

Selected Abstracts from Other Physical Review Journals

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Simultaneous QCD analysis of diffractive and inclusive deep-inelastic scattering data. A. D. Martin,¹ M. G. Ryskin,^{1,2} and G. Watt,¹ ¹*Institute for Particle Physics Phenomenology, University of Durham, DH1 3LE, United Kingdom,* ²*Petersburg Nuclear Physics Institute, Gatchina, St. Petersburg, 188300, Russia.* (Received 12 July 2004; published 8 November 2004)

We perform a next-to-leading order (NLO) QCD analysis of deep-inelastic scattering data, in which we account for absorptive corrections. These corrections are determined from a simultaneous analysis of diffractive deep-inelastic data. The absorptive effects are found to enhance the size of the gluon distribution at small x , such that a negative input gluon distribution at $Q^2=1$ GeV² is no longer required. We discuss the problem that the gluon distribution is valence-like at low scales, whereas the sea quark distribution grows with decreasing x . Our study hints at the possible importance of power corrections for $Q^2 \approx 1$ -2 GeV². [Phys. Rev. D **70**, 091502 (2004)]

Tricritical point of lattice QCD with Wilson quarks at finite temperature and density. Xiang-Qian Luo, *CCAST (World Laboratory), P.O. Box 8730, Beijing 100080, China, Department of Physics, Zhongshan (Sun Yat-Sen) University, Guangzhou 510275, China.* (Received 8 April 2004; published 16 November 2004)

First principle study of QCD at finite temperature T and chemical potential μ is essential for understanding a wide range of phenomena from heavy-ion collisions to cosmology and neutron stars. However, in the presence of finite density, the critical behavior lattice gauge theory without species doubling, is unknown. At strong coupling, we examine the phase structure on the (μ, T) plane, using Hamiltonian lattice QCD with Wilson fermions. A tricritical point is found, separating the first and second order chiral phase transitions. Such a tricritical point at finite T has not been found in previous work in the Hamiltonian formalism with Kogut-Susskind fermions or naive fermions. [Phys. Rev. D **70**, 091504 (2004)]

Precision measurements and CKM unitarity. Andrzej Czarnecki, *Department of Physics, University of Alberta, Edmonton, Alberta, Canada T6G 2J1.* William J. Marciano, *Brookhaven National Laboratory, Upton, New York 11973, USA, and Institut für Theoretische Teilchenphysik, Universität Karlsruhe, D-76128 Karlsruhe, Germany.* Alberto Sirlin, *Department of Physics, New York University, 4 Washington Place, New York, New York 10003, USA, and II. Institut für Theoretische Physik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany.* (Received 29 June 2004; published 11 November 2004)

Determinations of $|V_{ud}|$ and $|V_{us}|$ along with their implications for the unitarity test $|V_{ud}|^2 + |V_{us}|^2 + |V_{ub}|^2 = 1$ are discussed. The leading two-loop radiative corrections to neutron β decay are evaluated and used to derive a refined relationship $|V_{ud}|^2 \tau_n (1 + 3g_A^2) = 4908(4)s$. Employing $|V_{ud}| = 0.9740(5)$ from superallowed nuclear decays and the measured neutron lifetime $\tau_n = 885.7(7)s$ leads to the precise prediction $g_A = 1.2703(8)$ which is compared with current direct experimental values. Various extractions of $|V_{us}|$ are described and updated. The long accepted Particle Data Group value of $|V_{us}|$ from fitted K_{e3} decay rates suggests a deviation from CKM unitarity but it is contradicted by more recent experimental results which confirm unitarity with good precision. An outlook for possible future advances is given. [Phys. Rev. D **70**, 093006 (2004)]

Double distributions for the proton. B. C. Tiburzi, W. Detmold, and G. A. Miller, *Department of Physics, University of Washington, Box 351560, Seattle, Washington 98195-1560, USA.* (Received 8 September 2004; published 12 November 2004)

We derive double distributions for the proton in a simple model that contains scalar as well as axial-vector diquark correlations. The model parameters are tuned so that the experimentally measured electromagnetic form factors of the proton are reproduced for small momentum transfer. Resulting generalized parton distributions satisfy known constraints, including the positivity bounds. [Phys. Rev. D **70**, 093008 (2004)]

Untangling CP violation and the mass hierarchy in long baseline experiments. Olga Mena and Stephen Parke, *Theoretical Physics Department, Fermi National Accelerator Laboratory, P.O. Box 500, Batavia, Illinois 60510, USA.* (Received 18 August 2004; published 18 November 2004)

In the overlap region, for the normal and inverted hierarchies, of the neutrino-antineutrino bi-probability space for $\nu_\mu \rightarrow \nu_e$ appearance, we derive a simple identity between the solutions in the $(\sin^2 2\theta_{13}, \sin\delta)$ plane for the different hierarchies. The parameter $\sin^2 2\theta_{13}$ sets the scale of the $\nu_\mu \rightarrow \nu_e$ appearance probabilities at the atmospheric $\delta m_{\text{atm}}^2 \approx 2.4 \times 10^{-3}$ eV² whereas $\sin\delta$ controls the amount of CP violation in the lepton sector. The identity between the solutions is that the difference in the values of $\sin\delta$ for the two hierarchies equals twice the value of $\sqrt{\sin^2 2\theta_{13}}$ divided by the critical value of $\sqrt{\sin^2 2\theta_{13}}$. We apply this identity to the two proposed long baseline experiments, T2K and NOvA, and we show how it can be used to provide a simple understanding of when and why fake solutions are excluded when two or more experiments are combined. This identity demonstrates the true complementarity of T2K and NOvA. [Phys. Rev. D **70**, 093011 (2004)]

Electron antineutrino search at the Sudbury Neutrino Observatory. B. Aharmim,⁵ S. N. Ahmed,¹⁰ E. W. Beier,⁹ A. Bellerive,³ S. D. Biller,⁸ J. Boger,² M. G. Boulay,⁷ T. J. Bowles,⁷ S. J. Brice,⁷ T. V. Bullard,¹³ Y. D. Chan,⁶ M. Chen,¹⁰ X. Chen,⁶ B. T. Cleveland,⁸ G. A. Cox,¹³ X. Dai,^{3,8} F. Dalnoki-Veress,³ P. J. Doe,¹³ R. S. Dosanjh,³ G. Doucas,⁸ M. R. Dragowsky,⁷ C. A. Duba,¹³ F. A. Duncan,¹⁰ M. Dunford,⁹ J. A. Dunmore,⁸ E. D. Earle,¹⁰ S. R. Elliott,⁷ H. C. Evans,¹⁰ G. T. Ewan,¹⁰ J. Farine,^{5,3} H. Fergani,⁸ F. Fleurot,⁵ J. A. Formaggio,¹³ M. M. Fowler,⁷ K. Frame,^{8,3,7} W. Frati,⁹ B. G. Fulsom,¹⁰ N. Gagnon,^{13,7,6,8} K. Graham,¹⁰ D. R. Grant,³ R. L. Hahn,² A. L. Hallin,¹⁰ E. D. Hallman,⁵ A. S. Hamer,⁷ W. B. Handler,¹⁰ C. K. Hargrove,³ P. J. Harvey,¹⁰ R. Hazama,¹³ K. M. Heeger,⁶ W. J. Heintzelman,⁹ J. Heise,⁷ R. L. Helmer,^{12,1} R. J. Hemingway,³ A. Hime,⁷ M. A. Howe,¹³ P. Jagam,⁴ N. A. Jelley,⁸ J. R. Klein,^{14,9} L. L. Kormos,¹⁰ M. S. Kos,^{7,10} A. Krüger,⁵ C. B. Krauss,¹⁰ A. V. Krumins,¹⁰ T. Kutter,¹ C. C. M. Kyba,⁹ H. Labranche,⁴ R. Lange,² J. Law,⁴ I. T. Lawson,⁴ K. T. Lesko,⁸ J. R. Leslie,¹⁰ I. Levine,³ S. Luoma,⁵ R. MacLellan,¹⁰ S. Majerus,⁸ H. B. Mak,¹⁰ J. Maneira,¹⁰ A. D. Marino,⁶ N. McCauley,⁹ A. B. McDonald,¹⁰ S. McGee,¹³ G. McGregor,⁸ C. Mifflin,³ K. K. S. Miknaitis,¹³ G. G. Miller,⁷ B. A. Moffat,¹⁰ C. W. Nally,¹ M. S. Neubauer,⁹ B. G. Nickel,⁴ A. J. Noble,^{10,3,12} E. B. Norman,⁶ N. S. Oblath,¹³ C. E. Okada,⁶ R. W. Ollerhead,⁴ J. L. Orrell,¹³ S. M. Oser,^{1,9} C. Ouellet,¹⁰ S. J. M. Peeters,⁸ A. W. P. Poon,⁶ K. Rielage,¹³ B. C. Robertson,¹⁰ R. G. H. Robertson,¹³ E. Rollin,³ S. S. E. Rosendahl,⁶ V. L. Rusu,⁹ M. H. Schwendener,⁵ O. Simard,³ J. J. Simpson,⁴ C. J. Sims,⁸ D. Sinclair,^{3,12} P. Skensved,¹⁰ M. W. E. Smith,¹³ N. Starinsky,³ R. G. Stokstad,⁶ L. C. Stonehill,¹³ R. Tafirout,⁵ Y. Takeuchi,¹⁰ G. Tešić,³ M. Thomson,¹⁰ T. Tsui,¹ R. Van Berg,⁹ R. G. Van de Water,⁷ C. J. Virtue,⁵ B. L. Wall,¹³ D. Waller,³ C. E. Waltham,¹ H. Wan Chan Tseung,⁸ D. L. Wark,¹¹ N. West,⁸ J. B. Wilhelmy,⁷ J. F. Wilkerson,¹³ J. R. Wilson,⁸ P. Wittich,⁹ J. M. Wouters,⁷ M. Yeh,² and K. Zuber,⁸ ¹Department of Physics and Astronomy, University of British Columbia, Vancouver, British Columbia V6T 1Z1 Canada, ²Chemistry Department, Brookhaven National Laboratory, Upton, New York 11973-5000, USA, ³Ottawa-Carleton Institute for Physics, Department of Physics, Carleton University, Ottawa, Ontario K1S 5B6 Canada, ⁴Physics Department, University of Guelph, Guelph, Ontario N1G 2W1 Canada, ⁵Department of Physics and Astronomy, Laurentian University, Sudbury, Ontario P3E 2C6 Canada, ⁶Institute for Nuclear and Particle Astrophysics and Nuclear Science Division, Lawrence Berkeley National Laboratory, Berkeley, California 94720, USA, ⁷Los Alamos National Laboratory, Los Alamos, New Mexico 87545, USA, ⁸Department of Physics, University of Oxford, Denys Wilkinson Building, Keble Road, Oxford, OX1 3RH, United Kingdom, ⁹Department of Physics and Astronomy, University of Pennsylvania, Philadelphia, Pennsylvania 19104-6396, USA, ¹⁰Department of Physics, Queen's University, Kingston, Ontario K7L 3N6 Canada, ¹¹Rutherford Appleton Laboratory, Chilton, Didcot, Oxon, OX11 0QX, United Kingdom and University of Sussex, Physics and Astronomy Department, Brighton BN1 9QH, United Kingdom, ¹²TRIUMF, 4004 Wesbrook Mall, Vancouver, BC V6T 2A3, Canada, ¹³Center for Experimental Nuclear Physics and Astrophysics and Department of Physics, University of Washington, Seattle, Washington 98195, USA ¹⁴Department of Physics, University of Texas at Austin, Austin, Texas 78712-0264, USA, SNO Collaboration, (Received 15 July 2004; published 29 November 2004)

Upper limits on the $\bar{\nu}_e$ flux at the Sudbury Neutrino Observatory have been set based on the $\bar{\nu}_e$ charged-current reaction on deuterium. The reaction produces a positron and two neutrons in coinci-

dence. This distinctive signature allows a search with very low background for $\bar{\nu}_e$'s from the Sun and other potential sources. Both differential and integral limits on the $\bar{\nu}_e$ flux have been placed in the energy range from 4–14.8 MeV. For an energy-independent $\nu_e \rightarrow \bar{\nu}_e$ conversion mechanism, the integral limit on the flux of solar ν_e 's in the energy range from 4–14.8 MeV is found to be $\Phi_{\bar{\nu}_e} \leq 3.4 \times 10^4 \text{ cm}^{-2} \text{ s}^{-1}$ (90% C.L.), which corresponds to 0.81% of the standard solar model ^8B ν_e flux of $5.05 \times 10^6 \text{ cm}^{-2} \text{ s}^{-1}$, and is consistent with the more sensitive limit from KamLAND in the 8.3–14.8 MeV range of $3.7 \times 10^2 \text{ cm}^{-2} \text{ s}^{-1}$ (90% C.L.). In the energy range from 4–8 MeV, a search for $\bar{\nu}_e$'s is conducted using coincidences in which only the two neutrons are detected. Assuming a $\bar{\nu}_e$ spectrum for the neutron induced fission of naturally occurring elements, a flux limit of $\Phi_{\bar{\nu}_e} \leq 2.0 \times 10^6 \text{ cm}^{-2} \text{ s}^{-1}$ (90% C.L.) is obtained. [Phys. Rev. D. **70**, 093014 (2004)]

Electromagnetic form factors of the ρ meson in light cone QCD sum rules. T. M. Aliev and M. Savcı, *Physics Department, Middle East Technical University, 06531 Ankara, Turkey.* (Received 23 August 2004; published 5 November 2004)

We investigate the electromagnetic form factors of the ρ meson in light cone QCD sum rules. We find that the ratio of the magnetic and charge form factors is larger than 2 at all values of Q^2 , ($Q^2 \geq 0.5 \text{ GeV}^2$). The values of the individual form factors at fixed values of Q^2 predicted by the light cone QCD sum rules are quite different compared to the results of other approaches. These results can be checked in the future, when more precise data on ρ meson form factors is available. [Phys. Rev. D. **70**, 094007 (2004)]

$D_{sJ}^+(2632)$: An excellent candidate of tetraquarks. Y.-R. Liu and Shi-Lin Zhu, *Department of Physics, Peking University, Beijing 100871, China.* Y.-B. Dai and C. Liu, *Institute of Theoretical Physics, Chinese Academy of Sciences, P.O. Box 2735, Beijing 100080, China.* (Received 27 July 2004; published 8 November 2004)

We analyze various possible interpretations of the narrow state $D_{sJ}(2632)$ which lies 100 MeV above threshold. This interesting state decays mainly into $D_s \eta$ instead of $D^0 K^+$. If this relative branching ratio is further confirmed by other experimental groups, we point out that the identification of $D_{sJ}(2632)$ either as a $c\bar{s}$ state or more generally as a $\bar{3}$ state in the $\text{SU}(3)_F$ representation is probably problematic. Instead, such an anomalous decay pattern strongly indicates $D_{sJ}(2632)$ is a four-quark state in the $\text{SU}(3)_F$ **15** representation with the quark content $\frac{1}{2}\sqrt{2}(ds\bar{d} + s\bar{d}d + su\bar{u} + usu - 2s\bar{s}s)\bar{c}$. We discuss its partners in the same multiplet and the similar four-quark states composed of a bottom quark $B_{sJ}^0(5832)$. Experimental searches of other members especially those exotic ones are strongly called for. [Phys. Rev. D. **70**, 094009 (2004)]

Whitening of the quark-gluon plasma. Cristina Manuel, ¹*Instituto de Física Corpuscular, C.S.I.C.-Universitat de València, Edificio de Institutos de Paterna, Apt 2085, 46071 València, Spain.* Stanisław Mrówczyński ²*Soltan Institute for Nuclear Studies, ul. Hoża 69,*

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Parton-parton collisions do not neutralize local color charges in the quark-gluon plasma as they only redistribute the charges among momentum modes. We discuss color diffusion and color conductivity as the processes responsible for the neutralization of the plasma. For this purpose, we first compute the conductivity and diffusion coefficients in the plasma that is significantly colorful. Then, the time evolution of the color density due to the conductivity and diffusion is studied. The conductivity is shown to be much more efficient than the diffusion in neutralizing the plasma at the scale longer than the screening length. Estimates of the characteristic time scales, which are based on close to global equilibrium computations, suggest that first the plasma becomes white and then the momentum degrees of freedom thermalize. [Phys. Rev. D. **70**, 094019 (2004)]

Pentaquark baryons in the SU(3) quark model. Yongseok Oh, *Department of Physics and Astronomy, University of Georgia, Athens, Georgia 30602, USA*. Hungchong Kim, *Institute of Physics and Applied Physics, Yonsei University, Seoul 120-749, Korea*. (Received 6 May 2004; published 12 November 2004)

We study the SU(3) group structure of pentaquark baryons which are made of four quarks and one antiquark. The pentaquark baryons form **1**, **8**, **10**, **10**, **27**, and **35** multiplets in the SU(3) quark model. First, the flavor wave functions of all the pentaquark baryons are constructed in the SU(3) quark model and then the flavor SU(3) symmetry relations for the interactions of the pentaquarks with three-quark baryons and pentaquark baryons are obtained. Constructing the general interactions in SU(3) could be important for understanding the pentaquark baryon properties from reaction mechanisms. We also discuss possible pentaquarks in **27**-plet and **35**-plet and their decay channels that can be used to identify them in future experiments. The mass sum rules for the pentaquark baryons are also presented. [Phys. Rev. D. **70**, 094022 (2004)]

Covariant baryon charge radii and magnetic moments in a chiral constituent-quark model. K. Berger, R. F. Wagenbrunn, and W. Plessas, *Theoretische Physik, Karl-Franzens-Universität, Graz, Austria*. (Received 18 June 2004; published 17 November 2004)

The charge radii and magnetic moments of all the light and strange baryons are investigated within the framework of a constituent-quark model based on Goldstone-boson-exchange dynamics. Following the pointform approach to relativistic quantum mechanics, the calculations are performed in a manifestly covariant manner. Relativistic (boost) effects have a sizeable influence on the results. The direct predictions of the constituent-quark model are found to fall remarkably close to the available experimental data. [Phys. Rev. D. **70**, 094027 (2004)]

Heavy quark $\bar{q}q$ matrix elements in the nucleon from perturbative QCD. Andrei Kryjevski, *Dept. of Physics and Institute for Nuclear Theory, University of Washington, Seattle, Washington 98195, USA*. (Received 31 March 2004; published 17 November 2004)

The scalar heavy quark content of the nucleon, $\mathcal{M}_q = \langle N | m_q \bar{q}q | N \rangle$, is relevant for computing the interaction of dark matter candidates with ordinary matter, while $\mathcal{M}_s$ is important for predicting the properties of dense matter. We compute $\mathcal{M}_q$ in perturbative QCD to $\mathcal{O}(\alpha^3)$. As one goes from $\mathcal{M}_t$ to $\mathcal{M}_c$ the leading order contribution decreases as the number of light quarks is dropping, while the radiative corrections grow and are all positive. The leading source of uncertainty in the calculation is due to the poorly known value of $\mathcal{M}_s$. The Higgs-nucleon coupling is estimated to be $g_{hNN} \approx 1.7 \times 10^{-3}$. [Phys. Rev. D. **70**, 094028 (2004)]

Screening masses in a neutral two-flavor color superconductor. Mei Huang and Igor A. Shovkovy, *Institut für Theoretische Physik, J.W. Goethe-Universität, D-60054 Frankfurt/Main, Germany*. (Received 6 September 2004; published 17 November 2004)

The Debye and Meissner screening masses of the gluons and the photon in neutral and β -equilibrated dense two-flavor quark matter are calculated. The results are presented in a general form that can be used in gapped as well as gapless color superconducting phases. The results for the magnetic screening masses indicate that the system develops a chromomagnetic instability. Possible consequences of the instability are discussed. [Phys. Rev. D. **70**, 094030 (2004)]

Chiral model for $\bar{q}q$ and $q\bar{q}qq$ mesons. Mauro Napsuciale and Simón Rodríguez, *Instituto de Física, Universidad de Guanajuato, Lomas del Bosque 103, Fraccionamiento Lomas del Campestre, 37150, León Guanajuato, México* (Received 26 July 2004; published 29 November 2004)

We point out that the spectrum of pseudoscalar and scalar mesons exhibits a quasidegenerate chiral nonet in the energy region around 1.4 GeV whose scalar component has a slightly inverted spectrum. Based on the empirical linear rising of the mass of a hadron with the number of constituent quarks which yields a mass around 1.4 GeV for tetraquarks, we conjecture that this quasichiral nonet arises from the mixing of a chiral nonet composed of tetraquarks with conventional $\bar{q}q$ states. We explore this possibility in the framework of a chiral model assuming a tetraquark chiral nonet around 1.4 GeV with chiral symmetry realized directly. We stress that $U_A(1)$ transformations can distinguish $\bar{q}q$ from tetraquark states, although it cannot distinguish specific dynamics in the later case. We find that the measured spectrum is consistent with this picture. In general, pseudoscalar states arise as mainly $\bar{q}q$ states but scalar states turn out to be strong admixtures of $\bar{q}q$ and tetraquark states. We work out also the model predictions for the most relevant couplings and calculate explicitly the strong decays of the $a_0(1450)$ and $K_0^*(1430)$ mesons. [Phys. Rev. D. **70**, 094043 (2004)]

Heavy and light pentaquark effective chiral Lagrangian. Y.-R. Liu, A. Zhang, P.-Z. Huang, W.-Z. Deng, and X.-L. Chen, *Department of Physics, Peking University, Beijing 100871, China*. Shi-Lin Zhu, *Department of Physics, Peking University, Beijing 100871, China and COSPA, Department of Physics, National Taiwan University, Taipei 106, Taiwan, Republic of China*. (Received 15 April 2004; revised 13 September 2004; published 29 November 2004)

Using the SU(3) flavor symmetry, we construct the effective chiral Lagrangians for the light and heavy pentaquarks. With the correction from the nonzero current quark mass, we derive the Gell-Mann–Okubo type relations for various pentaquark multiplet masses. We also derive Coleman-Glashow relations for antisextet heavy pentaquark magnetic moments. We study possible decays of pentaquarks into conventional hadrons and interactions between and within various pentaquark multiplets and derive their coupling constants in the SU(3) flavor symmetry limit. Possible kinematically allowed pionic decay modes are pointed out. Finally we discuss the possible mixing between different pentaquark multiplets induced by the quark mass which breaks SU(3) symmetry. The pentaquark decay patterns receive correction from this breaking effect. [Phys. Rev. D. **70**, 094045 (2004)]

Finite temperature transition for 2-flavor lattice QCD at finite isospin density. J. B. Kogut¹ and D. K. Sinclair,² ¹*Dept. of Physics, University of Illinois, 1110 West Green Street, Urbana, Illinois 61801-3080, USA*. ²*HEP Division, Argonne National Laboratory, 9700 South Cass Avenue, Argonne, Illinois 60439, US*. (Received 23 July 2004; published 4 November 2004)

We simulate 2-flavor lattice QCD at finite isospin chemical potential μ_I , for temperatures close to the finite temperature transition from hadronic matter to a quark-gluon plasma. The μ_I dependence of the transition coupling is observed and used to estimate the decrease in the transition temperature with increasing μ_I . These simulations are performed on an $8^3 \times 4$ lattice at three different quark masses. Our estimate of the magnitude of the fluctuations of the phase of the fermion determinant at small quark-number chemical potential μ , suggest that the position of the small μ and small μ_I transitions should be the same for $\mu_I = 2\mu$, and we argue that the nature of these transitions should be the same. For all $\mu_I < m_\pi$ the smoothness of these transitions and the values of the Binder cumulant B_4 , indicate that these transitions are mere crossovers, and show no sign of a critical endpoint corresponding to that expected at finite μ . This suggests that this finite μ critical endpoint, if it exists, lies at $\mu > m_\pi/2$ over the considered range of quark masses. For $\mu_I > m_\pi$ and a small isospin (I_3) breaking term λ , we do find evidence of a critical endpoint which would indicate that, for $\lambda = 0$, there is a tricritical point on the phase boundary where the pion condensate evaporates, where this phase transition changes from second to first-order. [Phys. Rev. D. **70**, 094501 (2004)]

Neutrino mass in GUT constrained supersymmetry with R-parity violation in light of neutrino oscillations. Marek Gózdź and Wiesław A. Kamiński, *Department of Theoretical Physics, Maria Curie-Skłodowska University, Lublin, Poland*. Fedor Simkovic, *Department of Nuclear Physics, Comenius University, Bratislava, Slovakia*. (Received 5 August 2004; published 11 November 2004)

The neutrino masses are generated in grand unified theory (GUT) constrained supersymmetric model with R-parity violation. The neutrinos acquire masses via tree-level neutrino-neutralino mixing as well as via one-loop radiative corrections. The theoretical mass matrix is compared with the phenomenological one, which is reconstructed by using neutrino oscillation and neutrinoless double beta decay data. This procedure allows to obtain significantly stronger constraints on R-parity breaking parameters than those existing in the literature. The implication of normal and inverted neutrino mass hierarchy on the sneutrino expectation values, lepton-Higgs bilinear and trilinear R-parity breaking couplings is also discussed. [Phys. Rev. D. **70**, 095005 (2004)]

Quantization of exotic states in SU(3) soliton models: A solvable quantum mechanical analog. Aleksey Cherman, Thomas D. Cohen, and Abhinav Nellore, *Department of Physics, University of Maryland, College Park, Maryland 20742-4111, USA*. (Received 27 August 2004; published 11 November 2004)

The distinction between the rigid-rotor and Callan-Klebanov approaches to the quantization of SU(3) solitons is considered in the context of exotic baryons. A numerically tractable quantum mechanical analog system is introduced to test the reliability of the two quantization schemes. We find that in the equivalent of the large N_c limit of QCD, the Callan-Klebanov approach agrees with a numerical solution of the quantum mechanical analog. Rigid-rotor quantization generally does not. The implications for exotic baryons are briefly discussed. [Phys. Rev. D. **70**, 096003 (2004)]

$D_s^{*+}(2317)$ and $D_s^{*+}(2460)$: Tetraquarks bound by the 't Hooft instanton-induced interaction? V. Dmitrašinović, *Vinča Institute, lab 010, P.O. Box 522, 11001 Belgrade, Serbia*. (Received 28 January 2004; revised 10 August 2004; published 22 November 2004)

We calculate the influence of the 't Hooft interaction on the single-charm ($C=1$) tetraquark ($cq\bar{q}^2$) mass spectrum and find that three SU(3)-flavor multiplets ($\bar{\mathbf{3}}_A, \mathbf{6}, \mathbf{15}$) are significantly lowered, while the $\bar{\mathbf{3}}_S$ -plet is lifted, as compared with their unperturbed masses. States with the D_s^+ quantum numbers appear in two of the three lowered multiplets. The lower of the two states drops below both of the Okubo-Zweig-Iizuka (OZI)-allowed decay thresholds, thus being identified with $D_s^{*+}(2320)$, while the heavier state drops below the $\eta + D_s^+$ threshold, but stays above the $K + D$ one. A signature prediction of this theory is the lowering of the exotic tetraquark $\mathbf{6}$ -plet and $\mathbf{15}$ -plet: most of these states cannot consist of only one quark and one antiquark. As a test we suggest a search for two quasistable exotic tetraquarks with open-charm and strangeness: the (isotriplet) $cs\bar{q}\bar{q}$ and the (isodoublet) $cq\bar{s}\bar{s}$. [Phys. Rev. D. **70**, 096011 (2004)]

SU(3) Clebsch-Gordan coefficients for baryon-meson coupling at arbitrary N_c . 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, Arizona 85287-1504, USA.* (Received 2 September 2004; published 29 November 2004)

We present explicit formulas for the SU(3) Clebsch-Gordan coefficients that are relevant for the couplings of large N_c baryons to mesons. In particular, we compute the Clebsch-Gordan series for the coupling of the octet (associated with mesons, and remains the correct representation at large N_c) to the large N_c analogs of the baryon octet and decuplet representations. [Phys. Rev. D. **70**, 096015 (2004)]

Detector depth dependence of the high energy atmospheric neutrino flux. John M. LoSecco, *Physics Department, University of Notre Dame, Notre Dame, Indiana 46556 USA.* (Received 25 June 2004; published 15 November 2004)

We note that detector depth can influence the decay path length available for the primary and secondary particles that are the source of atmospheric neutrinos. As a consequence there is a location dependent modulation to the neutrino flux. [Phys. Rev. D. **70**, 097301 (2004)]

Comparative study of radio pulses from simulated hadron-, electron-, and neutrino-initiated showers in ice in the GeV-PeV range. Shahid Hussain and Douglas W. McKay, *Department of Physics & Astronomy, University of Kansas, Lawrence, Kansas 66045, USA.* (Received 2 July 2004; published 11 November 2004)

High energy particle showers produce coherent Cherenkov radio emission in dense, radio-transparent media such as cold ice. Using PYTHIA and GEANT simulation tools, we make a comparative study among electromagnetic (EM) and hadronic showers initiated by single particles and neutrino showers initiated by multiple particles produced at the neutrino-nucleon event vertex. We include all the physics processes and do a complete 3D simulation up to 100 TeV for all showers and to 1 PeV for electron- and neutrino-induced showers. We calculate the radio pulses for energies between 100 GeV and 1 PeV and find hadron showers, and consequently neutrino showers, are not as efficient below 1 PeV at producing radio pulses as the electromagnetic showers. The agreement improves as energy increases, however, and by a PeV and above the difference disappears. By looking at the 3D structure of the showers in time, we show that the hadronic showers are not as compact as the EM showers and hence the radiation is not as coherent as EM shower emission at the same frequency. We show that the ratio of emitted pulse strength to shower tracklength is a function only of a single, coherence parameter, independent of species and energy of initiating particle. [Phys. Rev. D. **70**, 103003 (2004)]

Quark-antiquark pair production in space-time dependent fields. Dennis D. Dietrich, *Laboratoire de Physique Théorique, Université Paris XI, Orsay, France.* (Received 2 February 2004; revised 4 October 2004; published 11 November 2004)

Fermion-antifermion pair production in the presence of classical fields is described based on the retarded and advanced fermion propagators. They are obtained by solving the equation of motion for the Dirac Green's functions with the respective boundary conditions to all orders in the field. Subsequently, various approximation schemes fit for different field configurations are explained. This includes longitudinally boost-invariant forms. Those occur frequently in the description of ultrarelativistic heavy-ion collisions in the semiclassical limit. As a next step, the gauge invariance of the expression for the expectation value of the number of produced fermion-antifermion pairs as a functional of said propagators is investigated in detail. Finally, the calculations are carried out for a longitudinally boost-invariant model field, especially taking care of the last issue. [Phys. Rev. D. **70**, 105009 (2004)]

Random walks of partons in $SU(N_c)$ and classical representations of color charges in QCD at small x . Sangyong Jeon, *Physics Department, McGill University, Montreal, QC H3A-2T8, Canada and RIKEN-BNL Research Center, Brookhaven National Laboratory, Upton, New York 11973, USA.* Raju Venugopalan, *Physics Department, Brookhaven National Laboratory, Upton, New York 11973, USA.* (Received 9 July 2004; published 12 November 2004)

The effective action for wee partons in large nuclei includes a sum over static color sources distributed in a wide range of representations of the $SU(N_c)$ color group. The problem can be formulated as a random walk of partons in the N_c-1 dimensional space of the Casimir operators of $SU(N_c)$. For a large number of sources, $k \gg 1$, we show explicitly that the most likely representation is a classical representation of order $O(\sqrt{k})$. The quantum sum over representations is well approximated by a path integral over classical sources with an exponential weight whose argument is the quadratic Casimir operator of the group. The contributions of the higher N_c-2 Casimir operators are suppressed by powers of k . Other applications of the techniques developed here are discussed briefly. [Phys. Rev. D. **70**, 105012 (2004)]

Non-Fermi-liquid specific heat of normal degenerate quark matter. A. Gerhold, A. Ipp, and A. Rebhan, *Institut für Theoretische Physik, Technische Universität Wien, Wiedner Hauptstrasse 8-10, A-1040 Vienna, Austria.* (Received 31 August 2004; published 16 November 2004)

We compute the low-temperature behavior of the specific heat of normal (non-color-superconducting) degenerate quark matter as well as that of an ultradegenerate electron gas. Long-range magnetic interactions lead to non-Fermi-liquid behavior with an anomalous leading $T \ln T^{-1}$ term. Depending on the thermodynamic potential used as a starting point, this effect appears as a consequence of the logarithmic singularity in the fermion self-energy at the Fermi surface or directly as a contribution from the only weakly screened quasistatic magnetic gauge bosons. We show that a calculation of Boyanovsky and de Vega claiming the absence of a leading $T \ln T^{-1}$

term missed it by omitting vector boson contributions to the internal energy. Using a formulation which collects all nonanalytic contributions in bosonic ring diagrams, we systematically calculate corrections beyond the well-known leading-log approximation. The higher-order terms of the low-temperature expansion turn out to also involve fractional powers $T^{(3+2n)/3}$ and we explicitly determine their coefficients up to and including order $T^{7/3}$ as well as the subsequent logarithmically enhanced term $T^3 \ln(c/T)$. We derive

also a hard-dense-loop resummed expression which contains the infinite series of anomalous terms to leading order in the coupling and which we evaluate numerically. At low temperatures, the resulting deviation of the specific heat from its value in naive perturbation theory is significant in the case of strongly coupled normal quark matter and thus of potential relevance for the cooling rates of (proto)neutron stars with a quark matter component. [Phys. Rev. D. **70**, 105015 (2004)]