ICTP SAIFR International Centre for Theoretical Physics
South American Institute for Fundamental Research

unesp UNIVERSIDADE ESTADUAL PAULISTA "JÚLIO DE MESQUITA FILHO"

Workshop on Magnetic Fields in Hadron Physics

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List of Abstracts

MONDAY – May 9

Uses and misuses of the NJL model – Heavy-light mesons, magnetic fields, chiral imbalance, superdense matter

Gastão Krein

IFT-UNESP

Fermionic contact interactions find widespread applications in hadron physics with Nambu--Jona-Lasinio type of models. A great deal of qualitative insight on the phenomenon of hadron mass generation via dynamical chiral symmetry breaking and the role of the pions as the associated (quasi) Goldstone bosons has been gleaned from such models. The lack of confinement, asymptotic freedom and nonrenormalizability are the major weaknesses of contact fermionic models. The nonrenormalizability carries the danger of introducing gross violations of global symmetries due to the regularization procedure; ambiguities arising from momentum shifts in divergent integrals are the main cause of problems. Despite well known, practitioners at large ignore these problems. In the present talk I discuss a subtraction scheme that allows to separate symmetry-offending parts in Bethe-Salpeter amplitudes in contact-interaction models in a way independent of choices of momentum routing in divergent integrals. I discuss applications of the scheme to three problems of current interest: heavy-light mesons, chiral transition in the presence of a chiral imbalance, and color superconductivity in quark matter.

The phases of cold magnetized quark matter in NJL-type models

Norberto Scoccola

Comisión Nacional de Energía Atómica – CNEA

The influence of intense magnetic fields on the phase structure of cold quark matter is investigated using some extended versions of the SU(2)f NJL model. We consider first one that includes general flavor mixing and vector interactions. Charge neutrality and beta equilibrium effects, which are relevant to the study of compact stars are taken into account for this case. Finally, superconducting quark matter is also studied through the introduction of diquark pairing interactions. Special attention is paid to issues related to the model regularization.

Magnetic shift of the chemical freezeout and electric charge fluctuations

Kenji Fukushima

Tokyo University

The inverse magnetic catalysis has been established, but it is still non-trivial how this implies to the chemical freezeout lines. I will talk about our latest study using the hadron resonance gas with an empirical freezeout condition that an average energy per thermal degrees of freedom is 1GeV. I will emphasize a non-trivial role played by the electric charge conservation. Also, the electric charge fluctuation is a quantity very sensitive to the magnetic field, which is affected by the charge conservation, but is still enhanced significantly enough to probe the magnetic field.

QCD Sum Rules approach for the gluon condensate and deconfinement

Marcelo Loewe

PUC-Chile

After a brief introduction of the QCD Sum Rules approach, including its extension to the finite temperature and density scenario, we will concentrate on the finite energy sum rules (FESR) for the two point axial-vector current correlator in the presence of an external magnetic field, in the weak limit and at zero temperature. Both the perturbative QCD and the hadronic contribution to the sum rules get explicit magnetic-field-dependent corrections which in turn induce a magnetic field dependence on the hadronic continuum threshold s0 and on the gluon condensate. We find from the dimension d=2 first FESR that the magnetic field dependence of s0 is proportional to the absolute value of the light-quark condensate increasing, therefore, with an increasing field strength. This shows that the parameter describing chiral symmetry restoration and deconfinement behave similarly as functions of the magnetic field. At zero temperature, the magnetic field plays the role of a catalyzing agent of both chiral symmetry breaking and confinement. From the second FESR, dimension d=4, we obtain also the behavior of the gluon condensate as function of the magnetic field. This condensate also increases as function of the magnetic field.

Strongly coupled quark-gluon plasma in a magnetic field - a holographic perspective

Jorge Noronha

Universidade de São Paulo (USP)

Lattice data for the QCD equation of state and the magnetic susceptibility at zero magnetic field are used to construct black hole solutions in a five dimensional Einstein-Maxwell-Dilaton holographic model that can be used to study the effects of a magnetic field on the equilibrium and transport properties of the strongly coupled quark-gluon plasma. Our results for the thermodynamics of the plasma and the crossover temperature (determined via the inflection of the entropy density) are in agreement with current lattice data for different values of the magnetic field. This type of black hole engineering is used to compute how hydrodynamic transport coefficients of the quark-gluon plasma change in strong magnetic fields.

TUESDAY – May 10

The equation of state of QCD in magnetic fields from lattice simulations

Gunnar Bali

Universität Regensburg

After a short motivation, we discuss how QCD in the background of a magnetic field can be simulated at zero and non-zero temperatures on the lattice. We discuss renormalization issues and different methods of determining the magnetization and pressure(s) of the QCD medium. We also point out a relation to the Adler function of QED and present results on these quantities from numerical simulations.

Magnetic phase diagram of QCD: current status from the lattice

Gergely Endrodi

Regensburg University

Lattice simulations have demonstrated that background magnetic fields reduce the chiral/deconfinement transition temperature of quantum chromodynamics for eB < 1 GeV^2. The enhancement of the Polyakov loop, the suppression of the light quark condensates (inverse magnetic catalysis) and the polarization of quark spins are the relevant effects in the transition region. Do these trends continue to yet higher values of the magnetic field? In this talk, I report on recent lattice simulations that aim to answer this question.

Thermodynamics of magnetic QCD in light of the Gribov-Zwanziger framework

Letícia Palhares

Universidade do Estado do Rio de Janeiro (UERJ)

We build a novel non-perturbative quark model based on the Gribov-Zwanziger framework. Interactions are encoded in a nonlocal quark propagator that displays dynamical chiral symmetry breaking in the IR, while reproducing the perturbative one in the UV. Results for the thermodynamics of quark matter at finite temperature, density and external Abelian magnetic fields are then discussed.

Magnetized effective QCD phase diagram

Luis A. Hernandez

University of Cape Town

We will explore the effective QCD phase diagram in the presence of magnetic fields. By using the linear sigma model coupled to quarks, we computed the effective potential and we analysed the chiral symmetry restoration with finite quark chemical potential and in the presence of magnetic fields. We will discuss the importance to include:

(1) the plasma screening properties in the effective potential,

(2) the proper thermo-magnetic corrections to the boson self-coupling and to the coupling between fermions and bosons.

Finally, we will show the behaviour of the critical end point as function of magnetic field strength.

First order chiral transition under magnetic fields

Marcus Benghi Pinto

Universidade Federal de Santa Catarina

Using the Nambu--Jona-Lasinio model we discuss how the presence of a strong magnetic background influences the first order chiral transition pattern within cold and dense quark matter. We investigate how magnetically driven oscillatory effects influence the baryonic density as well as the coexistence region. This allows us to evaluate the surface tension whose numerical value plays an important role regarding, e.g., the existence of a mixed phase within hybrid stars. Our predicted values for this quantity oscillate between 15 MeV/fm^2 and 40 MeV/fm^2 for eB up to 10 m_pi^2.

WEDNESDAY – May 11

Anisotropic Coupling Constant and Inverse Magnetic Catalysis in Strongly Magnetized Quark Matter

Efrain J. Ferrer

University of Texas El Paso

In this talk I will discuss three important points to be considered when investigating the magnetic catalysis of chiral symmetry breaking:

1. That the magnetic catalysis of chiral symmetry breaking leads to the generation of two independent condensates, the conventional chiral condensate and a spin-one condensate that gives rise to a dynamical anomalous magnetic moment for the fermions. The new condensate enhances the critical temperature for chiral symmetry restoration.
2. That a strong magnetic field affects the QCD coupling constant making it anisotropic with respect to the field direction.
3. That the quarks, confined by the field to the lowest Landau level where they pair with antiquarks, produce an antiscreening effect.

Finally, I will show that these results lead to inverse magnetic catalysis, providing a natural explanation for the behavior of the critical temperature in the strong-field region.

Anomalous Properties of Dense Quark Matter in a Magnetic Field

Vivian de la Incera

University of Texas El Paso

In this talk I will discuss the realization of the Magnetic Dual Chiral Density Wave condensate in a NJL model of quark matter at intermediate densities in the presence of a magnetic field. This phase is a viable candidate to describe the region of cold QCD at intermediate densities in a magnetic field, so it is relevant for neutron stars and for the planned heavy-ion collision experiments at higher densities at NICA. I will show how the interaction of the electromagnetic field with the Magnetic DCDW medium leads to the equations of axion electrodynamics that contain an anomalous electric charge density and an anomalous, nondissipative Hall current density. This system exhibits magnetoelectricity and wave attenuation for certain frequencies, properties all associated with the nontrivial topology produced by the asymmetry of the Lowest Landau Level modes. The analogies between this phase of dense QCD and the properties of new topological materials will be outlined.

THURSDAY – May 12

Anomalous chiral plasmas: effects of finite size and inhomogeneities

Igor Shovkovy

Arizona State University

Chiral relativistic plasmas play an important role in many high-energy systems, as well as in a number of condensed matter systems with pseudo-relativistic quasiparticles. Interestingly, the quantum anomalies of the theory and the chirality of constituent particles may profoundly affect certain physical properties of the corresponding plasmas. By now, a large number of interesting phenomena were proposed and investigated. In many cases, however, systematic generalizations of underlying phenomena are not obvious when the systems are inhomogeneous and/or have finite sizes. This talk will review recent advances in developing a systematic approach to account for inhomogeneous in such plasmas. Several new effects associated with inhomogeneities will be discussed.

On the problem of light absorption in graphene

Alfredo Raya

Universidad de Michoacán

Among the remarkable features of this novel material, transparency of graphene membranes radiated with visible light is outstanding. In this talk I considerations in the presence of background magnetic fields and/or distortions of the membrane.

The chiral magnetic effect in planar condensed matter systems

Ana Julia Mizher

Universidad Nacional Autónoma de México

The chiral magnetic effect (CME) has been suggested to take place in peripheral relativistic heavy ion collisions as a mechanism that would allow us to probe in the laboratory fundamental features of the vacuum of the Quantum Chromodynamics (QCD). Although experimental data is in accordance with the predictions, it remains ambiguous if the sign observed is really due to the CME or to the collective behavior and statistical fluctuations taking place in the quark gluon plasma, and probing the QCD topological nature is still an open issue. In this talk I propose an analogue of the CME in the framework of planar condensed matter systems based on the similarities between QCD and the Quantum Electrodynamics (QED) in 2+1 dimensions. I show that, similarly to the CME, a conserved current must be generated in the direction of an in-plane external magnetic field. Exploring this connection must shed light into the observables of the CME and has potential technological applications in material physics.

Study of thermo-magnetic hadron matter using the local Nambu-Jona-Lasinio model and its compatibility with Lattice QCD

Juan Cristobal Rojas

Universidad Catolica del Norte

In this talk, we show our study of the behavior coupling constant in the NJL model, using a hybrid point of view: using the gap equation, we introduce the value of the quark condensate given by the lattice results. In that way, we obtain the value of the coupling constant as a function of temperature an magnetic field strength. It is also shown the behavior of the masses and the pressure.

Finally, we discuss the compatibility of the model with lattice QCD.

Effect of a uniform magnetic field on the inflaton decay process in a warm inflation scenario

Angel Sánchez

Universidad Nacional Autónoma de México

Magnetic fields appear everywhere in the universe. Their widespread presence at high redshifts and very large scales suggests that their origin could be primordial. In particular, their presence during the inflationary epoch can certainly not be ruled out. In the warm inflation scenario, the coupling of the inflaton to other bosonic and fermionic fields gives rise to dissipative effects that modify the inflationary dynamics. Since primordial magnetic fields could have an effect on both the effective inflationary potential and the inflaton decay process, their contribution must be considered together with the finite temperature corrections. We review here their effect on the inflationary potential and present preliminary results of their intervention in the dissipation process.

FRIDAY – May 13

Heavy quarkonium production in a strong magnetic field

Fernando Navarra

Universidade de São Paulo

It is well known that in noncentral heavy-ion collisions a transient strong magnetic field is generated in the direction perpendicular to the reaction plane. The maximal strength of this field is estimated to be eB = 0.02 GeV2 at the RHIC and eB = 0.3 GeV2 at the LHC. We Investigate the effects of a strong magnetic field on B and D mesons, focusing on the changes of the energy levels and the masses of the bound states. Using the Color Evaporation Model we discuss the possible changes in the production of J/\psi and \Upsilon.

The thermo-magnetic quark-gluon vertex

Maria Elena Tejeda-Yeomans

Universidad de Sonora

The properties of the effective quark-gluon coupling in the presence of a magnetic field are an important ingredient for the study of the inverse magnetic catalysis phenomenon. In order to gain insight into this phenomenon, we recently obtained the correction to the quark-gluon vertex in the presence of a weak magnetic field within the hard thermal loop approximation. In this talk we report on this calculation, the phenomenological implications of our results on the behaviour of the coupling and further developments based on this result.

Thermal photon production from gluon fusion induced by magnetic fields in relativistic heavy-ion collisions

Alejandro Ayala

Universidad Nacional Autónoma de México

We compute the production of thermal photons in relativistic heavy-ion collisions by gluon fusion in the presence of an intense magnetic field, and during the early stages of the reaction. This photon yield is an excess over calculations that do not consider magnetic field effects. We add this excess to recent hydrodynamic calculations that are close to describing the experimental transverse momentum distribution in RHIC and LHC. We then show that with reasonable values for the temperature, magnetic field strength, and strong coupling constant, our results provide a very good description of such excess. These results support the idea that the origin of at least some of the photon excess observed in heavy-ion experiments may arise from magnetic field induced processes.

Thermal QCD at extremely large magnetic fields

Eduardo Fraga

Universidade Federal do Rio de Janeiro

Strong interactions at finite temperature become considerably simpler at magnetic fields much larger than the other energy scales essentially due to dimensional reduction. After discussing a few lessons learned from effective models and QCD studies of strong interactions in the presence of a magnetic background, we revisit the magnetic bag model which proves to be an unexpectedly adequate framework in the extreme case.

Magnetic (anti)catalysis in Bose-Einstein condensation

Cristián Villavicencio

Universdad del Bío-Bío

The formation a superfluid phase is altered by the presence of an external magnetic field. To observe this, we obtain the magnetic dependence of the critical temperature for the formation of a Bose-Einsten condensate. In particular, the second order phase transition for cold and dilute charged bosons is analyzed as well as the linear sigma model and the condensation of pions. The parameters involved are chosen to mimic compact star conditions.