Selected Abstracts from Other Physical Review Journals

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High statistics search for the $\theta^+(1.54)$ pentaquark state. M. J. Longo,[8] R. A. Burnstein,[5] A. Chakravorty,[5] Y. C. Chen,[1] W. S. Choong,[2,7] K. Clark,[9] E. C. Dukes,[10] C. Durandet,[10] J. Felix,[4] Y. Fu,[7] G. Gidal,[7] H. R. Gustafson,[8] T. Holmstrom,[10] M. Huang,[10] C. James,[3] C. M. Jenkins,[9] T. Jones,[7] D. M. Kaplan,[5] L. M. Lederman,[5] N. Leros,[6] F. Lopez,[8] L. C. Lu,[10] W. Luebke,[5] K. B. Luk,[2,7] K. S. Nelson,[10] H. K. Park,[8] J.-P. Perroud,[6] D. Rajaram,[5] H. A. Rubin,[5] J. Volk,[3] C. G. White,[5] S. White,[5] and P. Zyla,[7] [1]*Institute of Physics, Academia Sinica, Taipei 11529, Taiwan, Republic of China,* [2]*University of California, Berkeley, California 94720, USA,* [3]*Fermi National Accelerator Laboratory, Batavia, Illinois 60510, USA,* [4]*Universidad de Guanajuato, 37000 León, Mexico,* [5]*Illinois Institute of Technology, Chicago, Illinois 60616, USA,* [6]*Université de Lausanne, CH-1015 Lausanne, Switzerland,* [7]*Lawrence Berkeley National Laboratory, Berkeley, California 94720, USA,* [8]*University of Michigan, Ann Arbor, Michigan 48109, USA,* [9]*University of South Alabama, Mobile, Alabama 36688, USA,* [10]*University of Virginia, Charlottesville, Virginia 22904, USA.* (Received 8 October 2004; published 1 December 2004)

We have searched for $\theta^+(1.54) \to K^0 p$ decays using data from the 1999 run of the HyperCP experiment at Fermilab. We see no evidence for a narrow peak in the $K^0_S p$ mass distribution near 1.54 GeV/c among 106 000 $K^0_S p$ candidates, and obtain an upper limit for the fraction of $\theta^+(1.54)$ to $K^0_S p$ candidates of $<0.3\%$ at 90% confidence. [Phys. Rev. D **70**, 111101 (2004)]

Pseudoscalar meson mass to two loops in three-flavor partially quenched chiral perturbation theory. Johan Bijnens,[1] Niclas Danielsson,[1,2] and Timo A. Lähde,[1] [1]*Department of Theoretical Physics, Lund University, Sölvegatan 14A, S 223 62 Lund, Sweden,* [2]*Division of Mathematical Physics, LTH, Lund University, Box 118, S 221 00 Lund, Sweden.* (Received 11 June 2004; published 13 December 2004)

This paper presents a first study of the pseudoscalar meson masses to two loops, or next-to-next-to-leading order, within the supersymmetric formulation of partially quenched chiral perturbation theory (PQχPT). The expression for the pseudoscalar meson mass in the case of three valence and three sea quarks with equal masses, but different from each other, is given to $\mathcal{O}(p^6)$, along with a numerical analysis. [Phys. Rev. D **70**, 111503 (2004)]

Antidecuplet candidate $\Xi^{--}(1862)$ as a heptaquark with the overlap of two antikaons and a nucleon. P. Bicudo, *Dep. Física and CFIF, Instituto Superior Técnico, Av. Rovisco Pais, 1049-001 Lisboa, Portugal.* (Received 10 March 2004 revised 29 July 2004; published 14 December 2004)

I study the very recently discovered $S=-2$ resonance $\Xi^{--}(1886)$ by the NA49 Collaboration at the CERN SPS. I find that repulsion excludes the Ξ^{--} as a $ddss\bar{u}$ s-wave pentaquark. I explore the Ξ^{--} as a heptaquark, equivalent to a $N+K+K$ linear molecule, with positive parity and total isospin $I=3/2$. I find that the kaon-kaon repulsion is canceled by the attraction existing in the kaon-nucleon channels. In our framework this state is easier to bind than the Θ^+ described by a $\pi+K+N$ Borromean bound state. The remaining $I=1/2$ doublet and $I=1$ triplet of the exotic antidecuplet are also studied, and the coupling to p-wave decay channels is briefly addressed. [Phys. Rev. D **70**, 111504 (2004)]

Strange quark asymmetry in the nucleon and the NuTeV anomaly. J. Alwall[1] and G. Ingelman,[1,2] [1]*High Energy Physics, Uppsala University, Box 535, S-75121 Uppsala, Sweden,* [2]*Deutsches Elektronen-Synchrotron DESY, D-22603 Hamburg, Germany.* (Received 25 August 2004; published 17 December 2004)

The NuTeV anomaly of a nonuniversal value of the fundamental parameter $sin^2\theta_W$ in the electroweak theory has been interpreted as an indication for new physics beyond the standard model. However, the observed quantity depends on a possible asymmetry in the momentum distributions of strange quarks and antiquarks in the nucleon. This asymmetry occurs naturally in a phenomenologically successful physical model for such parton distributions, which reduces the NuTeV result to only about 2 standard deviations from the standard model. [Phys. Rev. D **70**, 111505 (2004)]

Propagators of light scalar mesons. N. N. Achasov and A. V. Kiselev *Laboratory of Theoretical Physics, Sobolev Institute for Mathematics, Novosibirsk, 630090, Russia.* (Received 1 September 2004; published 17 December 2004)

For the first time, as far as we know, in field theory are found explicit forms of propagators satisfying the Källen-Lehmann representation. To be exact, it is shown that scalar meson propagators, taking into account a virtual intermediate state contribution to the resonance self-energy, satisfy the Källen-Lehmann representation in the wide domain of coupling constants of the light scalar mesons with the two-particle states. It is proposed to use these propagators in routine fitting data about light scalar mesons to reveal physics underlying the light scalar mesons. [Phys. Rev. D **70**, 111901 (2004)]

Enhanced solar antineutrino flux in random magnetic fields. O. G. Miranda,[1] T. I. Rashba,[2,3] A. I. Rez,[2,3] and J. W. F. Valle,[2] [1]*Departamento de Física, Centro de Investigación y de Estudios Avanzados del IPN, Apdo. Postal 14-740 07000 Mexico, DF, Mexico,* [2]*Instituto de Física Corpuscular—C.S.I.C., Universitat de València Edificio Institutos, Apt. 22085, E-46071 València, Spain,* [3]*Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation of the Russian Academy of Sciences, 142190, Troitsk, Moscow region, Russia.* (Received 9 June 2004; published 1 December 2004)

We discuss the impact of the recent KamLAND constraint on the solar antineutrino flux on the analysis of solar neutrino data in the presence of Majorana neutrino transition magnetic moments and solar magnetic fields. We consider different stationary solar magnetic field models, both regular and random, highlighting the strong enhancement in the antineutrino production rates that characterize turbulent solar magnetic field models. Moreover, we show that for such magnetic fields inside the Sun, one can constrain the *intrinsic* neutrino magnetic moment down to the level of $\mu_\nu \lesssim$ few $\times 10^{-12} \mu_B$ irrespective of details of the underlying turbulence model. This limit is more stringent than all current experimental sensitivities, and similar to the most stringent bounds obtained from stellar cooling. We also comment on the robustness of this limit and show that at most it might be weakened by 1 order of magnitude, under very unlikely circumstances. [Phys. Rev. D **70**, 113002 (2004)].

Observables sensitive to absolute neutrino masses: Constraints and correlations from world neutrino data. G. L. Fogli,[1] E. Lisi,[1] A. Marrone,[1] A. Melchiorri,[2] A. Palazzo,[1] P. Serra,[2] and J. Silk,[3] [1]*Dipartimento di Fisica and Sezione INFN di Bari, Via Amendola 173, 70126, Bari, Italy,* [2]*Dipartimento di Fisica and Sezione INFN, Università degli Studi di Roma "La Sapienza", P.le Aldo Moro 5, 00185, Rome, Italy,* [3]*Astrophysics, Denys Wilkinson Building, Keble Road, OX13RH, Oxford, United Kingdom.* (Received 5 August 2004; published 3 December 2004)

In the context of three-flavor neutrino mixing, we present a thorough study of the phenomenological constraints applicable to three observables sensitive to absolute neutrino masses: The effective neutrino mass in Tritium beta-decay (m_β); the effective Majorana neutrino mass in neutrinoless double beta-decay ($m_{\beta\beta}$); and the sum of neutrino masses in cosmology (Σ). We discuss the correlations among these variables which arise from the combination of all the available neutrino oscillation data, in both normal and inverse neutrino mass hierarchy. We set upper limits on m_β by combining updated results from the Mainz and Troitsk experiments. We also consider the latest results on $m_{\beta\beta}$ from the Heidelberg-Moscow experiment, both with and without the lower bound claimed by such experiment. We derive upper limits on Σ from an updated combination of data from the Wilkinson Microwave Anisotropy Probe (WMAP) satellite and the two degrees Fields (2dF) Galaxy Redshifts Survey, with and without Lyman-α forest data from the Sloan Digital Sky Survey (SDSS), in models with a nonzero running of the spectral index of primordial inflationary perturbations. The results are discussed in terms of two-dimensional projections of the globally allowed region in the $(m_\beta, m_{\beta\beta}, \Sigma)$ parameter space, which neatly show the relative impact of each data set. In particular, the (in)compatibility between Σ and $m_{\beta\beta}$ constraints is highlighted for various combinations of data. We also briefly discuss how future neutrino data (both oscillatory and nonoscillatory) can further probe the currently allowed regions. [Phys. Rev. D **70**, 113003 (2004)]

Determination of θ_{23} in long-baseline neutrino oscillation experiments with three-flavor mixing effects. Hisakazu Minakata Masashi Sonoyama, *Department of Physics, Tokyo Metropolitan University, Hachioji, Tokyo 192-0397, Japan* Hiroaki Sugiyama Theory Group, *KEK, Tsukuba, Ibaraki 305-0801, Japan.* (Received 8 June 2004 20 October 2004; published 23 December 2004)

We examine the accuracy of θ_{23} determination in future long-baseline (LBL) ν_μ disappearance experiments in the three-flavor mixing scheme of neutrinos. Despite that the error of $sin^2 2\theta_{23}$ is indeed a few percent level at around the maximal mixing, we show that the error of physics variable s^2_{23} is large, $\delta(s^2_{23})/s^2_{23} \simeq 10\text{-}20\%$, depending upon regions of θ_{23}. The errors are severely affected by the octant degeneracy of θ_{23}, and $\delta(s^2_{23})$ is largely amplified by the Jacobian factor relating these two variables in a region near the maximal mixing. The errors are also affected by the uncertainty due to the unknown value of θ_{13}; $\delta(s^2_{23})$ is doubled at off maximal in the second octant of θ_{23} where the effect is largest. To overcome this problem, we discuss combined analysis with ν_e appearance measurement in LBL experiments, or with reactor measurement of θ_{13}. For possible relevance of subleading effects even in the next generation LBL experiments, we give a self-contained derivation of the survival probability to the next to leading order in s^2_{13} and $\Delta m^2_{21}/\Delta m^2_{31}$. [Phys. Rev. D **70**, 113012 (2004)]

Critique of the angular momentum sum rules and a new angular momentum sum rule. B. L. G. Bakker,[1] E. Leader,[2] and T. L. Trueman,[3] [1]*Department of Physics and Astronomy, Vrije Universiteit, Amsterdam,* [2]*Imperial College London, SW7 2BW, United Kingdom,* [3]*Physics Department, Brookhaven National Laboratory, Upton, New York 11973, USA.* (Received 14 June 2004; published 1 December 2004)

We present a study of the tensorial structure of the hadronic matrix elements of the angular momentum operators $\boldsymbol{J}$. Well known results in the literature are shown to be incorrect, and we have taken pains to derive the correct expressions in three different ways, two involving explicit physical wave packets and the third, totally independent, based upon the rotational properties of the state vectors. Surprisingly it turns out that the results are very sensitive to the type of relativistic spin state used to describe the motion of the particle, i.e., whether a canonical (i.e., boost) state or a helicity state is utilized. We present results for the matrix elements of the angular momentum operators, valid in an arbitrary Lorentz frame, for both helicity states and canonical states. These results are relevant for the construction of angular momentum sum rules, relating the angular momentum of a nucleon to the spin and orbital angular momentum of its constituents. It turns out that it is necessary to distinguish carefully whether the motion of the partons is characterized via canonical or helicity spin states. Fortunately, for the simple parton model interpretation, when the proton moves along OZ, our results for the sum rule based upon the matrix elements of J_z agree with the often used sum rule found in the literature. But for the components J_x, J_y the results are different and lead to a new and very intuitive sum rule for transverse polar. [Phys. Rev. D **70**, 114001 (2004)]

Octet, decuplet, and antidecuplet magnetic moments in the chiral quark soliton model reexamined. Ghil-Seok Yang,[1] Hyun-Chul Kim,[1] Michał Praszałowicz,[2] and KlausGoeke,[3] [1]*Department of Physics, and Nuclear Physics & Radiation Technology Institute (NuRI), Pusan National University, 609-735 Busan, Republic of Korea,* [2]*M. Smoluchowski Institute of Physics, Jagellonian University, ul. Reymonta 4, 30-059 Kraków, Poland* [3]*Institut für Theoretische Physik II, Ruhr-Universit Bochum, D–44780 Bochum, Germany.* (Received 3 October 2004; published 1 December 2004)

We reanalyze the magnetic moments of the baryon octet, decuplet, and antidecuplet within the framework of the chiral quark-soliton model, with SU(3) symmetry-breaking taken into account. We consider the contributions of the mixing of higher representations to the magnetic moment operator arising from the SU(3) symmetry-breaking. Dynamical parameters of the model are fixed by experimental data for the magnetic moments of the baryon octet and from the masses of the octet, decuplet and of Θ^+. The magnetic moment of Θ^+ depends rather strongly on the pion-nucleon sigma term and reads -1.19 nm to -0.33 nm for $\Sigma_{\pi N}=45$ and 75 MeV, respectively. The recently reported mass of $\overline{\Xi_{10}}$--(1862) is compatible with $\Sigma_{\pi N}=73$ MeV. As a by-product the strange magnetic moment of the nucleon is obtained with a value of $\mu_N^{(s)}=+0.39$ nm. [Phys. Rev. D **70**, 114002 (2004)]

Abelianization of QCD plasma instabilities. Peter Arnold and Jonathan Lenaghan, *Department of Physics, University of Virginia, P.O. Box 400714 Charlottesville, Virginia 22901-4714, USA.* (Received 5 August 2004; published 7 December 2004)

QCD plasma instabilities appear to play an important role in the equilibration of quark-gluon plasmas in heavy-ion collisions in the theoretical limit of weak coupling (i.e. asymptotically high energy). It is important to understand what nonlinear physics eventually stops the exponential growth of unstable modes. It is already known that the initial growth of plasma instabilities in QCD closely parallels that in QED. However, once the unstable modes of the gauge fields grow large enough for non-Abelian interactions between them to become important, one might guess that the dynamics of QCD plasma instabilities and QED plasma instabilities become very different. In this paper, we give suggestive arguments that non-Abelian self-interactions between the unstable modes are ineffective at stopping instability growth, and that the growing non-Abelian gauge fields become approximately Abelian after a certain stage in their growth. This in turn suggests that understanding the development of QCD plasma instabilities in the nonlinear regime may have close parallels to similar processes in traditional plasma physics. We conjecture that the physics of collisionless plasma instabilities in SU(2) and SU(3) gauge theory becomes equivalent, respectively, to (i) traditional plasma physics, which is U(1) gauge theory, and (ii) plasma physics of U(1)×U(1) gauge theory. [Phys. Rev. D **70**, 114007 (2004)]

Stable pentaquarks from strange chiral multiplets. Silas R. Beane, *Department of Physics, University of New Hampshire, Durham, New Hampshire 03824-3568, USA Jefferson Laboratory, 12000 Jefferson Avenue, Newport News, Virginia 23606, USA.* (Received 3 September 2004; published 6 December 2004)

The assumption of strong diquark correlations in the QCD spectrum suggests flavor multiplets of hadrons that are degenerate in the chiral limit. Generally it would be unnatural for there to be degeneracy in the hadron spectrum that is not protected by a QCD symmetry. Here we show—for pentaquarks constructed from diquarks—that these degeneracies can be naturally protected by the full chiral symmetry of QCD. The resulting chiral multiplet structure recovers the ideally mixed pentaquark mass spectrum of the diquark model, and interestingly, requires that the axial couplings of the pentaquarks to states outside the degenerate multiplets vanish in the chiral limit. This result suggests that if these hadrons exist, they are stable in the chiral limit and therefore have widths that scale as the fourth power of the kaon mass over the chiral-symmetry breaking scale. Natural-size widths are of order a few MeV. [Phys. Rev. D **70**, 114010 (2004)]

Padé-related resummations of the pressure of quark-gluon plasma by approximate inclusion of g_s^6 terms. G. Cvetič, *Department of Physics, Universidad Técnica Federico Santa María, Valparaíso, Chile,* R. Kögerler, *Department of Physics, Universität Bielefeld, 33501 Bielefeld, Germany.* (Received 3 June 2004; revised 5 November 2004; published 13 December 2004)

We perform various resummations of the hot QCD pressure based on the actual knowledge of the perturbation series which includes the $\sim g_s^6 \ln(1/g_s)$ and part of the $\sim g_s^6$ terms. Resummations are performed separately for the short- and long-distance parts. The $\sim g_s^6$ term of the short-distance pressure is estimated on the basis of the known UV cutoff dependence of the long-distance part. The resummations are of the Padé and Borel-Padé type, using in addition the (Padé) resummed expression QCD coupling parameter g_E^2. The resummed results depend weakly on the yet unknown $\sim g_s^6$ terms and on the short-range renormalization scale, at all temperatures $T<\sim 1$ GeV. The resulting dependence of pressure on temperature T is compatible with the results of the lattice calculations at low T. [Phys. Rev. D **70**, 114016 (2004)]

Inclusive two-gluon and valence-quark-gluon production in DIS and *pA* collisions. Jamal Jalilian-Marian[1] and Yuri V. Kovchegov[2] [1]*Institute for Nuclear Theory, University of Washington, Box 351550, Seattle, Washington 98195, USA,* [2]*Department of Physics, University of Washington, Box 351560, Seattle, Washington 98195, USA.* (Received 1 June 2004; published 9 December 2004)

We calculate production cross sections of a forward quark-gluon pair and of two gluons at midrapidity in deep inelastic scattering and in high energy proton-nucleus collisions. The calculation is performed in the framework of the color glass condensate formalism. We first calculate the cross sections in the quasiclassical approximation, which includes multiple rescatterings in the target. We then proceed to include the effects of nonlinear small-x evolution in the production cross sections. It is interesting to note that our result for the two-gluon production cross section appears to be in direct violation of Abramovsky-Gribov-Kanchelli cutting rules, which is the first example of such violation in QCD. The calculated quark-gluon and gluon-gluon production cross sections can be used to construct theoretical predictions for two-particle azimuthal correlations at the Relativistic Heavy Ion Collider and LHC ($I^{p(d)A}$) as well as for deep inelastic scattering experiments at the Hadron Electron Ring Accelerator and the Electron-Relativistic Heavy Ion Collider. [Phys. Rev. D **70**, 114017 (2004)]

Electromagnetic form factors of the nucleons from generalized Skyrme models. Jimmy Fortier and Luc Marleau, *Département de Physique, de Génie Physique et d'Optique, Université Laval, Québec, Québec, Canada G1K 7P4.* (Received 30 September 2004; Revised 16 November 2004; published 13 December 2004)

We compare the prediction of Skyrme-like effective Lagrangians with data for electromagnetic form factors of nucleons and consider the possibility of fixing the parameters of these higher-order Lagrangians. Our results indicate that one- or two-parameter models can lead to better agreement with the data but more accurate determination of the effective Lagrangian faces theoretical uncertainties. [Phys. Rev. D **70**, 114021 (2004)]

Pentaquark masses in chiral perturbation theory. Vivek Mohta, *Center for Theoretical Physics and Laboratory for Nuclear Science, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139, USA, Department of Mathematics, Harvard University, Cambridge, Massachusetts 02138, USA.* (Received 10 August 2004; published 13 December 2004)

Heavy baryon chiral perturbation theory for pentaquarks is applied beyond leading order. The mass splitting in the pentaquark antidecuplet is calculated up to next-to-next-to-leading order in the absence of other exotic multiplets nearby in mass. An expansion in the coupling of the antidecuplet to nonexotic baryons simplifies calculations and makes the pentaquark masses insensitive to the pentaquark-nucleon mass difference. It is assumed that no other pentaquark multiplets are nearby in the mass spectrum. The possibility of determining coupling constants in the chiral Lagrangian on the lattice is discussed. Both positive and negative parities are considered. [Phys. Rev. D **70**, 114022 (2004)]

Kaon-soliton bound state approach to the pentaquark states. Byung-Yoon Park,[1] Mannque Rho,[1,2] and Dong-Pil Min,[1,3] [1]*CSSM, University of Adelaide, Adelaide 5005, Australia and Department of Physics,Chungnam National University, Daejon 305-764, Korea,* [2]*Service de Physique Théorique, CEA Saclay, 91191 Gif-sur-Yvette, France and Department of Physics, Hanyang University, Seoul 133-791, Korea,* [3]*School of Physics and Center for Theoretical Physics, Seoul National University, Seoul 151-747, Korea.* (Received 29 September 2004; published 16 December 2004)

We show that in hidden local symmetry theory with the vector manifestation (VM), a K^+ can be bound to skyrmion to give an exotic baryon that has the quantum numbers of the Θ^+ pentaquark with spin 1/2 and even parity which is consistent with large N_c counting. The vector meson K^* subject to the VM in the chiral limit plays an essential role in inducing the binding. [Phys. Rev. D **70**, 114026 (2004)]

Production of the pentaquark Θ^+ in *np* scattering. Seung-Il Nam,[1,2] Atsushi Hosaka,[1] and Hyun-Chul Kim[2], [1]*Research Center for Nuclear Physics (RCNP), Ibaraki, Osaka 567-0047, Japan,* [2]*Department of Physics and Nuclear Physics & Radiation Technology Institute (NuRI), Pusan National University, Busan 609-735, Korea.* (Received 1 March 2004; published 16 December 2004)

We study $np \to \Lambda \Theta^+$ and $np \to \Sigma^0 \Theta^+$ processes for both of the positive and negative parities of the Θ^+. Employing the effective chiral Lagrangians for the KNY and K^*NY interactions, we calculate differential cross sections as well as total cross sections for the $np \to \Sigma^0 \Theta^+$ and $np \to \Lambda \Theta^+$ reactions. The total cross sections for the positive parity Θ^+ turn out to be approximately 10 times larger than those for the negative parity Θ^+ in the range of the c.m. energy $E^{\rm th}_{\rm c.m.} \leqslant E_{\rm c.m.} \leqslant 3.5$ GeV. The results are rather sensitive to the parameters of K exchanges in the t channel. [Phys. Rev. D **70**, 114027 (2004)]

General effective action for high-density quark matter. Philipp T. Reuter,[1] Qun Wang,[1,2] and Dirk H. Rischke,[1] [1]*Institut für Theoretische Physik, Johann Wolfgang Goethe-Universität, D-60054 Frankfurt, Germany,* [2]*Physics Department, Shandong University, Jinan, Shandong, 250100, People's Republic of China.* (Received 4 June 2004; published 23 December 2004)

We derive a general effective action for quark matter at nonzero temperature and/or nonzero density. For this purpose, we distinguish irrelevant from relevant quark modes, as well as hard from soft gluon modes by introducing two separate cutoffs in momentum space, one for quarks, Λ_q, and one for gluons, Λ_g. We exactly integrate out irrelevant quark modes and hard gluon modes in the functional integral representation of the QCD partition function. Depending on the specific choice for Λ_q and Λ_g, the resulting effective action contains well-known effective actions for hot and/or dense quark matter, for instance the ''Hard Thermal Loop'' or the ''Hard Dense Loop'' action, as well as the high-density effective theory proposed by Hong and others. We then apply our effective action to review the calculation of the color-superconducting gap parameter to subleading order in weak coupling, where the strong coupling constant $g \ll 1$. In this situation, relevant quark modes are those within a layer of thickness $2\Lambda_q$ around the Fermi surface. The nonperturbative nature of the gap equation invalidates naive attempts to estimate the importance of the various contributions via power counting on the level of the effective action. Nevertheless, once the gap equation has been derived within a particular many-body approximation scheme, the cutoffs Λ_q, Λ_g provide the means to rigorously power count different contributions to the gap equation. We recover the previous result for the QCD gap parameter for the choice $\Lambda_q \lesssim g\mu \ll \Lambda_g \lesssim \mu$, where μ is the quark chemical potential. We also point out how to improve this result beyond subleading order in weak coupling. [Phys. Rev. D **70**, 114029 (2004)]

Scattering of shock waves in QCD. Ian Balitsky, *Physics Department, ODU, Norfolk Virginia 23529, USA Theory Group, Jlab, 12000 Jeffeson Ave, Newport News, Virginia 23606, USA.* (Received 30 September 2004; published 21 December 2004)

The cross section of heavy-ion collisions is represented as a double functional integral with the saddle point being the classical solution of the Yang-Mills equations with boundary conditions/sources in the form of two shock waves corresponding to the two colliding ions. I develop the expansion of this classical solution in powers of the commutator of the Wilson lines describing the colliding particles and calculate the first two terms of the expansion-.[Phys. Rev. D **70**, 114030 (2004)]

Influence of diffractive interactions on cosmic ray air showers. R. Luna and A. Zepeda, *Departamento de Física, Cinvestav, Avenida IPN 2508, Colonia San Pedro Zacatenco, 07360 Mexico DF, Mexico,* C. A. García Canal and S. J. Sciutto, *Departamento de Física and IFLP/CONICET, Universidad Nacional de La Plata, C. C. 67–1900 La Plata, Argentina.* (Received 26 August 2004; published 23 December 2004)

A comparative study of commonly used hadronic collision simulation packages is presented. The characteristics of the products of hadron-nucleus collisions are analyzed from a general perspective, but focusing on their correlation with diffractive processes. One of the purposes of our work is to give quantitative estimations of the impact that different characteristics of the hadronic models have on air shower observables. Several sets of shower simulations using different settings for the parameters controlling the diffractive processes are used to analyze the correlations between diffractivity and shower observables. We find that the relative probability of diffractive processes during the shower development have a non-negligible influence over the longitudinal profile as well as the distribution of muons at ground level. The implications on experimental data analysis are discussed. [Phys. Rev. D **70**, 114034 (2004)]

Neutrino emission from ungapped quark matter. Thomas Schäfer[1,2] and Kai Schwenzer,[1] [1]*Department of Physics, North Carolina State University, Raleigh, North Carolina 27695, USA,* [2]*Riken-BNL Research Center, Brookhaven National Laboratory, Upton, New York 11973, USA.* (Received 20 October 2004; published 30 December 2004)

We study neutrino emission from a normal, ungapped, quark phase in the core of a compact star. Neutrino emission from noninteracting quark matter leads to an emissivity that scales as $\epsilon \sim T^7$. We show that the emissivity is enhanced by a combination of Fermi liquid and non-Fermi liquid effects. Fermi liquid effects lead to an emissivity that scales as $\epsilon \sim \alpha_s T^6$, as originally shown by Iwamoto. We demonstrate that non-Fermi liquid effects further enhance the rate, leading to $\epsilon \sim \alpha_s^3 T^6 \log(m/T)^2$, where m is the electric screening scale and $m \gg T$ under the conditions found in compact stars. We show, however, that combined with non-Fermi liquid effects in the specific heat the enhancement in the emissivity only leads to a modest reduction in the temperature of the star at late times. Our results confirm existing bounds on the presence of ungapped quark matter in compact stars. We also discuss neutrino emission from superconducting phases with ungapped fermionic excitations. [Phys. Rev. D **70**, 114037 (2004)]

Nuclear antishadowing in neutrino deep inelastic scattering. Stanley J. Brodsky,[1] Ivan Schmidt,[2] and Jian-Jun Yang,[2,3,4] [1]*Stanford Linear Accelerator Center, Stanford University, Stanford, California 94309, USA,* [2]*Departamento de Física, Universidad Téchnica Federico Santa María, Casilla 110-V, Valparaíso, Chile,* [3]*Institut für Theoretische Physik, Universität Regensburg, D-93040 Regensburg, Germany,* [4]*Department of Physics, Nanjing Normal University, Nanjing 210097, China.* (Received 21 September 2004; published 2 December 2004)

The shadowing and antishadowing of nuclear structure functions in the Gribov-Glauber picture is due, respectively, to the destructive and constructive interference of amplitudes arising from the multiple scattering of quarks in the nucleus. The effective quark-nucleon scattering amplitude includes Pomeron and Odderon contributions from multigluon exchange as well as Reggeon quark-exchange contributions. We show that the coherence of these multiscattering nuclear processes leads to shadowing and antishadowing of the electromagnetic nuclear structure functions in agreement with measurements. This picture leads to substantially different antishadowing for charged and neutral current reactions, thus affecting the extraction of the weak-mixing angle θ_W. We find that part of the anomalous NuTeV result for θ_W could be due to the nonuniversality of nuclear antishadowing for charged and neutral currents. Detailed measurements of the nuclear dependence of individual quark structure functions are thus needed to establish the distinctive phenomenology of shadowing and antishadowing and to make the NuTeV results definitive. [Phys. Rev. D **70**, 116003 (2004)]

QCD radiative and power corrections and generalized Gerasimov-Drell-Hearn sum rules. J. Soffer[1] and O. Teryaev,[1,2] [1]*Centre de Physique Théorique, CNRS-Luminy, Case 907, F-13288 Marseille Cedex 9, France,* [2]*Bogoliubov Laboratory of Theoretical Physics, Joint Institute for Nuclear Research, 141980 Dubna, Moscow region, Russia.* (Received 23 July 2004; published 2 December 2004)

We extend the earlier suggested QCD-motivated model for the Q^2 dependence of the generalized Gerasimov-Drell-Hearn (GDH) sum rule which assumes the smooth dependence of the structure function g_T, while the sharp dependence is due to the g_2 contribution and is described by the elastic part of the Burkhardt-Cottingham sum rule. The model successfully predicts the low crossing point for the proton GDH integral, but is at variance with the recent very accurate JLAB data. We show that, at this level of accuracy, one should include the previously neglected radiative and power QCD corrections, as boundary values for the model. We stress that the GDH integral, when measured with such a high accuracy achieved by the recent JLAB data, is very sensitive to QCD power corrections. We estimate the value of these power corrections from the JLAB data at $Q^2 \sim 1$ GeV^2. The inclusion of all QCD corrections leads to a good description of proton, neutron, and deuteron data at all Q^2. [Phys. Rev. D **70**, 116004 (2004)]

Dilepton low p_T suppression as an evidence of the color glass condensate. M. A. Betemps[1] and M. B. Gay Ducati,[1] [1]*High Energy Physics Phenomenology Group, GFPAE Instituto de Física, Universidade Federal do Rio Grande do Sul, Caixa Postal 15051, CEP 91501-970, Porto Alegre, RS, Brazil.* (Received 6 August 2004; published 6 December 2004)

The dilepton production is investigated in proton-nucleus collisions in the forward region using the Color Glass Condensate approach. The transverse momentum distribution (p_T), more precisely the low p_T region, where the saturation effects are expected to increase, is analyzed. The ratio between proton-nucleus and proton-proton differential cross section for RHIC and LHC energies is evaluated, showing the effects of saturation at small p_T, and presenting a suppression of the Cronin type peak at moderate p_T. These features indicate the dilepton as a most suitable probe to study the properties of the saturated regime and the Cronin effect. [Phys. Rev. D **70**, 116005 (2004)]

Thermodynamics of O(N) sigma models: 1/N corrections. Jens O. Andersen, *Nordita, Blegdamsvej 17, DK-2100 Copenhagen, Denmark,* Daniël Boer and Harmen J. Warringa, *Department of Physics and Astronomy, Vrije Universiteit, De Boelelaan 1081, 1081 HV Amsterdam, The Netherlands.* (Received 4 August 2004; published 7 December 2004)

The thermodynamics of the O(N) linear and nonlinear sigma models in $3+1$ dimensions is studied. We calculate the pressure to next-to-leading order in the $1/N$ expansion and show that at this order, temperature-independent renormalization is only possible at the minimum of the effective potential. The $1/N$ expansion is found to be a good expansion for N as low as 4, which is the case relevant for low-energy QCD phenomenology. We consider the cases with and without explicit symmetry breaking. We show that previous next-to-leading-order calculations of the pressure are either breaking down at the temperatures of interest, or based on unjustifiable high-energy approximations. [Phys. Rev. D **70**, 116007 (2004)]

Large N_c QCD at nonzero chemical potential. Thomas D. Cohen, *Physics, University of Maryland, College Park, Maryland 20742-4111, USA.* (Received 22 October 2004; published 13 December 2004)

The general issue of large N_c QCD at nonzero chemical potential is considered with a focus on understanding the difference between large N_c QCD with an isospin chemical potential and large N_c QCD with a baryon chemical potential. A simple diagrammatic analysis analogous to 't Hooft's analysis at $\mu=0$ implies that the free energy with a given baryon chemical potential is equal to the free energy with an isospin chemical potential of the same value plus $1/N_c$ corrections. Phenomenologically, these two systems behave quite differently. A scenario to explain this difference in light of the diagrammatic analysis is explored. This scenario is based on a phase transition associated with pion condensation when the isospin chemical potential exceeds $m_\pi/2$; associated with this transition there is breakdown of the $1/N_c$ expansion—in the pion condensed phase there is a distinct $1/N_c$ expansion including a larger set of diagrams. While this scenario is natural, there are a number of theoretical issues which at least superficially challenge it. Most of these can be accommodated. However, the behavior of quenched QCD which raises a number of apparently analogous issues cannot be easily understood completely in terms of an analogous scenario. Thus, the overall issue remains open. [Phys. Rev. D **70**, 116009 (2004)]

Effective restoration of the $U_A(1)$ symmetry with temperature and density. P. Costa, M. C. Ruivo, and C. A. de Sousa, *Departamento de Física, Universidade de Coimbra, P-3004-516 Coimbra, Portugal,* Yu. L. Kalinovsky, *Université de Liège, Départment de Physique B5, Sart Tilman, B-4000, LIEGE 1, Belgium.* (Received 2 August 2004; published 30 December 2004)

We investigate the full $U(3)\otimes U(3)$ chiral symmetry restoration, at finite temperature and density, on the basis of a quark model which incorporates the most relevant properties of QCD in this context: explicit and spontaneous breaking of chiral symmetry and axial $U_A(1)$ symmetry breaking. A specific lattice-inspired behavior of the topological susceptibility, combined with the convergence of chiral partners, signals the onset of an effective chiral symmetry restoration. The results suggest that the axial part of the symmetry is restored before the possible restoration of the full $U(3)\otimes U(3)$ chiral symmetry can occur. This conclusion is valid in the context of both finite temperature and density. [Phys. Rev. D **70**, 116013 (2004)]

Single-spin asymmetries: The Trento conventions. Alessandro Bacchetta, *Institut für Theoretische Physik, Universität Regensburg, D-93040 Regensburg, Germany,* Umberto D'Alesio, *INFN, Sezione di Cagliari and Dipartimento di Fisica, Università di Cagliari, I-09042 Monserrato, Italy,* Markus Diehl, *Deutsches Elektronen-Synchroton DESY, D-22603 Hamburg, Germany,* C. Andy Miller, *TRIUMF, Vancouver, British Columbia V6T 2A3, Canada.* (Received 8 October 2004; published 22 December 2004)

During the workshop "Transversity: New Developments in Nucleon Spin Structure" (ECT*, Trento, Italy, 14–18 June 2004), a series of recommendations was put forward by the participants concerning definitions and notations for describing effects of intrinsic transverse-momentum of partons in semi-inclusive deep inelastic scattering. [Phys. Rev. D **70**, 117504 (2004)]

Sum rule for a difference of proton and neutron total photoproduction cross sections. E. Bartoš,[1] S. Dubnicka,[2] and E. A. Kuraev,[1] [1]*Joint Institute for Nuclear Research, 141980 Dubna, Russia,* [2]*Institute of Physics, Slovak Academy of Science, Dúbravská cesta 9, 845 11 Bratislava, Slovakia.* (Received 25 March 2003; revised 10 September 2004; published 2 December 2004)

Starting from very high-energy inelastic electron-nucleon scattering with a production of a hadronic state X to be moved closely to the direction of the initial nucleon, then utilizing analytic properties of part of forward virtual Compton scattering amplitudes on proton and neutron, one obtains the relation between nucleon form factors and a difference of proton and neutron differential electroproduction cross sections. In particular, for the case of small transferred momenta, one finally derives sum rule, relating Dirac proton mean square readius and anomalous magnetic moments of proton and neutron to the integral over a difference of the total proton and neutron photoproduction cross sections. [Phys. Rev. D **70**, 117901 (2004)]

Rotating compact stars with exotic matter. Sarmistha Banik,[1] Matthias Hanauske,[2] Debades Bandyopadhyay,[1] and Walter Greiner,[3] [1]*Saha Institute of Nuclear Physics, 1/AF Bidhannagar, Calcutta 700 064, India,* [2]*Institut für Theoretische Physik, J. W. Goethe Universität, D-60054 Frankfurt am Main, Germany,* [3]*Frankfurt Institute for Advanced Studies (FIAS), J. W. Goethe Universität, D-60054 Frankfurt am Main, Germany.* (Received 15 June 2004; published 8 December 2004)

We have constructed models of uniformly rotating compact stars including hyperons, Bose-Einstein condensates of antikaons, and quarks. First order phase transitions from hadronic to antikaon condensed matter and then to quark matter are considered here. For the equation of state undergoing phase transitions to antikaon condensates, the third family of compact stars are found to exist in the fixed angular velocity sequences. However, the third family solution disappears when the compact stars rotate very fast. For this equa-

tion of state, the fixed baryon number supramassive sequence shows a second stable part after the unstable region but no back bending phenomenon. On the other hand, we observe that the rotation gives rise to a second maximum beyond the neutron star maximum for the equation of state involving phase transitions to both antikaon condensed and quark matter. In this case, the back bending phenomenon has been observed in the supramassive sequence as a consequence of the first order phase transition from K^- condensed to quark matter. And the back bending segment contains stable configurations of neutron stars. [Phys. Rev. D **70**, 123004 (2004)]