Gauge Field Topology: From Lattice Simulations and Solvable Models workshop Talk Schedule

Events for:
Monday, August 17th - Friday, August 21st

Monday, August 17th

9:00am **Edward Shuryak - SCGP 102**

10:00am **Mithat Unsal - SCGP 102**

Title: Confinement in compactified SUSY setting

Abstract: Using the twisted partition function on R3×S1, we argue that the deconfinement phase transition in pure Yang-Mills theory for all simple gauge groups is continuously connected to a quantum phase transition that can be studied in a controlled way. We explicitly consider two classes of theories, gauge theories with a center symmetry, such as SU(Nc) gauge theory for arbitrary Nc, and theories without a center symmetry, such as G2 gauge theory. The mechanism governing the phase transition is universal and valid for all simple groups. The perturbative one-loop potential as well as monopole-instantons generate attraction among the eigenvalues of the Wilson line. This is counter-acted by neutral bions — topological excitations which generate eigenvalue repulsion for all simple groups. The transition is driven by the competition between these three effects. We study the transition in more detail for the gauge groups SU(Nc), Nc>2, and G2. In the case of G2, there is no change of symmetry, but the expectation value of the Wilson line exhibits a discontinuity. We also examine the effect of the ?-angle on the phase transition and critical temperature Tc(?). The critical temperature is a multi-branched function, which has a minimum at ?=? as a result of topological intereference.

11:00am **Coffee Break - SCGP Cafe**

11:20am **Ismail Zahed - SCGP 102**

Title: Dense instanton-dyon plasma

12:05pm **Yizhuang Liu - SCGP 102**

Title: Fermions in a dense instanton-dyon plasma

12:40pm **Lunch - SCGP Cafe**

2:00pm **Rasmus Larsen - SCGP 102**

Title: Classical interactions and numerical studies of the instanton--dyon ensemble

Abstract: "Instanton-dyons, also known as instanton-monopoles or instanton-quarks, are topological constituents of the instantons at nonzero temperature and holonomy. Classical interactions of the dyons have been found and included in numerical simulations of the ensemble of interacting dyons for SU(2) pure gauge theory. The focus of the talk is the back reaction on the holonomy and the issue of confinement, but I will also devote time to explain the structure of the dyons and their classical interactions. The free energy has been calculated as a function of the holonomy and the dyon densities, using standard Metropolis Monte Carlo and integration over parameter methods. It is observed that as the temperature decreases and the dyon density grows, the minimum of the free energy indeed moves from small holonomy to the value corresponding to confinement."

2:40pm **Tin Sulejmanpasic - SCGP 102**

Title: Instanton interactions in (SUSY) quantum mechanics

3:20pm **Coffee Break - SCGP Cafe**

3:40pm **Dmitri Kharzeev - SCGP 102**

Title: Overview of the chiral magnetic effect

4:30pm **Huan Huang - SCGP 102**

Title: Experimental Searches for Chirality and Magnetic Field Effects in Heavy Ion Collisions at RHIC

5:00pm **Michael Ogilvie - SCGP 102**

Title: A holistic approach to instantons on R^3 x S^1

Abstract: Abelianizing deformations provide important tools for understanding the phase structure and topological excitations in both continuum and lattice field theories. Such deformations typically produce a rich phase structure, and allow additional analytic control over nonperturbative effects. In lattice models, Abelianizing deformations typically lead to the emergence of the constituents of instantons as primary objects. They can also provide a stabilizing mechanism for classically conformal theories, removing problems in the naive instanton expansion. Finally, Abelianizing deformations play a crucial role in phenomenological models of QCD at nonzero temperature and density, thus providing a bridge between theory and phenomenology.

Tuesday, August 18th

9:00am **Ernst-Michael Ilgenfritz - SCGP 102**

Title: Signatures of dyons or KvBLL calorons from lattice gluodynamics at nonzero temperature Abstract 1: We will present an overview of attempts and results of a Berlin-ITEP (Moscow) collaboration to establish evidence for Kraan-van Baal/Lee-Lu calorons and fordyon structures in lattice gauge field ensembles, whichhas begun more than 10 years ago. Some attempts are alsodescribed to perform simulations of confinement within corresponding models.

9:50am **Michael Muller-Preussker - SCGP 102**

Title: Determining the topological susceptibility in lattice QCD at nonzero temperature Abstract 2: We would like to present an overview of recent determinations of the topological suceptibility in lattice QCD using (and comparing) various smoothing methods, in particular the gradient flow. How the latter works will be first demonstrated in the simple one-dimensional quantum mechanical case of an (un)harmonic oscillator. Finally we will focus on the topological susceptibility in full QCD with flavor number N_f=2 and the more realistic case 2+1+1 at non-zero temperature.

10:40am **Coffee Break - SCGP Cafe**

11:00am **Leonid Glozman - SCGP 102**

Title: Hadrons with and without zero-mode-zone

11:50am **Ivan Horvath - SCGP 102**

Title: Studies of fermionic zero-mode-zone states

Abstract: I discuss elements of a long-term effort to characterize QCD vacuum (and its thermal states) in a model-independent manner using lattice QCD. Local behavior of topological density and properties of (overlap) Dirac eigenmodes are given a particular attention. Regarding the latter, construction of non-Pearson correlations describing chiral polarization of modes will be covered in some detail, including the proposed equivalence between chiral symmetry breaking and condensation of local chirality defined accordingly. In the last part of the talk, recent developments suggesting connections between the properties of Dirac modes and confinement are discussed, emphasizing the existence of deconfined phase with broken valence chiral symmetry in thermal QCD, and in systems with many light fundamental flavors.

12:40pm **Lunch - SCGP Cafe**

2:00pm **Sayatan Sharma - SCGP 102**

Title: The axial U(1) anomaly and topological structures in finite temperature QCD

Abstract: The magnitude of axial U(1) symmetry breaking is believed to affect nature of Nf = 2 QCD chiral phase transition. The explicit breaking of chiral symmetry due to realistic light quark masses is small hence it is important to use fermions which do not break chiral symmetry on the lattice, to understand the fate of axial U(1) near the chiral crossover temperature, Tc. I discuss on our recent study of the eigenvalue spectrum of QCD with two different lattice fermion discretizations which retain a remnant of the continuum chiral symmetry, using exact chiral overlap fermions as probes. From the eigenvalue spectrum of the overlap operator, we do not observe any hints of the effective restoration of axial U(1) near Tc. A pile up of the near-zero eigenmodes is observed to persist even at 1.5Tc which are primarily responsible for its breaking. These eigenmodes are localized unlike those in the bulk, with a mobility edge similar to a Mott-Anderson like system. The origin of such near-zero mode spectrum can be traced back to the dilute instanton gas ensemble already setting in at 1.5 Tc.

2:45pm **Maria Lombardo - SCGP 102**

Title: Scale separation, walking dynamics and approach to criticality in QCD with varying number of flavors.

Abstract: QCD with Nf fundamental fermions has a rich phase structure which has been explored with analytic and numerical studies. In the massless case and at zero temperature an essential singularity is expected to separate the QCD-like phase from the conformal phase, and this should be reflected by Miransky scaling of infrared observables. In turn, the conformal phase can be seen as the zero temperature limit of a (strongly)interactive quark gluon plasma when the number of flavors approach its critical value. In lattice simulations a nonzero quark mass is usually included, and conformality is explicitely broken, with two main consequences: a) The would-be conformal phase is continuously connected with the QCD-like phase and features of the conformal phase such as the anomalous dimension are still observable below the critical number of flavors; b)The critical singularity disappears however ratios of homogeneous observables still carry an imprinting of the critical dynamics. The talk is a brief overview of these phenomena, elucidated by the behaviour of the (pseudo)critical temperature, mass spectrum, string tension and Wilson flow in the preconformal region.

3:30pm **Coffee Break - SCGP Cafe**

4:00pm **Kenji Fukushima - SCGP 102**

Title: QCD under curvature and magnetic effects

5:15pm **Vasily Sazonov - SCGP 102**

Title: Convergent Series

Wednesday, August 19th

9:00am **Misha Shifman - SCGP 102**

Title: Topological defects in Yang-Mills with non-abelian moduli and their implications.

Abstract: "I discuss developments of the last decade in Yang-Mills theories (including those at strong coupling) with or without supersymmetry. I focus on the progress in understanding non-Abelian dynamics, 2D-4D correspondence and various applications. In the supersymmetric case remarkable exact results ensue."

10:00am **Gerald Dunne - SCGP 102**

Title: Overview of the resurgence program

11:00am **Coffee Break - SCGP Cafe**

11:20am **Ariel Zhitnitsky - SCGP 102**

Title: Vacuum energy, contact term and all that in gauge systems with nontrivial holonomy

Abstract: I present few highly nontrivial features of the gauge theories when the configurations with nontrivial holonomy play the crucial role in dynamics. First example is the computation of the contact term in a weakly coupled gauge theory, the so-called "deformed QCD". I argue that the configurations with nontrivial holonomy saturate the contact term which was conjectured for strongly coupled QCD long ago by Witten and Veneziano. Second example is computations of the contact term in nontrivial curved hyperbolic background. I argue that correction to the energy is linear in inverse size of the system L^{-1}. The correction is expressed in terms of gauge invariant holonomy, but can not be formulated in terms of local operators. It might be the key element in understanding of the observed cosmological dark energy, which is interpreted in this framework as the modification of the QCD vacuum energy in topologically nontrivial background.

12:05pm **Yachao Qian - SCGP 102**

Title: Spin Asymmetries and P-odd Effects through QCD Instantons

12:50pm **Juven Wang (IAS Princeton) - SCGP 102**

Title: Quantum Statistics, Spacetime Topology and Lattice Chiral Fermions of Condensed Matter

1:35pm **Lunch - SCGP Cafe**

Thursday, August 20th

9:00am **Jeff Greensite - SCGP 102**

Title: Confinement via center vortices

Abstract: I review the motivation and numerical evidence for the center vortex confinement mechanism.

10:00am **Kej-Ichi Kondo - SCGP 102**

Title: Monopoles and confinement

Abstract: We give a review on the recent developments on quark confinement from the viewpoint of dual superconductivity based on [Physics Report Vol.579, pp.1--226 (2015)]. First, we give the SU(N) extension of the Diakonov-Petrov version of the non-Abelian Stokes theorem for the Wilson loop operator to give a gauge-invariant definition for the magnetic monopole in the SU(N) Yang-Mills theory without the scalar field. Second, we give a new framework for reformulating the SU(N) Yang-Mills theory using new field variables. This includes the preceding works on field decompositions given by Cho, Duan and Ge, Faddeev and Niemi, as a special case called the maximal option in our reformulations. An advantage of the reformulations is that the original Yang-Mills gauge field variables can be changed into the new field variables such that one of them called the restricted field gives the dominant contribution to quark confinement in the gauge-independent way. Then, our reformulations can be combined with the non-Abelian Stokes theorem. In the so-called minimal option, especially, the restricted field is non-Abelian and involves the non-Abelian magnetic monopole with the stability group U(N-1). This suggests the non-Abelian dual superconductivity picture for quark confinement. This should be compared with the maximal option: the restricted field is Abelian and involves only the Abelian magnetic monopoles with the stability group U(1)$^{N-1}$, just like the Abelian projection. Third, we give the lattice version of the reformulations of the SU(N) Yang-Mills theory and present the results of the numerical simulations of the SU(3) Yang-Mills theory on a lattice. The numerical simulations include the derivation of the linear potential for static interquark potential, i.e., non-vanishing string tension, in which the restricted field dominance and magnetic monopole dominance are established, confirmation of the dual Meissner effect by measuring the chromoelectric flux tube between quark-antiquark pair, the induced magnetic-monopole current, and the type of dual superconductivity, etc.

11:00am **Coffee Break - SCGP Cafe**

11:20am **Chris Korthals-Altes - SCGP 102**

Title: The magnetic component of the QCD plasma.

Abstract: I review the necessity of a magnetic component in the QCD plasma, as seen by lattice simulations of spatial Wilsonloops.

12:00pm **Peter Petreczky - SCGP 102**

Title: The Polyakov loop from the lattice

12:40pm **Lunch: - SCGP Cafe**

3:30pm **Coffee Break - SCGP 102**

4:00pm **Jinfeng Liao - SCGP 102**

Title: Electric flux tube and thermal monopoles in the deconfined phase

Abstract: The QCD vacuum structure and the mechanism for confinement provides a persistent challenge to our understanding of nonperturbative gauge dynamics. One compelling idea is to consider the vacuum as a monopole condensate and the confinement/deconfinement transition as the Bose condensation of monopoles. In recent years a new route to explore this idea has been proposed, namely to understand confinement from above i.e. in the deconfined phase, by studying the thermal monopole ensemble in the vicinity of Tc. The so-called ``magnetic scenario" suggests that an ensemble of abundant and light thermal monopoles emerges above Tc and reaches condensation condition at Tc thus leading to confinement transition. In this talk we focus on how such a scenario sheds light on two interesting phenomena: (1) the survival of extended electric flux tube into the deconfined phase as indicated by the static Q-bar-Q potentials; (2) the dependence of the confinement transition parameters on the fermion contents, which provides a unique test of the the mechanism of confinement as monopole condensation. Lastly we briefly comment upon how these monopoles behave as a color-opaque low-viscosity matter and help understand a few key properties of the quark-gluon plasma observed in heavy ion collision experiments. [References: Jinfeng Liao & Edward Shuryak, PRL109(2012)152001; PRD82(2010)094007; PRL101(2008)162302; PRC75(2007)054907.]

4:40pm **Claudia Ratti - SCGP 102**

Title: Thermal monopoles and kinetics of sQGP

5:20pm **Shu Lin - SCGP 102**

Title: The Polyakov loop potential and semi-QGP

Abstract: I will discuss lattice results on gauge theory thermodynamics and Polyakov loop. In temperature window 1.2~2Tc, the interaction measure features a T^2 scaling law and smooth rising of Polyakov loop. This is the regime of semi-QGP with the scaling law and behavior of Polyakov loop due to non-perturbative effect. I will discuss model of semi-QGP and the non-perturbative effect on gluons and quarks. I will also discuss its phenomenological implications.

6:00pm **Jiechen Xu - SCGP 102**

Title: The sQGP as semi-quark-gluon & monopole plasma (sQGMP)

Abstract: In relativistic heavy-ion collisions at RHIC and LHC, it has been a long-standing puzzle for all pQCD based jet energy loss models to simultaneously explain data on the high p_T nuclear modification factor and azimuthal asymmetry of light hadrons/open heavy flavors. In this talk, I will present a new jet quenching framework, CUJET3.0, where three novel features of nonperturbative physics origin are integrated in the pQCD opacity expansion theory: (1) the Polyakov loop suppression of color-electric scatterings (a.k.a. "semi-QGP" of Pisarski et al.) and (2) the enhancement of jet scattering due to emergent chromomagnetic monopoles near T_c (a.k.a. "magnetic scenario" of Liao and Shuryak) and (3) thermodynamic properties constrained by lattice QCD data. CUJET3.0 reduces to the pQCD limit at high temperatures $T > 400$ MeV; but thanks to the presence of the semi-quark-gluon monopole plasma (sQGMP) near the QCD deconfinement transition temperature, it greatly enhances the jet quenching parameter $\hat{q}$ in this temperature range. This enhancement renders a perfect description of the observed high p_T jet suppression factor and elliptic harmonics simultaneously. Extrapolating the data-constrained $\hat{q}$ down to thermal energy scales, $E \sim 2$ GeV, a remarkable consistency between the high energy jet quenching and bulk perfect fluidity with $\eta/s\sim T^3/\hat{q} \sim 0.1$ near T_c is found for the first time.

6:30pm **Workshop Banquet**

Friday, August 21st

9:00am **Adam Szczepaniak - SCGP 102**

Title: Couloumb gauge confinement and emerging phenomenology

10:00am **Alexander Turbiner - SCGP 102**

Title: Energy gap in quantum mechanics: double well potential

Abstract: Exploring the Schr\"odinger equation the locally accurate wave function of the ground (and the first excited) states will be constructed for 1D double well potential for weak, intermediate and strong coupling. As for 3D case the example of hydrogen molecular ion will be considered briefly

11:00am **Coffee Break - SCGP Cafe**

11:30am **Ismail Zahed - SCGP 102**

Title: Holographic Pomeron

12:30pm **Lunch - SCGP Cafe**

2:00pm **Ioannis Iatrakis - SCGP 102**

Title: QCD strings and their interactions from the holographic perspective

2:50pm **T. Iritani - SCGP 102**

Title: QCD strings on the lattice

Abstract: In the QCD vacuum, quarks are confined inside hadrons, which can be understood by a linear rising interquark potential. This linear potential is produced by the string structure of chromo fields between quarks. We introduce how to observe this phenomenological QCD string in lattice QCD. Besides the mechanism of quark confinement, QCD string would cause interesting phenomena. For example, we demonstrate the non-trivial modification of chiral condensate in the presence of QCD string. We also discuss more precise determination of QCD string features using gradient flow.

3:30pm **Coffee Break & Workshop Closing - SCGP Cafe**

4:00pm **Tigran Kalaydzhyan - SCGP 102**

Title: QCD string interactions and implications for high energy collisions

Abstract: In this talk I would like to introduce an idea of interaction between QCD strings and discuss some of the consequences for the nucleus-nucleus (AA) and proton-nucleus (pA) collisions. From the academic point of view, the interaction provides new (high entropy) regimes of the string behavior near the Hagedorn point. Among the applications are the onset of the explosive regime in pA collisions, elliptic flow in pA collisions, jet quenching in the mixed phase, modification of the particle spectra in high-energy cosmic rays, etc. I will also comment on the evidence of similar collective phenomena in proton-proton (pp) collisions. The talk is based on recent papers 1402.7363 (PRD), 1404.1888 (PRC), 1503.05213 (PRC)

4:30pm **Rob Pisarski & Edward Shuryak - SCGP 102**

Title: Concluding remarks