Selected Abstracts from Other Physical Review Journals

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Experimental limits on the existence of strongly interacting massive particles bound to gold nuclei. D. Javorsek II,[1] D. Elmore,[1] E. Fischbach,[1] T. Miller,[1] D. Oliver,[2] and V. Teplitz,[3] [1]*Department of Physics, Purdue University, West Lafayette, Indiana 47907,* [2]*Department of Geological Sciences, Southern Methodist University, Dallas, Texas 75275,* [3]*Department of Physics, Southern Methodist University, Dallas, Texas 75275.* (Received 19 December 2000; published 8 June 2001)

We report the results from an experimental search for strongly interacting massive particles bound to gold nuclei. A scan for heavy gold isotopes with masses ranging from 186.3 to 325.9 GeV/c^2 was performed on laboratory gold and gold from western Australia using PRIME Lab, the Purdue Accelerator Mass Spectrometer facility. The results provide significant new constraints on current models which predict the existence of such particles with abundance ratios in the range 10^{-11}–10^{-10}. [Phys. Rev. D **64**, 012005 (2001)]

BCS versus Overhauser pairing in dense (2+1)-dimensional QCD. Prashanth Jaikumar and Ismail Zahed, *Department of Physics & Astronomy, SUNY at Stony Brook, New York 11794-3800.* (Received 21 March 2001; published 8 June 2001)

We compare the BCS and Overhauser effect as competing mechanisms for the destabilization of the quark Fermi surface at an asymptotically large chemical potential, for the special case of 2 space and 1 time dimensions. We use the framework of perturbative one-gluon exchange, which dominates the pairing at $\mu/g^2 \gg 1$. With screening in matter, we show that in the weak coupling limit the Overhauser effect can compete with the BCS effect only for a sufficiently large number of colors. Both the BCS and the Overhauser gaps are of order g^4/μ in the Landau gauge. [Phys. Rev. D **64**, 014035 (2001)]

Chromomagnetic catalysis of color superconductivity in a (2+1)-dimensional Nambu–Jona-Lasinio model. D. Ebert, *Research Center for Nuclear Physics, Osaka University, Ibaraki, Osaka 567, Japanand Institut für Physik, Humboldt-Universität zu Berlin, D-10115 Berlin, Germany;* K. G. Klimenko, *Institute for High Energy Physics, 142284 Protvino, Moscow Region, Russia;* H. Toki, *Research Center for Nuclear Physics, Osaka University, Ibaraki, Osaka 567, Japan.* (Received 24 November 2000; published 13 June 2001)

We investigate the influence of a constant uniform external chromomagnetic field H on the formation of color superconductivity. The consideration is made in the framework of a $(2+1)$-dimensional Nambu–Jona-Lasinio model with two different four-fermionic structures responsible for $\langle \bar{q}q \rangle$ and diquark $\langle qq \rangle$ condensates. In particular, it is shown that there exists a critical value H_c of the external chromomagnetic field such that at $H > H_c$ a nonvanishing diquark condensate is dynamically created (the so-called chromomagnetic catalysis effect of color superconductivity). Moreover, external chromomagnetic fields may in some cases enhance the diquark condensate of color superconductivity. [Phys. Rev. D **64**, 014038 (2001)]

Decays of the $\pi^+\pi^-$ atom. J. Gasser, *Institute for Theoretical Physics, University of Bern, Sidlerstrasse 5, CH-3012, Bern, Switzerland;* V. E. Lyubovitskij, *Institute of Theoretical Physics, University of Tübingen, Auf der Morgenstelle 14, D-72076 Tübingen, Germany and Department of Physics, Tomsk State University, 634050 Tomsk, Russia;* A. Rusetsky, *Institute for Theoretical Physics, University of Bern, Sidlerstrasse 5, CH-3012, Bern, Switzerland and HEPI, Tbilisi State University, University St. 9, 380086 Tbilisi, Georgia;* A. Gall, *SWITCH, Limmatquai 138, CH-8001, Zürich, Switzerland.* (Received 15 March 2001; published 7 June 2001)

We construct an effective non-relativistic quantum field theory that describes bound states of $\pi^+\pi^-$ pairs and their hadronic decays. We then derive a general expression for the lifetime of the ground state at next-to-leading order in isospin breaking. Chiral perturbation theory allows one to relate the decay rate to the two S-wave $\pi\pi$ scattering lengths and to several low-energy constants that occur in the chiral Lagrangian. Recent predictions for the scattering lengths give $\tau = (2.9 \pm 0.1) \times 10^{-15}$ s. This result may be confronted with $\pi^+\pi^-$ lifetime measurements, like the one presently carried out at CERN. [Phys. Rev. D **64**, 016008 (2001)]

Nearly bimaximal neutrino mixing, muon $g-2$ anomaly, and lepton-flavor-violating processes. Zhi-zhong Xing, *CCAST (World Laboratory), P.O. Box 8730, Beijing 100080, China and Institute of High Energy Physics, P.O. Box 918, Beijing 100039, China.* (Received 24 February 2001; published 8 June 2001)

We interpret the newly observed muon $g-2$ anomaly in the framework of a leptonic Higgs doublet model with nearly degenerate neutrino masses and nearly bimaximal neutrino mixing. Useful constraints are obtained on the rates of lepton-flavor-violating rare decays $\tau \to \mu\gamma$, $\mu \to e\gamma$ and $\tau \to e\gamma$ as well as the μ-e conversion ratio $R_{\mu e}$. We find that $\Gamma(\mu \to e\gamma)$, $\Gamma(\tau \to e\gamma)$ and $R_{\mu e}$ depend crucially on possible nonzero but small values of the neutrino mixing matrix element V_{e3}, and they are also sensitive to the Dirac-type CP-violating phase. In particular, we show that $\Gamma(\tau \to \mu\gamma)/m_\tau^5$, $\Gamma(\mu \to e\gamma)/m_\mu^5$ and $\Gamma(\tau \to e\gamma)/m_\tau^5$ are approximately in the ratio $1{:}2|V_{e3}|^2{:}2|V_{e3}|^2$ if $|V_{e3}|$ is much larger than $\mathcal{O}(10^{-2})$, and in the ratio $2(\Delta m^2_{\rm atm})^2{:}(\Delta m^2_{\rm sun})^2{:}(\Delta m^2_{\rm sun})^2$ if $|V_{e3}|$ is much lower than $\mathcal{O}(10^{-3})$, where $\Delta m^2_{\rm atm}$ and $\Delta m^2_{\rm sun}$ are the corresponding mass-squared differences of atmospheric and solar neutrino oscillations. [Phys. Rev. D **64**, 017304 (2001)]

High energy astrophysical neutrinos: The upper bound is robust. John Bahcall, *Institute for Advanced Study, Princeton, New Jersey 08540;* Eli Waxman, *Department of Condensed-Matter Physics, Weizmann Institute of Science, Rehovot 76100, Israel.* (Received 18 February 1999; revised manuscript received 4 December 2000; published 26 June 2001)

We elucidate the physical basis for the upper bound on high energy neutrino fluxes implied by the observed cosmic ray flux. We stress that the bound is valid for neutrinos produced either by p,γ reactions or by $p-p(n)$ reactions in sources which are optically thin for high energy protons to photo-meson and nucleon-meson interactions. We show that the upper bound is robust and conservative. The Waxman-Bahcall bound overestimates the most likely neutrino flux by a factor $\sim 5/\tau$, for small optical depths τ. The upper limit cannot be plausibly evaded by invoking magnetic fields, optically thick active galactic nuclei (AGNs), or large hidden fluxes of extragalactic protons. We describe the implications of the bound for future experiments including the AMANDA, ANTARES, Auger, ICECUBE, NESTOR, and OWL/AIRWATCH detectors. [Phys. Rev. D **64**, 023002 (2001)]

Color superconductivity and nondecoupling phenomena in (2+1)-dimensional QCD. V. A. Miransky, *Department of Applied Mathematics, University of Western Ontario, London, Ontario, Canada N6A 5B7;* G. W. Semenoff, *Department of Physics and Astronomy, University of British Columbia, 6224 Agricultural Road, Vancouver, British Columbia, Canada V6T 1Z1;* I. A. Shovkovy, *School of Physics and Astronomy, University of Minnesota, Minneapolis, Minnesota 55455;* L. C. R. Wijewardhana, *Physics Department, University of Cincinnati, Cincinnati, Ohio 45221-0011.* (Received 21 March 2001; published 6 June 2001)

The possibility of generating a color superconducting state in $(2+1)$-dimensional QCD is analyzed. The gap equation in the leading, hard-dense loop improved, one-gluon exchange approximation is derived and solved. The magnitude of the order parameter is proportional to a power of the coupling constant. For an asymptotically large chemical potential, a qualitatively new [with respect to the $(3+1)$-dimensional case] phenomenon of nondecoupling of the fermion pairing dynamics from the infrared one is revealed and discussed. [Phys. Rev. D **64**, 025005 (2001)]

***CP* violation effects and high energy neutrinos.** Paolo Lipari, *Dipartimento di Fisica, Universitàa di Roma "La Sapienza" and INFN, Sezione di Roma, P. A. Moro 2, I-00185 Roma, Italy.* (Received 5 February 2001; published 29 June 2001)

This work discusses critically the prospects of measuring CP and T violation effects in high-energy neutrino factories. For this purpose we develop, in the standard framework with three neutrino flavors, simple expressions for the oscillation probabilities in matter that are valid for high E_ν. All CP violating effects vanish $\propto E_\nu^{-3}$ and are very difficult to detect with high-energy neutrinos. A significantly easier task is the determination of the absolute value $|\delta|$ of the phase in the ν mixing matrix that controls the CP and T violation effects, performing precision measurements of the CP and T conserving part of the oscillation probabilities. [Phys. Rev. D **64**, 033002 (2001)]

Predictions for neutrino structure functions. S. Kretzer, *Institut für Physik, Universität Dortmund, Dept. of Physics, D-44227 Dortmund, Germany and Department of Physics and Astronomy, Michigan State University, East Lansing, Michigan 48824-1116;* F. I. Olness and R. J. Scalise, *Department of Physics, Southern Methodist University, Dallas, Texas 75275-0175;* R. S. Thorne, *Cavendish Laboratory, University of Cambridge, Madingley Road, Cambridge, CB3 0HE, United Kingdom;* U. K. Yang, *University of Chicago, Enrico Fermi Institute, Chicago, Illinois 60637-1434 and University of Rochester, Rochester, New York 14627.* (Received 19 January 2001; published 3 July 2001)

The first measurements of ΔxF_3 are higher than current theoretical predictions. We investigate the sensitivity of these theoretical predictions upon a variety of factors including the renormalization scheme and scale, quark mass effects, higher twist, isospin violation, and PDF uncertainties. [Phys. Rev. D **64**, 033003 (2001)]

Sum rules of neutrino masses and *CP* violation in the four-neutrino mixing scheme. Zhi-zhong Xing, *CCAST (World Laboratory), P.O. Box 8730, Beijing 100080, China and Institute of High Energy Physics, P.O. Box 918, Beijing 100039, China.* (Received 2 February 2001; published 10 July 2001)

We show that the commutator of lepton mass matrices is invariant under terrestrial matter effects in the four-neutrino mixing scheme. A set of model-independent sum rules for neutrino masses, which may be generalized to hold for an arbitrary number of neutrino families, is for the first time uncovered. Useful sum rules for the rephasing-invariant measures of leptonic CP violation have also been found. Finally we present a generic formula of T-violating asymmetries and expect it to be applicable to the future long-baseline neutrino oscillation experiments. [Phys. Rev. D **64**, 033005 (2001)]

Determination of nuclear parton distributions. M. Hirai and S. Kumano, *Department of Physics, Saga University, Saga, 840-8502, Japan;* M. Miyama, *Department of Physics, Tokyo Metropolitan University, Tokyo, 192-0397, Japan.* (Received 20 March 2001; published 19 June 2001)

Parametrization of nuclear parton distributions is investigated in the leading order of α_s. The parton distributions are provided at $Q^2=1$ GeV^2 with a number of parameters, which are determined by a χ^2 analysis of the data on nuclear structure functions. A quadratic or cubic functional form is assumed for the initial distributions. Although valence quark distributions in the medium x region are relatively well determined, the small x distributions depend slightly on the assumed functional form. It is difficult to determine the antiquark distributions at medium x and gluon distributions. From the analysis, we propose parton distributions at $Q^2=1$ GeV^2 for nuclei from deuteron to heavy ones with a mass number $A\sim 208$. They are provided either analytical expressions or computer subroutines for practical usage. Our studies should be important for understanding the physics mechanism of the nuclear modification and also for applications to heavy-ion reactions. This kind of nuclear parametrization should also affect existing parametrization studies in the nucleon because ''nuclear'' data are partially used for obtaining the optimum distributions in the ''nucleon.'' [Phys. Rev. D **64**, 034003 (2001)]

Polarized proton-nucleus scattering. B. Z. Kopeliovich, *Max-Planck Institut für Kernphysik, Postfach 103980, 69029 Heidelberg, Germany and Joint Institute for Nuclear Research, Dubna, 141980 Moscow Region, Russia;* T. L. Trueman, *Brookhaven National Laboratory, Upton, New York 11973.* (Received 11 December 2000; published 29 June 2001)

We show that, to a very good approximation, the ratio of the spin-flip to the non-flip parts of the elastic proton-nucleus amplitude is the same as for proton-nucleon scattering at very high energy. The result is used to do a realistic calculation of the analyzing power A_N for pC scattering in the Coulomb-nuclear interference region of momentum transfer. [Phys. Rev. D **64**, 034004 (2001)]

QCD at small nonzero quark chemical potentials. J. B. Kogut and D. Toublan, *Loomis Laboratory of Physics, University of Illinois, Urbana-Champaign, Illinois 61801.* (Received 25 March 2001; published 2 July 2001)

We study the effects of small chemical potentials associated with the three light quark flavors in QCD. We use a low-energy effective field theory that solely relies on the symmetries of the QCD partition function. We find three different phases: a normal phase, a pion superfluid phase and a kaon superfluid phase. The two superfluid phases are separated by a first order phase transition, whereas the normal phase and either of the superfluid phases are separated by a second order phase transition. We compute the quark-antiquark condensate, the pion condensate and the kaon condensate in each phase, as well as the isospin density, the strangeness density, and the mass spectrum. [Phys. Rev. D **64**, 034007 (2001)]

Instanton-induced inelastic collisions in QCD. Maciek A. Nowak, *M. Smoluchowski Institute of Physics, Jagellonian University, Cracow, Poland and Department of Physics and Astronomy, State University of New York, Stony Brook, New York 11794;* Edward V. Shuryak and Ismail Zahed, *Department of Physics and Astronomy, State University of New York, Stony Brook, New York 11794.* (Received 24 January 2001; published 3 July 2001)

We show that the instanton-induced inelastic processes, leading to multigluon production in high-energy parton-parton scattering, are considerably enhanced (by a factor of 100) over the quasielastic ones. The basic instanton-induced inelastic contribution causes the parton-parton cross section to increase as $\ln s$, due to prompt production of multigluon clusters of mass 2–3 GeV close to QCD sphalerons. The cross section is related to the Pomeron slope and intercept in the usual parametrization, which are evaluated. We show that the small intercept is due to the diluteness of the instantons in the QCD vacuum, while the small size of the Pomeron (seen via its slope) is related to the smallness of the instanton sizes. [Phys. Rev. D **64**, 034008 (2001)]

Transversity distributions in the nucleon in the large-N_c limit. P. Schweitzer,[1] D. Urbano,[2] M. V. Polyakov,[1,3] C. Weiss,[4] P. V. Pobylitsa,[1,3] and K. Goeke,[1] [1]*Institut für Theoretische Physik II, Ruhr-Universität Bochum, D-44780 Bochum, Germany,* [2]*Faculdade de Engenharia da Universidade do Porto, 4000 Porto, Portugal,* [3]*Petersburg Nuclear Physics Institute, Gatchina, St. Petersburg 188350, Russia,* [4]*Institut für Theoretische Physik, Universität Regensburg, D-93053 Regensburg, Germany.* (Received 20 March 2001; published 5 July 2001)

We compute the quark and antiquark transversity distributions in the nucleon at a low normalization point ($\mu \approx 600$ MeV) in the large-N_c limit, where the nucleon can be described as a soliton of an effective chiral theory (chiral quark-soliton model). The flavor-nonsinglet distributions $\delta u(x) - \delta d(x)$ and $\delta\overline{u}(x) - \delta\overline{d}(x)$ appear in leading order of the $1/N_c$ expansion, while the flavor-singlet distributions $\delta u(x) + \delta d(x)$ and $\delta\overline{u}(x) + \delta\overline{d}(x)$ are nonzero only in next-to-leading order. The transversity quark and antiquark distributions are found to be significantly different from the longitudinally polarized distributions $\Delta u(x) \pm \Delta d(x)$ and $\Delta\overline{u}(x) \pm \Delta\overline{d}(x)$, respectively, in contrast with the prediction of the naive nonrelativistic quark model. We show that this affects the predictions for the spin asymmetries in Drell-Yan pair production in transversely polarized pp and $p\overline{p}$ collisions. [Phys. Rev. D **64**, 034013 (2001)]

Incorporating next-to-leading order matrix elements for hadronic diboson productionin showering event generators. Matt Dobbs, *Department of Physics and Astronomy, University of Victoria, P.O. Box 3055, Victoria, British Columbia, Canada V8W 3P6.* (Received 25 April 2001; published 6 July 2001)

A method for incorporating information from next-to-leading order QCD matrix elements for hadronic diboson production into showering event generators is presented. In the hard central region (high jet transverse momentum) where perturbative QCD is reliable, events are sampled according to the first-order tree level matrix element. In the soft and collinear regions next-to-leading order corrections are approximated by calculating the differential cross section across the phase space accessible to the parton shower using the first-order (virtual graphs included) matrix element. The parton shower then provides an all-orders exclusive description of parton emissions. Events generated in this way provide a physical result across the entire jet transverse momentum spectrum, have next-to-leading order normalization everywhere, and have positive definite event weights. The method is generalizable without modification to any color singlet production process. [Phys. Rev. D **64**, 034016 (2001)]

Relativistic unitary description of $\pi\pi$ scattering. M. A. Pichowsky, A. Szczepaniak, and J. T. Londergan, *Department of Physics and Nuclear Theory Center, Indiana University, Bloomington, Indiana 47405.* (Received 18 January 2001; published 11 July 2001)

A unitary framework based on the Bakamjian-Thomas construction of relativistic quantum mechanics is used to describe two-pion scattering from threshold to 1400 MeV. The framework properly includes unitarity cuts for one-, two- and three-hadron states and provides an excellent description of the available data for $\pi\pi$ phase shifts and inelasticities. The role and importance of three-hadron cuts are calculated and discussed. [Phys. Rev. D **64**, 036009 (2001)]

Multi-Skyrmion solutions for the sixth order Skyrme model. I. Floratos and B. Piette, *Department of Mathematical Sciences, University of Durham, Durham DH1 3LE, United Kingdom.* (Received 2 April 2001; published 23 July 2001)

Following Marleau, we study an extended version of the Skyrme model to which a sixth order term has been added to the Lagrangian and we analyze some of its classical properties. We compute the multi-Skyrmion solutions numerically for up to $B=5$ and show that they have the same symmetries as the usual Skyrmion solutions. We use the rational map ansatz introduced by Houghton, Manton, and Sutcliffe to evaluate the energy and the radius for multi-Skyrmion solutions of up to $B=6$ for both the $SU(2)$ and $SU(3)$ models and compare these results to the ones obtained numerically. We show that the rational map ansatz works as well for the generalized model as for the pure Skyrme model. [Phys. Rev. D **64**, 045009 (2001)]

Reviving the energy independent suppression of the solar neutrino flux. Sandhya Choubey,[1] Srubabati Goswami,[1] Nayantara Gupta,[2] and D. P. Roy,[3] [1]*Saha Institute of Nuclear Physics, 1/AF, Bidhannagar, Calcutta 700 064, India,* [2]*Indian Association for the Cultivation of Sciences, Calcutta 700 032, India,* [3]*Tata Institute of Fundamental Research, Homi Bhabha Road, Mumbai 400 005, India.* (Received 12 April 2001; published 19 July 2001)

We explore the possibility of an energy independent suppression of the solar neutrino flux in the context of the recent SuperKamiokande data. From a global analysis of the rate and spectrum data, this scenario is allowed at only 14% probability with the observed Cl rate. If we allow for a 20% upward renormalization of the Cl rate along with a downward renormalization of the *B* neutrino flux then the fit improves considerably to a probability of $\sim 50\%$. We compare the quality of these fits with those of the MSW solutions. These renormalizations are also found to improve the quality of the fits with MSW solutions and enlarge the allowed region of their validity in the parameter space substantially. Over much of this enlarged region the matter effects on the suppression of the solar neutrino flux are found to be very weak, so that the solutions become practically energy independent. [Phys. Rev. D **64**, 053002 (2001)]

Analytic approximations for three neutrino oscillation parameters and probabilities in matter. Martin Freund, *Theoretische Physik, Physik Department, Technische Universität München, James-Franck-Strasse, 85748 Garching, Germany.* (Received 29 March 2001; published 19 July 2001)

The corrections to neutrino mixing parameters in the presence of matter of constant density are calculated systematically as series expansions in terms of the mass hierarchy $\Delta m^2_{21}/\Delta m^2_{31}$. The parameter mapping obtained is then used to find simple, but nevertheless accurate formulas for oscillation probabilities in matter including CP effects. Expressions with one to one correspondence to the vacuum case are derived, which are valid for neutrino energies above the solar resonance energy. Two applications are given to show that these results are a useful and powerful tool for analytical studies of neutrino beams passing through the Earth mantle or core: First, the ''disentanglement problem'' of matter and CP effects in CP asymmetry is discussed and second, estimations of the statistical sensitivity to the CP terms of the oscillation probabilities in neutrino factory experiments are presented. [Phys. Rev. D **64**, 053003 (2001)]

Low-scale seesaw mechanisms for light neutrinos. Francesca Borzumati, *Theory Group, KEK, Tsukuba, Ibaraki 305-0801, Japan and Scuola Internazionale Superiore di Studi Avanzati (SISSA), I–34013 Trieste, Italy;* Yasunori Nomura, *Department of Physics, University of Tokyo, Tokyo 113-0033, Japan.* (Received 12 September 2000; published 25 July 2001)

Alternatives to the seesaw mechanism are explored in supersymmetric models with three right-handed or sterile neutrinos. Tree-level Yukawa couplings can be drastically suppressed in a natural way to give sub-eV Dirac neutrino masses. If, in addition, a $B-L$ gauge symmetry broken at a large scale M_G is introduced, a wider range of possibilities opens up. The value of the right-handed neutrino mass M_R can be easily disentangled from that of M_G. Dirac and Majorana neutrino masses at the eV scale can be generated radiatively through the exchange of sneutrinos and neutralinos. Dirac masses m_D owe their smallness to the pattern of light-heavy scales in the neutralino mass matrix. The smallness of the Majorana masses m_L is linked to a similar seesaw pattern in the sneutrino mass matrix. Two distinct scenarios emerge. In the first, with very small or vanishing M_R, the physical neutrino eigenstates are, for each generation, either two light Majorana states with a mixing angle ranging from very small to maximal, depending on the ratio m_D/M_R, or one light Dirac state. In the second scenario, with a large value of M_R, the physical eigenstates are two nearly unmixed Majorana states with masses $\sim m_L$ and $\sim M_R$. In both cases, the $(B-L)$-breaking scale M_G is, in general, much smaller than that in the traditional seesaw mechanism. [Phys. Rev. D **64**, 053005 (2001)]