

Selected Abstracts from Other Physical Review Journals

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Supernova observation via neutrino-nucleus elastic scattering in the CLEAN detector. C. J. Horowitz, *Nuclear Theory Center and Department of Physics, Indiana University, Bloomington, Indiana 47405, USA*; K. J. Coakley, *National Institute of Standards and Technology, Boulder, Colorado 80305, USA*; D. N. McKinsey, *Physics Department, Princeton University, Princeton, New Jersey 08544, USA*. (Received 5 February 2003; published 28 July 2003)

Development of large mass detectors for low-energy neutrinos and dark matter may allow supernova detection via neutrino-nucleus elastic scattering. An elastic-scattering detector could observe a few, or more, events per ton for a galactic supernova at 10 kpc (3.1×10^{20} m). This large yield, a factor of at least 20 greater than that for existing light-water detectors, arises because of the very large coherent cross section and the sensitivity to all flavors of neutrinos and antineutrinos. An elastic scattering detector can provide important information on the flux and spectrum of ν_μ and ν_τ from supernovae. We consider many detectors and a range of target materials from ^4He to ^{208}Pb . Monte Carlo simulations of low-energy backgrounds are presented for the liquid-neon-based Cryogenic Low Energy Astrophysics with Noble gases detector. The simulated background is much smaller than the expected signal from a galactic supernova. [Phys. Rev. D **68**, 023005 (2003)]

Remarks on polarized quark distributions extracted from SIDIS experiments. A. N. Sissakian, O. Yu. Shevchenko, and O. N. Ivanov, *Joint Institute for Nuclear Research, Dubna, Moscow region 141980, Russia*. (Received 15 April 2003; published 18 August 2003)

The results of SIDIS experiments concerning the first moments of the polarized quark distributions are considered. The possible reasons for the deviation from the fundamental restrictions such as the Bjorken sum rule and the ways to properly improve the analysis of measured SIDIS asymmetries are discussed. The possibility of a broken polarized sea scenario is analyzed. [Phys. Rev. D **68**, 031502 (2003)]

Comparative study of electromagnetic shower track lengths in water and implications for Čerenkov radio emission. Jaime Alvarez-Muñiz, *Bartol Research Institute, University of Delaware, Newark, Delaware 19716, USA*; Enrique Marqués, Ricardo A. Vázquez, and Enrique Zas, *Departamento de Física de Partículas, Universidade de Santiago de Compostela, E-15706 Santiago de Compostela, Spain*. (Received 4 June 2002; published 12 August 2003)

We compare in detail the results of simulations of electromagnetic showers in ice in the GeV–TeV energy range, using both the GEANT package and the ZHS Monte Carlo code, a code specifically

designed to calculate coherent Čerenkov radio pulses from electromagnetic showers in dense media. The longitudinal and lateral profiles as well as the track lengths and excess projected track lengths are shown to agree below the 15% level. We briefly comment on the negligible influence of the Landau-Pomeranchuk-Migdal effect on the total shower track length. Our results are relevant for experiments exploiting the radio Čerenkov technique in dense media as well as for other detectors that rely on the Čerenkov effect in water or ice. [Phys. Rev. D **68**, 043001 (2003)]

Vanishing effective mass of neutrinoless double beta decay? Zhi-zhong Xing, *CCAST (World Laboratory), P.O. Box 8730, Beijing 100080, China, and Institute of High Energy Physics, Chinese Academy of Sciences, P.O. Box 918 (4), Beijing 100039, China*. (Received 15 May 2003; published 8 September 2003)

We stress the point that massive neutrinos may be Majorana particles even if the effective mass of the neutrinoless double beta decay $\langle m \rangle_{ee}$ vanishes. We show that current neutrino oscillation data *do* allow $\langle m \rangle_{ee} = 0$ to hold, if the Majorana CP -violating phases lie in two specific regions. Strong constraints on the neutrino mass spectrum can then be obtained. A possible texture of the neutrino mass matrix is also illustrated under the $\langle m \rangle_{ee} = 0$ condition. [Phys. Rev. D **68**, 053002 (2003)]

Neutrino processes in the K^0 condensed phase of color flavor locked quark matter. Sanjay Reddy, *Theoretical Division, Los Alamos National Laboratory, Los Alamos, New Mexico 87545, USA*; Mariusz Sadzikowski, *M. Smoluchowski Institute of Physics, Jagellonian University, Reymonta 4, 30-059 Kraków, Poland*; Motoi Tachibana, *Theoretical Physics Laboratory, RIKEN, Wako 351-0198, Japan*. (Received 18 June 2003; published 29 September 2003)

We study weak interactions involving Goldstone bosons in the neutral kaon condensed phase of color flavor locked quark matter. We calculate the rates for the dominant processes that contribute to the neutrino mean free path and to neutrino production. A light K^+ state, with a mass $\tilde{m}_{K^+} \propto (\Delta/\mu)(\Delta/m_s)(m_d - m_u)$, where μ and Δ are the quark chemical potential and superconducting gap respectively, is shown to play an important role. We identify unique characteristics of weak interaction rates in this novel phase and discuss how they might influence neutrino emission in core collapse supernova and neutron stars. [Phys. Rev. D **68**, 053010 (2003)]

Enhancement and suppression of the neutrino-nucleon total cross section at ultrahigh energies. Jamal Jalilian-Marian, *Physics Department, Brookhaven National Laboratory, Upton, New York 11973, USA*. (Received 2 February 2003; revised manuscript received 24 March 2003; published 3 September 2003)

We argue that high gluon density effects at small x are important for the calculation of ultrahigh energy neutrino-nucleon cross sections due to the phenomenon of geometric scaling. We calculate the cross section for $\nu N \rightarrow \mu X$, including high gluon density effects, using the all twist formalism of McLerran and Venugopalan and show that it can be related to the dipole nucleon cross section measured in deep inelastic scattering experiments. For neutrino energies of $E_\nu \sim 10^{12}$ GeV, the geometric scaling region extends all the way up to $Q^2 \sim M_W^2$. We show that geometric scaling can lead to an *enhancement* of the neutrino-nucleon total cross section by an order of magnitude compared to the leading twist cross section and discuss the implications for neutrino observatories. At extremely high energies, gluon saturation effects suppress the neutrino-nucleon total cross section and lead to its unitarization. [Phys. Rev. D **68**, 054005 (2003)]

QCD saturation and photoproduction on proton and nuclei targets. J. Bartels,¹ E. Gotsman,^{2,3} E. Levin,^{2,4} M. Lublinsky,⁴ and U. Maor² ¹*II Institut für Theoretische Physik, Universität Hamburg, D-22761 Hamburg, Germany,* ²*HEP Department School of Physics and Astronomy, Raymond and Beverly Sackler Faculty of Exact Science, Tel Aviv University, Tel Aviv, 69978, Israel,* ³*Department of Physics and Astronomy, University of California, Irvine, California 92612, USA,* ⁴*DESY Theory Group, 22607, Hamburg, Germany.* (Received 16 April 2003; published 12 September 2003)

We calculate inclusive photoproduction cross sections for both proton and nuclei targets, using a saturation model derived from an approximate solution to the Balitsky-Kovchegov nonlinear evolution equation. This paper extends our hypothesis that one can successfully use the dipole picture and saturation models to describe soft processes, instead of the soft Pomeron Regge parametrization. Our fit is compatible with our previous fit to deep inelastic scattering data, and utilizes the same phenomenological parameters as in our paper devoted to soft hadronic interactions. Using the Glauber formalism and no additional parameters, we calculate the cross sections for photoproduction on various nuclei, and compare our results with the relevant data. [Phys. Rev. D **68**, 054008 (2003)]

Saturation and parton level Cronin effect: Enhancement versus suppression of gluon production in p -A and A-A collisions. Rudolf Baier, *Fakultät für Physik, Universität Bielefeld, D-33615 Bielefeld, Germany, and Institute for Nuclear Theory, University of Washington, Box 351550, Seattle, Washington 98195, USA;* Alex Kovner, *Department of Mathematics and Statistics, University of Plymouth, Drake Circus, Plymouth PL4 8AA, United Kingdom, and Institute for Nuclear Theory, University of Washington, Box 351550, Seattle, Washington 98195, USA;* Urs Achim Wiedemann, *Theory Division, CERN, CH-1211 Geneva 23, Switzerland, and Institute for Nuclear Theory, University of Washington, Box 351550, Seattle, Washington 98195, USA.* (Received 27 May 2003; revised manuscript received 16 July 2003; published 12 September 2003)

We note that the phenomenon of perturbative saturation leads to transverse momentum broadening in the spectrum of partons produced in hadronic collisions. This broadening has a simple interpretation as the parton level Cronin effect for systems in which saturation is generated by the “tree level” Glauber-Mueller mechanism. For systems where the broadening results from the nonlinear QCD evolution to high energy, the presence or absence of the Cronin

effect depends crucially on the quantitative behavior of the gluon distribution functions at transverse momenta k_t outside the so called scaling window. We discuss the relation of this phenomenon to the recent analysis by Kharzeev, Levin, and McLerran of the momentum and centrality dependence of particle production in nucleus-nucleus collisions at BNL RHIC. [Phys. Rev. D **68**, 054009 (2003)]

Pressure of QCD at finite temperatures and chemical potentials. A. Vuorinen, *Department of Physical Sciences, Theoretical Physics Division, P.O. Box 64, FIN-00014 University of Helsinki, Finland.* (Received 4 June 2003; published 23 September 2003)

We compute the perturbative expansion of the pressure of hot QCD to order $g^6 \ln g$ in the presence of finite quark chemical potentials. In this process we evaluate all two- and three-loop vacuum diagrams of the theory at arbitrary T and μ and then use these results to analytically verify the outcome of an old order g^4 calculation of Freedman and McLerran for the zero-temperature pressure. The results for the pressure and the different quark number susceptibilities at high T are compared with recent lattice simulations showing excellent agreement especially for the chemical potential dependent part of the pressure. [Phys. Rev. D **68**, 054017 (2003)]

Expectation values of four-quark operators in the nucleon. E. G. Drukarev, M. G. Ryskin, and V. A. Sadovnikova, *Petersburg Nuclear Physics Institute, St. Petersburg 188300, Russia;* V. E. Lyubovitskij, Th. Gutsche, and Amand Faessler, *Institut für Theoretische Physik, Universität Tübingen, Tübingen D-72076, Germany.* (Received 16 June 2003; published 29 September 2003)

We calculate the expectation values of QCD operators consisting of the products of the four operators of the light quarks $\bar{q}\Gamma^X q \bar{q}\Gamma^Y q$, with $\Gamma^{X,Y}$ corresponding to the scalar, pseudoscalar, vector, pseudovector (axial), and tensor Lorentz structures, in the nucleon. All combinations of the light flavors are considered. For the evaluation we use elements of the perturbative chiral quark model (PCQM), approximating the contribution of the valence quarks by the contribution of the PCQM constituent quarks. The contribution of the sea quarks is treated by averaging over the QCD pions with the distribution of the pion field being determined by the PCQM. For quarks with the same flavor the expectation values are dominated by the contribution of the sea quarks. In the scalar case the contribution of the sea quarks is dominated by the “disconnected terms” where one of the pairs of the $\bar{q}q$ operators acts on the vacuum while the other one acts on the quarks of the pion. The role of the interference terms with one of the $\bar{q}q$ pairs acting on the sea quarks and the other one acting on the valence quarks increases for quarks with different flavors. The result for the scalar condensate is compared to that obtained earlier in the framework of the Nambu–Jona-Lasinio model. [Phys. Rev. D **68**, 054021 (2003)]

Compatibility of quark and resonant picture excited baryon multiplets in the $1/N_c$ expansion of QCD. Thomas D. Cohen, *Department of Physics, University of Maryland, College Park, Maryland 20742-4111, USA;* Richard F. Lebed, *Department of Physics and Astronomy, Arizona State University, Tempe,*

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We demonstrate that the two major complementary pictures of large N_c baryon resonances—as single-quark orbital excitations about a closed-shell core [giving $SU(2N_f) \times O(3)$ multiplets], and as resonances in meson-baryon scattering amplitudes—are completely compatible in a specific sense: Both pictures give rise to a set of multiplets of degenerate states, for which any complete spin-flavor multiplet within one picture fills the quantum numbers of complete multiplets in the other picture. This result is demonstrated by (i) straightforward computation of the lowest multiplets in both pictures, (ii) a study of the nature of quark excitations in a hedgehog picture, and (iii) direct group-theoretical comparison of the constraints in the two pictures. [Phys. Rev. D **68**, 056003 (2003)]

Majorana neutrino, the size of extra dimensions, and neutrinoless double beta decay. Marek Góźdz and Wiesław A. Kaminski, *Theoretical Physics Department, Maria Curie-Skłodowska University, Lublin, Poland.* (Received 14 April 2003; revised manuscript received 7 July 2003; published 24 September 2003)

The problem of the Majorana neutrino mass generated in the Arkani-Hamed–Dimopoulos–Dvali model with n extra spatial dimensions is discussed. Taking into account constraints on the neutrino masses coming from cosmological observations, it is possible to obtain lower limits on the size of the extra dimensions as large as 10^{-6} mm. In the case of $n=4$ it is easy to lower the fundamental

scale of gravity from the Planck energy to the electroweak scale ~ 1 TeV without imposing any additional constraints. A link between the half-life of neutrinoless double beta decay and the size of extra dimensions is discussed. [Phys. Rev. D **68**, 057901 (2003)]

Meson masses in large N_f QCD from the Bethe-Salpeter equation. Masayasu Harada, Masafumi Kurachi, and Koichi Yamawaki, *Department of Physics, Nagoya University, Nagoya 464-8602, Japan.* (Received 2 May 2003; published 1 October 2003)

We solve the homogeneous Bethe-Salpeter (HBS) equation for the scalar, pseudoscalar, vector, and axial-vector bound states of quarks and antiquarks in large N_f QCD with the improved ladder approximation in the Landau gauge. The quark mass function in the HBS equation is obtained from the Schwinger-Dyson (SD) equation in the same approximation for consistency with the chiral symmetry. Amazingly, because of the fact that the two-loop running coupling of large N_f QCD is explicitly written in terms of an analytic function, large N_f QCD turns out to be the first example in which the SD equation can be solved in the complex plane and hence the HBS equation directly in the time-like region. We find that approaching the chiral phase transition point from the broken phase, the scalar, vector, and axial-vector meson masses vanish to zero with the same scaling behavior, all degenerate with the massless pseudoscalar meson. This may suggest a new type of manifestation of the chiral symmetry restoration in large N_f QCD. [Phys. Rev. D **68**, 076001 (2003)]