Selected Abstracts from Other Physical Review Journals

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Hadronic decays involving heavy pentaquarks. Xiao-Gang He, *Department of Physics, Peking University, Beijing, China;* Xue-Qian Li, *Department of Physics, Nankai University, Tianjin, China.* (Received 29 March 2004; published 31 August 2004)

Recently several experiments have reported evidence for pentaquark Θ^+. H1 experiment at HERA-B has also reported evidence for Θ_c. Θ^+ is interpreted as a bound state of an $\bar{s}$ with four other light quarks *udud* which is a member of the antidecuplet of flavor $SU(3)_f$, while Θ_c is a heavy state obtained with the $\bar{s}$ in Θ^+ being replaced by a $\bar{c}$ which is a member of an antisixtet. A heavy pentaquark triplet can also be formed with a $\bar{c}$ and four light quarks. Similarly heavy pentaquark antisixtet and triplet can be formed with the $\bar{c}$ being replaced by a $\bar{b}$. We study decay processes involving at least one heavy pentaquark using $SU(3)_f$ and estimate the decay widths for some decay modes. We find several relations for heavy pentaquark decays into another heavy pentaquark and a $B(B^*)$ or a $D(D^*)$ which can be tested in the future. The B can also decay through weak interaction to charmed heavy pentaquarks. We also study some B decay modes with a heavy pentaquark in the final states. Experiments at B factories will provide important information about the heavy pentaquark properties. [Phys. Rev. D **70**, 034030 (2004)]

SN1987A and the properties of the neutrino burst. Maria Laura Costantini, *University of l'Aquila, L'Aquila, Italy and INFN;* Aldo Ianni and Francesco Vissani, *INFN, Laboratori Nazionali del Gran Sasso, Assergi (AQ), Italy.* (Received 16 April 2004; published 24 August 2004)

We reanalyze the neutrino events from SN1987A in IMB and Kamiokande-II (KII) detectors, and compare them with the expectations from simple theoretical models of the neutrino emission. In both detectors the angular distributions are peaked in the forward direction, and the average cosines are 2 sigma above the expected values. Furthermore, the average energy in KII is low if compared with the expectations; but, as we show, the assumption that a few (probably one) events at KII have been caused by elastic scattering is not in contrast with the ''standard'' picture of the collapse and yields more satisfactory distributions in angle and (marginally) in energy. The observations give useful information on the astrophysical parameters of the collapse. We find that the mean energy of electron antineutrinos is $\langle E\rangle = 12$–15 MeV, the total energy radiated around $(2-5)\times 10^{53}$ erg, and there is a hint for a relatively large radiation of nonelectronic neutrino species. These properties of the neutrino burst are not in disagreement with those suggested by the current theoretical paradigm, but the data leave wide space to nonstandard pictures, especially when neutrino oscillations are included. [Phys. Rev. D **70**, 043006 (2004)]

New calculation of the atmospheric neutrino flux in a three-dimensional scheme. M. Honda and T. Kajita, *Institute for Cosmic Ray Research, University of Tokyo, Kashiwa-no-Ha, Chiba 277-8582, Japan;* K. Kasahara, *Shibaura Institute of Technology, Fukasaku, Ohmiya, Saitama 330-8570, Japan;* S. Midorikawa, *Faculty of Engineering, Aomori University, Aomori 030-0943, Japan.* (Received 22 April 2004; published 26 August 2004)

We have revised the calculation of the flux of atmospheric neutrinos based on a three-dimensional scheme with the realistic IGRF geomagnetic model. The primary flux model has been revised, based on the AMS and BESS observations, and the interaction model updated to DPMJET-III. With a fast simulation code and computer system, the statistical errors in the Monte Carlo study are negligible. We estimate the total uncertainty of the atmospheric neutrino flux prediction is reduced to $\lesssim 10\,\%$ below 10 GeV. The ''three-dimensional effects'' are found to be almost the same as the study with the dipole magnetic field, but the muon-curvature effect remains up to a few tens of GeV for horizontal directions. The uncertainty of the absolute normalization of the atmospheric neutrino is still large, above 10 GeV, due to the uncertainty of the primary cosmic ray flux above 100 GeV. However, the zenith angle variation is not affected by these uncertainties. [Phys. Rev. D **70**, 043008 (2004)]

Hybrid stars with the color dielectric and the MIT bag models. C. Maieron, M. Baldo, G. F. Burgio, and H.-J. Schulze, *INFN, Sezione di Catania, Via Santa Sofia 64, 95123 Catania, Italy.* (Received 29 April 2004; published 27 August 2004)

We study the hadron-quark phase transition in the interior of neutron stars (NS). For the hadronic sector, we use a microscopic equation of state (EOS) involving nucleons and hyperons derived within the Brueckner-Bethe-Goldstone many-body theory, with realistic two-body and three-body forces. For the description of quark matter, we employ both the MIT bag model with a density dependent bag constant, and the color dielectric model. We calculate the structure of NS interiors with the EOS comprising both phases, and we find that the NS maximum masses are never larger than 1.6 solar masses, no matter the model chosen for describing the pure quark phase. [Phys. Rev. D **70**, 043010 (2004)]

MeV-mass dark matter and primordial nucleosynthesis. Pasquale D. Serpico and Georg G. Raffelt, *Max-Planck-Institut für Physik (Werner-Heisenberg-Institut), Föhringer Ring 6, 80805 München, Germany.* (Received 22 March 2004; published 20 August 2004)

The annihilation of new dark matter candidates with masses m_X in the MeV range may account for the galactic positrons that are

required to explain the 511 keV γ-ray flux from the galactic bulge. We study the impact of MeV-mass thermal relic particles on the primordial synthesis of ^{2}H, ^{4}He, and ^{7}Li. If the new particles are in thermal equilibrium with neutrinos during the nucleosynthesis epoch they increase the helium mass fraction for $m_X \lesssim 10$ MeV and are thus disfavored. If they couple primarily to the electromagnetic plasma they can have the opposite effect of lowering both helium and deuterium. For $m_X = 4-10$ MeV they can even improve the overall agreement between the predicted and observed ^{2}H and ^{4}He abundances. [Phys. Rev. D **70**, 043526 (2004)]

Chromomagnetic instability in dense quark matter. Mei Huang and Igor A. Shovkovy, *Institut für Theoretische Physik, J. W. Goethe-Universität, D-60054 Frankurt am Main, Germany.* (Received: 5 July 2004; published 20 September 2004)

The results for the Debye and Meissner screening masses of the gluons and the photon in the case of neutral and β-equilibrated dense two-flavor quark matter are presented. In the limits of the normal phase and the ideal two-flavor color superconducting phase, the screening masses coincide with the known results. Most interestingly, we find that the Meissner screening masses squared can be *negative*, indicating a plasma-type chromomagnetic instability in dense quark matter. [Phys. Rev. D **70**, 051501 (2004)]

Effective gap equation for the inhomogeneous Larkin-Ovchinnikov-Fulde-Ferrel superconductive phase. R. Casalbuoni, *Department of Physics, University of Florence, and INFN-Florence, Italy.* M. Ciminale, M. Mannarelli, G. Nardulli and M. Ruggieri, *Department of Physics, University of Bari and INFN-Bari, Italy.* R. Gatto. *Department of Physics, University of Geneva, Switzerland.* (Received: 13 April 2004; published 3 September 2004.

We present an approximate gap equation for different crystalline structures of the Larkin-Ovchinnikov-Fulde-Ferrel phase of high density QCD at $T=0$. This equation is derived by using an effective condensate term obtained by averaging the inhomogeneous condensate over distances of the order of the crystal lattice size. The approximation is expected to work better far off any second-order phase transition. As a function of the difference of the chemical potentials of the up and down quarks, $\delta\mu$, we get that the octahedron is energetically favored from $\delta\mu = \Delta_0/\sqrt{2}$ to $0.95\Delta_0$, where Δ_0 is the gap for the homogeneous phase, while in the range $0.95\Delta_0 - 1.32\Delta_0$ the face-centered cube prevails. At $\delta\mu = 1.32\Delta_0$ a first-order phase transition to the normal phase occurs. [Phys. Rev. D **70**, 054004 (2004)]

Non-Fermi liquid effects in QCD at high density. Thomas Schäfer[1,2] and Kai Schwenzer[1], [1]*Department of Physics, North Carolina State University, Raleigh, North Carolina 27695, USA. Riken-BNL Research Center, Brookhaven National Laboratory, Upton, New York 11973, USA.* (Received 12 May 2004; published 7 September 2004)

We study non-Fermi liquid effects due to the exchange of unscreened magnetic gluons in the normal phase of high density QCD by using an effective field theory. A one-loop calculation gives the well-known result that magnetic gluons lead to a logarithmic enhancement in the fermion self-energy near the Fermi surface. The self-energy is of the form $\Sigma(\omega) \sim \omega\gamma\log(\omega)$, where ω is the energy of the fermion, $\gamma = O(g^2)$, and g is the coupling constant. Using an analysis of the Dyson-Schwinger equations we show that, in the weak coupling limit, this result is not modified by higher order corrections even in the regime where the logarithm is large, $\gamma\log(\omega) \sim 1$. We also show that this result is consistent with the renormalization group equation in the high density effective field theory. [Phys. Rev. D **70**, 054007 (2004)]

Thermodynamics of two-color QCD and the Nambu Jona-Lasinio model. Claudia Ratti[1] and Wolfram Weise,[1,2] [1]*Physik-Department, Theoretische Physik, Technische Universität München, D-85747 Garching, Germany.* [2]*ECT, Villa Tambosi, I-38050 Villazzano (Trento), Italy.* (Received: 18 June 2004; published 20 September 2004)

We investigate two-flavor and two-color QCD at finite temperature and chemical potential in comparison with a corresponding Nambu and Jona-Lasinio model. By minimizing the thermodynamic potential of the system, we confirm that a second-order phase transition occurs at a value of the chemical potential equal to half the mass of the chiral Goldstone mode. For chemical potentials beyond this value the scalar diquarks undergo Bose condensation and the diquark condensate is nonzero. We evaluate the behavior of the chiral condensate, the diquark condensate, the baryon charge density and the masses of scalar diquark, antidiquark and pion, as functions of the chemical potential. Very good agreement is found with lattice QCD ($N_c = 2$) results. We also compare with a model based on leading-order chiral effective field theory. [Phys. Rev. D **70**, 054013 (2004)]

Free energy of a static quark-antiquark pair and the renormalized Polyakov loop in three flavor QCD. P. Petreczky and K. Petrov, *Physics Department, Brookhaven National Laboratory, Upton, New York 11973, USA.* (Received: 14 May 2004; published 14 September 2004)

We study the free energy of a static quark-antiquark ($Q\overline{Q}$) pair at finite temperature in three flavor QCD with degenerate quark masses using $N_\tau = 4$ and 6 lattices with Asqtad staggered fermion action. The static free energy was calculated for different values of the quark mass and the entropy contribution at large distances has been extracted. We also calculate the renormalized Polyakov loop following the approach by Kaczmarek *et al.* [Phys. Rev. D **70**, 054503 (2004)]

Dynamics of phase transitions: The 3D 3-state Potts model. Bernd A. Berg, Hildegard Meyer-Ortmanns and Alexander Velytsky, *Department of Physics, Florida State University, Tallahassee, Florida 32306, USA. School of Computational Science, Florida State University, Tallahassee, Florida 32306, USA. School of Engineering and Science, International University Bremen, P.O. Box 750561, D-28725 Bremen, Germany.* (Received: 16 May 2004; published 15 September 2004)

In studies of the QCD deconfining phase transition or crossover by means of heavy ion experiments, one ought to be concerned about nonequilibrium effects due to heating and cooling of the system. In this paper we extend our previous study of Glauber dynamics of 2D Potts models to the 3D 3-state Potts model, which serves as an effective model for some QCD properties. We investigate the linear theory of spinodal decomposition in some detail. It describes the early time evolution of the 3D model under a quench from the disordered into the ordered phase well, but fails in 2D. Further, the quench leads to competing vacuum domains, which are difficult to equilibrate, even in the presence of a small external magnetic field. From our hysteresis study we find, as before, a dynamics dominated by spinodal decomposition. There is evidence that some effects survive in the case of a crossover. But the infinite volume extrapolation is difficult to control, even with lattices as large as 120^3. [Phys. Rev. D **70**, 054505 (2004)]

Toward a theory of binary bound states in the quark-gluon plasma. Edward V. Shuryak, Ismail Zahed, *Department of Physics and Astronomy, State University of New York, Stony Brook, New York 11794-3800, USA.* (Received: 20 April 2004; published 16 September 2004).

Although at asymptotically high temperatures the quark-gluon plasma (QGP) is a gas of weakly interacting quasiparticles (modulo long-range magnetism), and it has quite different properties at temperatures of the order of a few times the critical temperature $T=(1-3)T_c$. As experiments and lattice simulations are now showing, in this region the QGP displays strong interactions between the constituents. In this paper we try to develop a theory of one of its consequences, namely, the properties of a large number of binary bound states, both hadronlike (colorless) and exotic (colored) bound pairs gq, qq, and gg. We evaluate their binding energies and zero-binding lines on the phase diagram and estimate their contribution to bulk thermodynamics (pressure). Their role in the transport properties (viscosity), emphasized in our previous paper, will be addressed elsewhere. [Phys. Rev. D **70**, 054507 (2004)]

Effective Lagrangian approach to nuclear μ^--e^- conversion and the role of vector mesons. Amand Faessler, Th. Gutsche, Sergey Kovalenko, V. E. Lyubovitskij, Ivan Schmidt and F. Šimkovi, *Institut für Theoretische Physik, Universität Tübingen, Auf der Morgenstelle 14, D-72076 Tübingen, Germany. Departamento de Física, Universidad Técnica Federico Santa María, Casilla 110-V, Valparaíso, Chile.* (Received: 19 May 2004; published 17 September 2004).

We study nuclear μ^--e^- conversion in the general framework of an effective Lagrangian approach without referring to any specific realization of the physics beyond the standard model (SM) responsible for lepton flavor violation ($Ł_f$). We examine the impact of a specific hadronization prescription on the analysis of new physics in nuclear μ^--e^- conversion and stress the importance of vector meson exchange between lepton and nucleon currents. A new issue of this mechanism is the presence of the strange quark vector current contribution induced by the ϕ meson. This allows us to extract new limits on the $Ł_f$ lepton-quark effective couplings from the existing experimental data. [Phys. Rev. D **70**, 055008 (2004)]

Dynamic universality class of the QCD critical point. D. T. Son and M. A. Stephanov, *Institute for Nuclear Theory, University of Washington, Seattle, Washington 98195-1550, USA. Department of Physics, University of Illinois, Chicago, Illinois 60607-7059, USA. RIKEN-BNL Research Center, Brookhaven National Laboratory, Upton, New York 11973, USA.* (Received: 4 February 2004; published 1 September 2004).

We show that the dynamic universality class of the QCD critical point is that of model H and discuss the dynamic critical exponents. We show that the baryon diffusion rate vanishes at the critical point. The dynamic critical index z is close to 3. [Phys. Rev. D **70**, 056001 (2004)]

Pseudogap of color superconductivity in heated quark matter. M. Kitazawa, T. Koide, T. Kunihiro and Y. Nemoto, *Department of Physics, Kyoto University, Kyoto 606-8502, Japan. Yukawa Institute for Theoretical Physics, Kyoto University, Kyoto 606-8502, Japan. RIKEN BNL Research Center, BNL, Upton, New York 11973, USA.* (Received: 3 September 2003; published 14 September 2004).

We show that the pseudogap of the quark density of states is formed in hot quark matter as a precursory phenomenon of the color superconductivity on the basis of a low-energy effective theory. We clarify that the decaying process of quarks near Fermi surface to a hole and the diquark soft mode $(\mathrm{qq})_{\mathrm{soft}}$ is responsible for the formation of the pseudogap. Our result suggests that the pseudogap is a universal phenomenon in strong coupling superconductors. [Phys. Rev. D **70**, 056003 (2004)]

Pion-nucleon scattering relations at next-to-leading order in $1/N_c$. Thomas D. Cohen, Daniel C. Dakin and Abhinav Nellore, *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: 15 March 2004; published 16 September 2004).

We obtain relations between partial-wave amplitudes for $\pi N \to \pi N$ and $\pi N \to \pi \Delta$ directly from large N_c QCD. While linear relations among certain amplitudes holding at leading order (LO) in $1/N_c$ were derived in the context of chiral soliton models two decades ago, the present work employs a fully model-independent framework based on consistency with the large N_c expansion. At LO in $1/N_c$ we reproduce the soliton model results; however, this

method allows for systematic corrections. At next-to-leading order (NLO), most relations require additional unknown functions beyond those appearing at LO and thus have little additional predictive power. However, three NLO relations for the $\pi N \to \pi\Delta$ reaction are independent of unknown functions and make predictions accurate at this order. The amplitudes relevant to two of these relations were previously extracted from experiment. These relations describe experiment dramatically better than their LO counterparts. [Phys. Rev. D **70**, 056004 (2004)]