations for these candidates of multiquark states. I will consider, in particular, QCD sum rules results, and compare them with other approaches and with experimental data.

Photon spectroscopy at PANDA and elsewhere

Kai-Thomas Brinkmann

(Brinkmann Giessen University)

The rapid development in hadron physics and adjacent fields calls for novel solutions in detectors that meet increasing demands in terms of countrate, resolution, challenging environments etc. For PANDA, lead-tungstate ($PbWO_4$)has been identified as the material of choice for the electromagnetic calorimeter. Optimization of all components of the apparatus in test experiments, simulations, procedures of quality assurance for the large number of detector components etc. will be addressed and implications for other applications will be discussed. Currentresearch for future detector designs will be highlighted.

QCD phase transition from Dyson-Schwinger equations

Christian S. Fischer

(Giessen University)

I summarize recent results on the study of the Columbia plot, the QCD critical end point and fluctuations related to experiment.

Heavy quarkonium in a hadron gas

Fernando Navarra

(University of São Paulo)

In this talk I review recent work on the interactions of heavy quarkonium with light mesons in a hot hadron gas. I show how to calculate the relevant cross sections and changes in the multiplicities. I conclude that in the end of a heavy ion collisions, i.e., in the hadron gas phase, charmonium is mildly absorbed whereas bottomonium is strongly absorbed.

Octet baryon double ratios G_E/G_M in a nuclear medium

Gilberto Tomás Ferreira Ramalho

(Cruzeiro do Sul University)

The ratios of the baryon electric (GE) to magnetic (GM) form factors, GE/GM reveal important information on the structure of baryons in the vacuum as demonstrated in recent studies for the proton and neutron systems. It has been suggested that the corresponding in-medium ratios, GE*/GM*, can also provide useful information on the electromagnetic structure of baryons in a nuclear medium. The deviation of the double ratios (GE*/GM*)/(GE/GM) from unity is a measure of the effect of the medium modification of the electromagnetic structure in a nuclear medium.

We present estimates of the double ratio for the octet baryons for different nuclear densities. The double ratio results show two different features, namely, enhancement or quenching depending on the octet baryon members. We analyze the reasons why the two different features appear in the double ratios.

Structure of the nucleon's low-lying excitations

Chen Chen

(IFT State University São Paulo)

A continuum approach to the three valence-quark bound-state problem in quantum field theory is used to perform a comparative study of the four lightest (I = 1/2, JP = 1/2 ±) baryon isospindoublets in order to elucidate their structural similarities and differences. Such analyses predict the presence of nonpointlike, electromagnetically-active quark-quark (diquark) correlations within all baryons; and in these doublets, isoscalar-scalar, isovector-pseudovector, isoscalar-pseudoscalar, and vector diquarks can all play a role. In the two lightest (1/2, 1/2 +) doublets, however, scalar and pseudovector diquarks are overwhelmingly dominant. The associated rest-frame wave functions are largely S-wave in nature; and the first excited state in this 1/2 + channel has the appearance of a radial excitation of the ground state. The two lightest (1/2, 1/2 −) doublets fit a different picture: accurate estimates of their masses are obtained by retaining only pseudovector diquarks; in their rest frames, the amplitudes describing their dressed-quark cores contain roughly equal fractions of even- and odd-parity diquarks; and the associated wave functions are predominantly P-wave in nature, but possess measurable S-wave components. Moreover, the first excited state in each negative-parity channel has little of the appearance of a radial excitation. In quantum field theory, all differences between positive- and negative-parity channels must owe to chiral symmetry breaking, which is overwhelmingly dynamical in the light-quark sector. Consequently, experiments that can validate the contrasts drawn herein between the structure of the four lightest (1/2, 1/2 ±) doublets will prove valuable in testing links between emergent mass generation and observable phenomena and, plausibly, thereby revealing dynamical features of confinement.

Minkowski space dynamics for hadrons

Tobias Frederico

(ITA São José dos Campos)

In this talk I will present the efforts in solving the Bethe-Salpeter equation in Minkowski space using integral representation for bound states of fermions-antifermion and fermion-boson, envisaging schematic description of mesons and nucleon. Some results for the self-energy fermion equation in a QED like theory in the Rainbow approximation in Minkowski space will be also presented, resorting to integral representation and also by exploring the analytic structure in the complex plane.

Heavy quark hadroproduction within dipole framework at FAIR

Fabio Kopp

(UFRGs)

In this work we calculate the inclusive production of ccbar and bbar to FAIR energies using four dipole models: GBW, b-CGC, BGBK and IP-SAT. In this framework, the first and second model do not include parton evolution, while the two latest include it. As a result this inclusion leads to a slightly different values for cross-section and rapidity. Further, one of the main advantages of the dipole models is the incorporation of high order and saturation effects going beyond the leading order. One of the main features of these models is that the growth of gluon distribution is tamed by non-linear term present in its formulation. It's worth to mention that this term is not present in parton model. Finally, we compare to our results the current data in the literature for total cross-section in terms of center-of-mass energy and rapidity for differents center-of-mass energy .

Experimental status and outlook of the XYZ mystery

Klaus Peters

(GSI Darmstadt)

The last few years have been witness to a proliferation of new results concerning heavy exotic hadrons, often referred to as XYZ states. Experimentally, many new signals have been discovered that could be pointing towards the existence of tetraquarks, pentaquarks, and other exotic configurations of quarks and gluons. It is thus an opportune time to evaluate the status of the field.

An overview of the new findings, imminent questions and foreseen measurement will be presented.

Heavy-Flavor Hadrons as a Probe of the Quark-Gluon Plasma

Marcelo Gameiro Munhoz

(University of São Paulo)

The measurement of hadrons containing heavy quarks produced in heavy-ion collisions is a very effective tool to study the Quark-Gluon Plasma (QGP). Since heavy quarks are produced in the very early stages of the collisions via hard scattering processes, they probe the whole medium evolution and lose energy via elastic and radiative processes. However, in order to obtain information regarding the QGP properties from AA collisions, reference measurements from pp and p-Pb collisions are crucial in order to isolate the effects of the medium on the observables from other effects. In this talk, I will present some recent results regarding the measurement of this probe in the Large Hadron Collider and the lessons we can take from them.

Out-of-equilibrium phenomena at finite density

Jorge Noronha

(University of São Paulo)

In this seminar I will present the first systematic study of the emergence of hydrodynamics in a far-from-equilibrium relativistic fluid with a critical point. For rapidly expanding systems such as the matter formed in heavy ion collisions, the onset of hydrodynamic behavior is shown to be significantly delayed by the presence of critical phenomena. We then switch gears to consider the out-of-equilibrium behavior of the extremely dense matter formed in neutron star mergers. We solved a long standing open problem in the field of viscous hydrodynamics and its coupling to general relativity by proving causality, existence, and uniqueness of the solutions of the highly nonlinear equations of motion of viscous hydrodynamics in curved spacetime. These results pave the way for the inclusion of viscous effects in state-of-the-art simulations of gravitational-wave signals coming from neutron star mergers.