10th Workshop on Non-Perturbative QCD
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Abstracts

R. Babich: ***"How Strange is the Nucleon?"*** The role of strange quarks in the nucleon has been an issue of long-standing theoretical and experimental interest. On the experimental side, significant effort has been invested in determining the strange quark contribution to electromagnetic form factors of the nucleon via parity-violating electron scattering. With input from neutrino scattering, the strange axial form factor is also accessible. Less accessible to experiment is the matrix element of the strange scalar density in the nucleon. This latter quantity is of fundamental importance for the interpretation of direct dark matter searches, since it enters into the cross-section for the scattering of dark matter off nuclei in supersymmetric extensions of the standard model. All of the strange form factors (electric, magnetic, axial, scalar) are in principle calculable within the lattice formulation of QCD. In practice, however, they have long presented a numerical challenge, since they involve "disconnected diagrams," which demand the full inversion of the discretized Dirac operator. Here I discuss methods for overcoming this challenge and present some recent results for the strange form factors on the lattice.

Ian Balitsky: ***"High-Eenergy Amplitudes in N=4 SYM in the Next-to-Leading Order".*** The pomeron contribution to a four-point amplitude in N=4 SYM is detemined by two functions: the pomeron intercept and the coefficient function - product of two pomeron residues. Using the high-energy operator expansion in conformal color dipoles, we find the pomeron intercept and the coefficient function in the next-to-leading order in perturbation theory. The NLO intercept coincides with the known result obtained by the direct computation of Feynman diagrams.

Bender, Carl: ***"Latest Results on PT Symmetry".*** The theme of *PT* quantum mechanics is that one can obtain new and interesting quantum theories by extending conventional Hermitian quantum mechanics into the complex domain. A brief summary of *PT* quantum mechanics will be given. In the past few months optics experiments have been performed in which some of these new kinds of *PT* theories have been simulated and predictions of *PT* quantum mechanics have been verified with precision. To help explain intuitively how *PT* quantum mechanics works it is shown how to extend classical mechanics into the complex domain as well. It is shown that in the complex domain classical mechanics behaves quite similarly to quantum mechanics. For example, complex classical mechanics can exhibit the phenomenon of tunneling.

Brodsky, Stanley: ***"Light-Front Holography and Non-Perturbative QCD".*** Light-front holography allows hadronic amplitudes in the AdS/QCD fifth dimension to be mapped to frame-independent nonperturbative light-front wavefunctions of hadrons in physical space-time, thus providing a relativistic description of hadrons at the amplitude level. The AdS coordinate z is identified with an invariant light-front coordinate zeta which separates the dynamics of quark and gluon binding from the kinematics of constituent spin and internal orbital angular momentum. The result is a single-variable light-front

Schrodinger equation for QCD which determines the eigenspectrum and the light-front wavefunctions of hadrons for general spin and orbital angular momentum. A new method for computing the hadronization of quark and gluon jets at the amplitude level using AdS/QCD light-front wavefunctions is outlined. The implications of in-hadron QCD condensates for the cosmological constant will be reviewed.

Casalderrey Solana, Jorge*: "Heavy Probes in Strongly Couple Plasmas and Strings Fluctuations"*. I will discuss different aspects of heavy probe propagation in strongly coupled plasmas via the AdS/CFT correspondence such as quark broadening and meson dispersion relations. These are controlled by a dynamically generated scale $Q = \sqrt{\gamma}T$. This scale also leads to stochastic string fluctuations. I will comment on possible consequence of these fluctuations.

Chernodub, Maxim*: "Quenched Lattice QCD in Strong Magnetic Field: Chiral Condensate, Magnetization and Chiral Magnetic Effect".* We investigate the effect of a uniform background magneticfield on chiral properties of quenched lattice QCD with two colors. Inagreement with predictions of the chiral perturbation theory, we observe the linear rise of chiral condensate with the increase of the field strength. We calculate the magnetization of the vacuum and find a simple parametrization of its nonlinear features. We also observe certain signatures of the chiral magnetic effect (separation of electric charges along the direction of magnetic field in the presence of the non-Abelian topological charge density) which was presumably observed by the STAR collaboration at RHIC.

Cohen, Thomas*: "The QCD Vacuum in External Static Electric and Magnetic Field".* The QCD vacuum responds to it environment. This talk focuses on the response to external static electric and magnetic fields. The magnetic field is intellectually simplest case as pair-creation does not occur. For small external fields chiral perturbation theory is a systematic tool. The change of the chiral condensate in response to an external field is calculated to next-to-leading order in chiral perturbation theory. External electric fields induce complex responses indicating instabilities due to Schwinger pair creation. The strong field region is also calculable - via QCD perturbation theory. Here the focus is on the magnetization of the vacuum. This is computed to 2nd order in perturbation theory.

De Forcrand, Philippe: ***"Nuclear Physics from Lattice QCD at Strong Coupling"***. It should be possible to study nuclear matter starting from first principles, that is from QCD. Unfortunately, numerical simulations of lattice QCD near its continuum limit, with an excess of matter over antimatter, are plagued by an insurmountable fermionic sign problem. Instead, we study the strong coupling limit of this theory, where the sign problem is mild, and present results on its phase diagram and on the properties of nuclear matter.

D'Enterria, David: ***"Prospects for Higgs and New Physics Measurements with Forward Protons at the LHC"***. The physics case of the FP420 R&D project aiming at the installation of proton detectors in the LHC tunnel at 420 m from the ATLAS and

CMS interaction points, will be presented. The physics motivations of the measurements accessible with FP420 — exclusive Higgs production $(pp \to pHp)$, and photon-induced processes $(pp \to p\gamma p \to pXp, pp \to p\gamma\gamma p \to pXp)$ at multi-TeV energies — will be outlined.

Detmold, William: ***"Many Body Lattice QCD"***

Di Giacomo, Adriano: ***"Confinement of Color and Geometry".*** A natural explanation of Confinement is in terms of symmetry. Since color is exact, the candidate symmetry is dual and related to homotopy , i.e. to magnetic charge conservation in (3+1)d. A set of r abelian 't Hooft like tensors (r = rank of the gauge group) can be defined and the dual charge is a violation of the corresponding Bianchi identities. It is shown that this is equivalently described by non-abelian Bianchi Identities.

Di Piazza, Antonino: ***"Refractive QED Effects in Strong Laser Fields".*** In view of the increasingly stronger available laser fields it is becoming feasible to use them to probe the nonlinear dielectric properties of vacuum as predicted by quantum electrodynamics (QED) and to test QED in the presence of intense laser beams.. We first investigate the process of light-by-light diffraction mediated by the virtual electron-positron pairs present in vacuum. A strong laser beam "diffracts", due to vacuum polarization effects (VPEs), a probe laser field changing its polarization. This change of the polarization is shown to be in principle measurable. The study of the properties of quantum vacuum is closely related to the possibility of testing QED in the presence of strong background fields. We show that in the collision of a high-energy proton and a strong laser beam, laser photons merge, due to VPEs, when interacting with the electromagnetic field of the proton. The process is very efficient and even multiphoton and non-perturbative VPEs can be in principle measurable. Another fundamental problem in electrodynamics is the so-called "radiation reaction": classically, when a charged particle (an electron, for definiteness) is accelerated by an external field, it emits radiation and this emission changes the motion of the electron. The Landau-Lifshitz (LL) equation consistently describes the motion of an electron in an external electromagnetic field by taking into account radiation reaction. The LL equation has not yet been tested experimentally. We explore a new regime of parameters in which the influence of radiation reaction on the electromagnetic spectra emitted by the electron is substantial. Moreover, we show that this parameters' regime can be experimentally investigated with presently available laser technology.

Fleming, George: ***"Lattice Strong Dynamics at TeV Scale".***

Fried, H. M.: ***"ANPAEQED II: A Mechanism for Finite Charge Renormalization in QED".*** Based upon Schwinger's functional solution for the photon propagator (in terms of the log of the fermion determinant L[A]), and upon Fradkin's exact representation for L[A], this second paper of the ANPAEQED series (with Y. Gabellini, Universite de Nice) describes a gauge-invariant method for extracting and summing the log divergences of every contributing perturbative order. The partial result for *1/(Z_3)*, corresponding to the sum of all virtual photons exchanged between and upon the fermion lines of a single, closed-fermion loop, remains divergent; but when the contributions of all the remaining closed-fermion loops are summed and included, all log divergences cancel. The requirement that Z_3 be real produces an "eigenvalue" equation for the bare charge; an approximate solution of this relation, together with the finite Z_3, then yields a fine-structure constant arbitrarily close to 1/137.

Gaisser, Thomas*: "Hadronic Interactions and Production of High-energy Muons and Neutrinos*. Neutrino telescopes, such as AMANDA, Baikal, Antares, IceCube and planned Km3Net, provide unprecedented size for detecting high-energy neutrinos and muons. I will discuss the role of hadronic interactions in determining the expected fluxes at the highest accessible energies.

Giordano, Matteo*: "A Nonperturbative Foundation of the Euclidean-Minkowskian Duality of Wilson-loop Correlation Functions"*. In this talk I discuss the analyticity properties of the Wilson-loop correlation functions relevant to the problem of soft high-energy scattering, directly at the level of the functional integral, in a genuinely nonperturbative way. The strategy is to start from the Euclidean theory and to push the dependence on the relevant variables ***theta*** (the relative angle between the loops) and ***T*** (the half-length of the loops) into the action by means of a field and coordinate transformation, and then to allow them to take complex values. In particular, we determine the analyticity domain of the relevant Euclidean correlation function, and we show that the corresponding Minkowskian quantity is recovered with the usual double analytic continuation in ***theta*** and ***T*** inside this domain. The formal manipulations of the functional integral are justified making use of a lattice regularisation. The new rescaled action so derived could also be used directly to get new insights (from first principles) in the problem of soft high-energy scattering.

Gonzalez-Arroyo, Antonio: From Confinement to Adjoint Zero-Modes". We will give an overview of the itinerary which led us from the understanding of Confinement in QCD to our recent work on adjoint zero-modes for calorons

Hansen, Hubert: *"The QCD Critical Behavior in the PNJL Model".* We explore the phase diagram of QCD with a special focus on its critical behavior in the context of the so-called Polyakov-Nambu-Jona-Lasinio model with two flavors. We show that this improved field theoretical effective model of QCD provides a successful candidate for studying the equation of state and the critical behavior around the critical end point. We derive the phase diagram, where the inclusion of the Polyakov loop moves the critical point to higher temperature compared with the Nambu--Jona-Lasinio model and present the critical properties of physical observables such as the baryon number susceptibility and the specific heat. We also pay attention to the parameter constraints imposed by the Nernst principle.

Hautmann, Francesco: *"Multi-particle Production from Unintegrated Parton Distributions".* This talk gives a concise overview on the application of the formalism of unintegrated parton distributions to the physics of parton showers and hadronic jets, with a view to its use for studies of hard processes in the forward region at the LHC.

Heslop, Paul: ***"The Wilson Loop / Amplitude Duality".*** We introduce the Wilson loop/amplitude duality, which states that MHV gluon amplitudes in $N=4$ SYM are equivalent to light-like polygonal Wilson loops in the planar limit. We will illustrate the duality's power by computing the one loop Wilson loop analytically (matching with the known amplitudes) and then the two loop Wilson loop numerically for any number of edges. If the duality continues to hold we thus compute two loop MHV amplitudes for any number of scattered particles.

Hwa, Rudy: ***"Probing Dense Medium by Dijets".*** Probing of dense medium by jets produced in heavy-ion collisions has revealed the suppression effects of deconfined plasma on high-p_T particles. However, because of the variation of path lengths of hard partons in the medium at any centrality, there is a need for more than a study of the average behavior. Furthermore, most data on jet-medium interaction are at intermediate p_T where pQCD is inadequate, so a reliable formalism is needed to relate the observed hadrons to the properties of the hot medium. In a comprehensive treatment of the problem, properties of dihadron correlation in near - and away-side jets are studied. Notions of trigger and antitrigger biases are quantified. The medium effects on the associated particles on the two sides are different, and their yields depend differently on the trigger momentum. Symmetric dijets reveal properties that can lead to the conclusion that tangential jets dominate. The implication is that tomography by single jet detection is not effective in revealing the properties of the interior of a highly attenuating dense medium.

Iancu, Edmond: ***"Partons and Jets in Strongly Coupled Plasmas from AdS/CFT".***

Jevicki, Antal: ***"Moduli Space of AdS Strings".*** We review techniques developed for constructing general time dependent classical solutions of strings in Anti de Sitter space-time. An investigation of the moduli given by (coordinates) of solitons is considered in AdS3. Their dynamics is related to the dynamics of singularities.

Klier, Constantin: ***"QED Vacuum Decay Phenomena Induced by Light Pulse - Matter Interaction".*** The advent of high intensity lasers and especially of ELI reopens the question if particle producing intense electromagnetic fields involving matter can be created, a topic of intense scrutiy 20 years ago. With present day laser technology a large number of heavy nuclei can be accelerated to energies allowing collisions at distances creating critical fields. We consider here how in this environment QED vacuum decay occurs. Collective ionization, the enhanced number of collisions, the possbility of close 3-body encounters may help to see a clear vacuum decay signal above the vast background of e^+e^--pair production. The current status of numerical evalulations will be presented.

Labun, Lance: ***"Modified Vacuum Energy in Strong QED Fields".*** We derive the energy-momentum trace anomaly inherent in the effective one-loop Euler-Heisenberg-Schwinger action $V_{\rm eff}$. We evaluate the anomaly and vacuum dielectric properties in the presence of arbitrarily strong, slowly-varying fields. We find that intense electromagnetic fields generate an observable modification of the vacuum energy and gravitational properties: the trace anomaly has the form of and produces the (anti-) gravitational effect of the Einstein cosmological constant. For this vacuum effect to be dominant over the gravity of the field, the polarization function, $\varepsilon = -dV_{\rm eff}/dS$, must be small - which is the case for metastable, but `magnetic' ($B^2 > E^2$) field configurations. We note important astrophysical applications.

Lappi, Tuomas: ***"Saturation at RHIC and LHC".*** The Physics of the Initial Conditions of heavy Ion collisions is dominated by the nonlinear gluonic interactions of QCD. These lead to the concept of parton saturation. A consistent first-principles framework to understand the physics of saturation is provided by the Color Glass Condensate (CGC). This talk reviews some aspects of the initial conditions at RHIC, and discusses implications for LHC heavy ion phenomenology. The CGC provides a way compute bulk particle production and understand recent experimental observations of long range rapidity correlations in terms of the classical glasma field in the early stages of the collision.

Lee, Jen-Chi: ***" Kummer Function and High Energy String Scattering Amplitudes".*** Based on a summation algorithm for Stirling number identity developed recently, we discover that the ratios calculated previously among high energy string scattering amplitudes in the Gross regime (GR) can be extracted from the Kummer function of the second kind. This function naturally shows up in the leading order of high energy string scattering amplitudes in the Regge regime (RR). As a result, the identity suggested by string theory calculation can be rigorously proved by a totally di¤erent but sophisticated mathematical method. We conjecture and give evidences that the existence of these ratios in the RR persists to all orders in the Regge expansion of high energy string scattering amplitudes.

Moffat, J. W.: ***"Redesigning Electroweak Theory: Does the Higgs Particle Exist?".*** An electroweak model in which the masses of the W and Z bosons and the fermions are generated by quantum loop graphs through a symmetry breaking of the vacuum is investigated. The model is based on a regularized quantum field theory in which the quantum loop graphs are finite to all orders of perturbation theory and the massless theory is gauge invariant, Poincaré invariant, and unitary to all orders. The breaking of the electroweak symmetry $SU_L(2)$ X $U_Y(1)$ is achieved without a Higgs particle. A fundamental energy scale Λ_W (not to be confused with a naive cutoff) enters the theory through the regularization of the Feynman loop diagrams. The finite regularized theory with Λ_W allows for a fitting of low energy electroweak data. $\Lambda_W \sim 542$ GeV is determined at the Z pole by fitting it to the Z mass m_Z, and anchoring the value of $\sin^2\theta_w$ to its experimental value at the Z pole yields a prediction for the W mass m_W that is accurate to about 0.5% without radiative corrections. The scattering amplitudes for W_LW_L -> W_LW_L and e^+e^- -> $W^+_LW^-_L$ processes do not violate unitarity at high energies due to the suppression of the amplitudes by the running of the coupling constants at vertices. There is no Higgs hierarchy fine-tuning problem in the model. The unitary tree level amplitudes for W_LW_L -> W_LW_L scattering and e^+e^- -> $W^+{}_LW^-{}_L$ annihilation, predicted by the finite electroweak model are compared with the amplitudes obtained from the standard model with Higgs exchange. These predicted amplitudes can be used to distinguish at the LHC between the standard electroweak model and the Higgsless model.

Moffat, J. W.: ***"Verifiable Consequences of a Modified Gravity Theory".*** Modified Gravity (MOG) has been used successfully to explain the rotation curves of galaxies,the motion of galaxy clusters, the Bullet Cluster, and cosmological observations without the use of dark matter or Einstein's cosmological constant. It is demonstrated how these solutions can be obtained directly from the action principle, without resorting to ad-hoc parameter choices or empirical formulae. We obtain exact numerical solutions to the theory's field equations that, after the values for initial conditions are determined from observation, show good agreement with data from the scale of the solar system to cosmological scales. With no undetermined free parameters, the theory can be used to make firm predictions that may be practically verifiable in the foreseeable future. The cosmological consequences of Modified Gravity (MOG) are explored, and using a minimal number of parameters good fits to data, including CMB temperature anisotropy, galaxy power spectrum, and supernova luminosity-distance observations, are obtained without exotic non-baryonic dark matter. MOG predicts a bouncing cosmology with a vacuum energy term that yields accelerating expansion and an age of about 14 billion years.

Mourou, Gerard: ***"Extreme Light Physics and Applications".*** ELI will be the first infrastructure dedicated to the fundamental study of laser-matter interaction in a new and unsurpassed regime of laser intensity: the ultra-relativistic regime (I_L>10^{23} W/cm^2). At its centre will be an exawatt-class laser ~1000 times more powerful than either the Laser Mégajoule in France or the National Ignition Facility (NIF) in the US. In contrast to these projects, ELI will attain its extreme power from the shortness of its pulses (femtosecond and attosecond). The infrastructure will serve to investigate a new generation of compact accelerators delivering energetic particle and radiation beams of femtosecond (10^{-15} s) to attosecond (10^{-18} s) duration. Relativistic compression offers the potential of intensities exceeding I_L>10^{25} W/cm^2, which will challenge the vacuum critical field as well as provide a new avenue to ultrafast attosecond to zeptosecond (10^{-21} s) studies of laser-matter interaction. ELI will afford wide benefits to society ranging from improvement of oncology treatment, medical imaging, fast electronics and our understanding of aging nuclear reactor materials to development of new methods of nuclear waste processing.

Mueller, Berndt: ***"What Does a Quark-Gluon Plasma Sound Like?*** I will briefly review why the quark-gluon plasma produced in the RHIC experiments has been called "an (almost) perfect liquid." One possible consequence of the low shear viscosity is that the matter should be able to transport sound waves with little dissipative loss. An energetic, and hence supersonic, parton creates a conical "boom", which trails the parton as it travels though the quark-gluon quark-gluon plasma. The sound has the form of a steady crescendo.

Orginos, Kostas: ***"Charmed and Bottom Hadron Physics from Lattice QCD".*** In this talk I am reviewing some recent results on charmed and baryon hadron spectroscopy from Lattice QCD. In particular I will discuss charmed and bottom baryon spectroscopy using both the static approximation and a relativistic formulation for the heavy quark action. I will also discuss some results on charmed hardron elastic scattering lengths that reveal information about hadron-hadron interactions at low energies. These latter calculations have been performed for the first time in Lattice QCD.

Pancheri, Giulia: "Total Cross-sections at Very High Energy: from Protons to Photons". In this talk we discuss models for total cross-section and compare their predictions at very high energies. We examine both purely hadronic processes as well as processes involving photons. We illustrate in detail a model which is based on QCD mini-jets and soft gluon re-summation and compare its results with HERA data as well as with other models. At cosmic ray energies, our model predicts substantially higher cross-sections at TeV energies than models based on factorization but lower than models based on mini-jets alone, without soft gluons. We discuss the origin of this difference.

Peschanski, Robert: ***"Boost-Invariant Dynamics from AdS/CFT".*** We investigate the boost-invariant dynamics of heavy-ion reactions and plasma formation in the idealized framework of strongly coupled N=4 supersymmetric Yang-Mills Theory using the AdS/CFT correspondence. The first part of the talk is devoted to a review of the known aspects, starting with the derivation of the dual geometry for late proper-times and its holographic consequences on the physical brane. In the second part of the talk we will introduce the problem of the early-time dynamics and give new results on the early time geometry and its resulting holographic features.

Pineda, Antonio: ***"Breakdown of the Operator Product Expansion in the 't Hooft Model."*** We consider deep inelastic scattering in the 't Hooft model. Being solvable, this model allows us to directly compute the moments associated to the cross section at next-to-leading order in the $1/Q^2$ expansion. We perform the same computation using the operator product expansion. We find that all the terms match in both computations except for one in the hadronic side, which is proportional to a non-local operator. The basics of the result suggest that a similar phenomenon may occur in four dimensions in the large N_c limit.

Pica, Claudio: ***"Technicolor on the Lattice".*** Technicolor theories provide an elegant mechanism for dynamical electroweak symmetry breaking. I will discuss the use of lattice simulations to study the strongly-interacting dynamics of some of the candidate theories, with matter fields in representations other than the fundamental. To be viable candidates for phenomenology, such theories need to be different from a scaled-up version of QCD, which were ruled out by LEP precision measurements, and represent a challenge for modern lattice computations.

Poppitz, Erich: ***"Chiral Gauge Dynamics and Dynamical Supersymmetry Breaking".*** We study the dynamics of an SU(2) chiral gauge theory with a Weyl fermion in the $I=3/2$

representation, and of its supersymmetric generalization, using compactification on a circle, and in the nonsupersymmetric case - a center-stabilizing deformation. In the non-SUSY case we find an exotic mechanism of confinement, due to the condensation of "magnetic quintets". In the SUSY case we present arguments that the theory does not break supersymmetry upon adding a tree-level superpotential coupling. We also compare the similarities and differences between the dynamics of vectorlike and chiral supersymmetric theories.

Rafelski, Johann: ***"Challenges of Strong Field in QCD Research".*** The prospects of investigating fundamental physical properties of space-time and matter using ultra-intense lasers has dramatically improved over the last few years. The strong field offers an opportunity to probe new physics. The most challenge is the riddle why the QCD vacuum does not gravitate. This requires a fine tuning at the level of about 130 orders of magnitude. Since the quark vacuum fluctuations (condensate) respond to the strong EM field. this question becomes accessible – the external field detunes the vacuum balance. In this context we should be able to also address the question of the vacuum energy density (The Dark Matter), which suggests that the Universe is captured in a slightly wrong vacuum state – its decay would not destroy the world. Other more conventional issues arise considering the influence of the QCD vacuum state on the general particle and nuclear properties. The talk will look at the shopping list of the accessible phenomena.

Rubin, Jacques: ***"When Quantum Mechanics Complies with Bell's Inequalities".*** Contrasting Quantum Mechanics with classical statistical and Kolmogorov formalisms, the existence of joint probability distributions is first recognized a (if not ``the'') crucial key-point, before any subsequent physical interpretation (like the ruin of ``local realism'' as the most striking and famous example) is ventured. If joint probabilities can be defined, then Bell's inequalities are satisfied. Years ago, for Quantum Mechanics, conditions were identified (A. Fine's theorem) under which joint distributions are known to exist and are shown to be equivalent to the existence of hidden variables theories (local realism). Though preliminary, results are here proposed showing how Quantum Mechanics also complies with Bell's inequalities: In particular, for families of states, we are able to exhibit weaker conditions under which joint probability distributions can be defined and Bell's inequalities are satisfied, even though not all of the local quantum operators do commute. The very value of Bell's inequalities in catching the quantum specificity is also criticized.

Ruf, Matthias*:* ***"Lepton Pair Production in Intense Laser Fields".*** Various mechanisms of lepton pair production in intense laser fields are considered. First we examine electron-positron pair production in counterpropagating laser fields. The study of this process so far, has been based on the approximation of neglecting the spatial dependence of the laser fields. By employing a fully numerical approach, we show that for high frequencies inclusion of the space dependence, and thus the lasermagnetic field, strongly affects the process: the production probability is reduced, the resonant Rabi-oscillation pattern is significantly modified and the resonance positions are shifted and multiplied.

Moreover we discuss electron-positron pair production by a gamma photon in a nuclear field (Bethe-Heitler process) which is assisted by a strong, subcritical laser wave. It is demonstrated that the laser assistance leads to a pronounced channeling of the produced particles.

Finally muon-antimuon pair production by few photon absorption from an x-ray laser beam colliding with an ultra-relativistic nucleus is addressed. The process is shown to be sensitive to the nuclear form factor and experimentally feasible with near future laser and accelerator technology.

Sheu, Yeuan-Ming: ***"Ghost Magic - MGI, MLC & Qluonless QCD under Eikonal Approximations".*** We present a model of quark scattering as an example in the context of QCD with explicit manifestation of both Gauge Invariance and Lorentz Covariance using functional method for all values of coupling constants. Under the quenched, eikonal approximation, we sum all virtual gluon exchange for scattering of quarks and/or anti-quarks. The conventional boson-like gluon propagators disappear after summing all virtual gluon exchange between quarks or anti-quarks, and are interpreted as ghost fields; and this ghost magic of vanishing virtual gluon propagators is only possible by including gluonic cubic and quartic interaction of non-Abelian gauge theory. The resulting formulation of quark scattering is an effective, 'almost contact' interaction mediated by Halpern's tensorial fields which preserves both Gauge invariance and Lorentz covariance.

Shigemori, Masaki: ***"Brownian Motion in AdS/CFT"***. The recently discovered gravity-fluid correspondence maps the hydrodynamical Navier-Stokes equation to the horizon dynamics of AdS black holes, and vice versa. Historically, a crucial step toward the microphysics of nature underlying hydrodynamics was Brownian motion. In this talk, I study Brownian motion in AdS/CFT, to understand the microphysics underlying the above correspondence. A Brownian particle on the boundary corresponds to a fundamental string stretching between the AdS boundary and the horizon in the bulk. In particular, we will see that the Langevin equation governing the boundary Brownian motion is closely related to the Hawking radiation on the fundamental string.

Sivers, Dennis: **"*A Field-Strength Description of a Rapidly Expanding Non-Abelian Flux Tube*".** Non-Abelian flux configurations have two properties that distinguish them dynamically from fundamental strings: 1) hadronic transverse dimensions, 2) significant internal structure. We can demonstrate these properties for a "monojet" configuration involving a cylindrically symmetric flux tube expanding longitudinally. Our considerations have implications for how flux tubes break in high energy collisions and for spin observables in these processes.

Snellings, Raimond: **"*The Nearly Perfect Fluid at RHIC*"**. The large elliptic flow observed at RHIC is considered to be evidence for nearly perfect liquid behavior of the strongly coupled Quark Gluon Plasma produced in the collisions. In this presentation we review our current understanding of this new state of matter and investigate what constrains we have on the ratio of shear viscosity to entropy density.

Sokatchev, Emery: ***"Scattering Amplitudes, Wilson Loops and Their Symmetries".*** We discuss scattering amplitudes in the maximally supersymmetric gauge theory and compare them with Wilson loops on lightlike polygon contours. We show that the amplitudes have a hidden dynamical symmetry, which coincides with the conformal symmetry of the dual Wilson loop. We study the implications of this dual symmetry in the form of anomalous Ward identities. We also discuss the extension to full dual superconformal symmetry of amplitudes.

Szymanowski, Lech: ***"Recent Advances in Hard Exclusive Reactions".*** Recent progress in the study of hard exclusive reactions have lead to the definition of non-perturbative objects which describe the hadronic structure in a much more detailed way than the usual parton distribution functions. Emphasizing the examples of the generalized parton distributions (GPDs) and of the transition distribution amplitudes (TDAs), we will show how they can be extracted from experiments. Current model-estimates of these quantities are quite unsatisfactory. Their better determination in non perturbative QCD need the development of new methods. We will briefly comment on the non-applicability of the AdS-QCD method to the calculation of such partonic densities .

Tiburzi, Brian: ***"Lattice QCD in Background Fields"***. Electromagnetic properties of hadrons can be computed by lattice simulations of QCD in background fields. We demonstrate new techniques for the investigation of charged hadron properties in electric fields. Our current calculations employ large electric fields, motivating us to analyze chiral dynamics in strong QED backgrounds, and subsequently uncover surprising non-perturbative effects present at finite volume.

Travaglini, Gabriele: ***"One-loop Amplitude in N=4 Super Yang-Mills and Dual (Super)Conformal Symmetry"***. We discuss the role of dual superconformal symmetry in constraining tree-level and one-loop scattering amplitudes in N=4 super Yang-Mills. At tree level, an appropriate supersymmetric on-shell recursion relation incorporates the symmetries of the theory at the diagrammatic level. At one loop, we discuss how several coefficients of the expansion of the amplitude on a basis of box functions can be determined just from symmetry considerations, i.e. without performing any loop calculation.

Tuominen, Kimmo: ***"Lattice Studies of SU(2) Gauge Theory with Two Adjoint Flavors"***. Current experimental data indicate that in phenomenologically viable Technicolor theories coupling must walk: from asymptotic freedom at short distances the beta-function approaches a quasi-stable fixed point and evolves very slowly over a large scale separation. Recently we proposed a specific class of gauge theories, with higher representation matter fields, which would have a nontrivial infrared fixed point, and could serve as an important concrete resource for model building. In this talk, a Technicolor model based on gauge dynamics of two (techni)colors with two adjoint Dirac flavors is considered. After a brief discussion of the phenomenological implications of this theory, both for colliders and cosmology, I will concentrate on our recent extensive Monte Carlo simulations of this theory and show how these results suggest that this theory indeed is conformal in the infrared.

Unsal, Mithat: ***"Confinement, Conformal Window and Deformed Yang-Mills Theories"***. The non-perturbative dynamics of non-supersymmetric QCD-like and chiral gauge theories remained largely elusive despite much effort over the years. Recently, novel techniques (such as center stabilizing double trace deformations, twisted partition functions) which allow us to continuously connect the physics of these gauge theories on R^4 to small S^1 x R^3 are found. In most cases, the physics of small S^1 is analytically tractable. The types of topological excitations that appear in this regime are far richer than anticipated earlier. For example, a type of composite referred to as magnetic bion with net magnetic charge *+2* is responsible for the appearance of a mass gap in large class of QCD-like theories. What makes this excitation interesting is also an exotic mechanism of pairing, induced by fermions. These techniques may also find useful applications in chiral gauge theories, in the estimation of conformal window and supersymmetric gauge theories. In this talk, I will give an elementary introduction to the dynamics of gauge theories through this window.

Ulrich, Ralf: "Hadronic Production Cross Section from Cosmic Ray Experiments".

Vergu, Cristian: ***"N=4 Scattering Amplitudes and AdS/CFT"***. In the past years we have learnt how to treat the strong coupling scattering amplitudes in *N=4* super Yang-Mills gauge theory by using the AdS/CFT correspondence. This has lead to a very surprising connection between scattering amplitudes and polygonal Wilson loops with light-like edges. In this talk I will review the evidence supporting this scattering amplitudes - Wilson loops correspondence.

Warringa, Harmen: ***"Implications of Topological Charge Fluctuations on Heavy Ion Collisions"***. In heavy ion collisions it is possible to generate gauge field configurations which carry topological charge. Such gauge field configurations will induce P- and CP-odd effects. In this talk I will argue that if topological charge is generated in heavy ion collisions, positively charged particles will be emitted oppositely to negatively charge particles along the direction of angular momentum of the collision. This is the Chiral Magnetic Effect. I will argue that the Chiral Magnetic Effect can be studied experimentally and will discuss exciting new results from the STAR collaboration.

Werner, Klaus: ***"How Air Shower and Heavy Ion Physics Benefit from Each Other"***. We report on recent progress concerning the EPOS model, being used both for simulating heavy ion collisions and as interaction model in air showercalculations. Certain features of the model, being introduced based on heavy ion data, seem to explain some long standing problems in air shower simulations (like muon deficit). Other features, related to leading particle production and carefully studied for air shower applications, help to understand heavy ion data (like elliptical flow).

Zayakin, A.: ***"Wilson Loops and Field Correlators from Dyson-Schwinger Equations".*** We suggest a self-consistent framework of evaluating Wilson loops and gauge-invariant field strength correlators in QCD. Combining Bethe-Salpeter equations of Erickson-Zarembo type for Wilson loops and Dyson-Schwinger equations for Green functions we obtain QCD observables of relevance to lattice and experiment: quark-quark potential and condensate. Our method properly takes into account rainbow diagram resummation, non-perturbative IR couping behaviour and correct UV logs. We find good agreement of our results to lattice calculations.