

## Selected Abstracts from Other Physical Review Journals

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**Precision spectroscopy with reactor antineutrinos.** Patrick Huber and Thomas Schwetz, *Physik-Department, Technische Universität München, James-Frank-Strasse, D-85748 Garching, Germany.* (Received 19 July 2004; published 17 September 2004)

In this work we present an accurate parameterization of the antineutrino flux produced by the isotopes  $^{235}\text{U}$ ,  $^{239}\text{Pu}$ , and  $^{241}\text{Pu}$  in nuclear reactors. We determine the coefficients of this parameterization, as well as their covariance matrix, by performing a fit to spectra inferred from experimentally measured beta spectra. Subsequently we show that flux shape uncertainties play only a minor role in the KamLAND experiment, however, we find that future reactor-neutrino experiments to measure the mixing angle  $\theta_{13}$  are sensitive to the fine details of the reactor-neutrino spectra. Finally, we investigate the possibility to determine the isotopic composition in nuclear reactors through an antineutrino measurement. We find that with a three month exposure of a 1 ton detector the isotope fractions and the thermal reactor power can be determined at a few percent accuracy, which may open the possibility of an application for safeguard or nonproliferation objectives. [Phys. Rev. D **70**, 053011 (2004)]

**$K^-$ -meson condensation and phase transition from nuclear matter to color-flavor-locked matter.** Xiao-Bing Zhang and Xue-Qian Li, *Department of Physics, Nankai University, Tianjin 300071, China.* (Received 23 June 2004; published 10 September 2004)

We investigate effects of discontinuous  $K^-$ -meson condensation on the phase transition from nuclear matter to color-flavor-locked quark matter. Two specific scenarios (one is a first-order transition via mixing of opposite-charged phases, whereas the other is a coexisting phase of the nuclear matter with  $K^-$ -meson condensation and the color-flavor-locked matter) are examined. It is found that the presence of electrically neutral color-flavor-locked matter is preceded by the coexisting phase in the sense of the hadron-quark continuity, once  $K^-$ -meson condensation occurs in a neutron star environment. [Phys. Rev. D **70**, 054010 (2004)]

**Combined analysis of short-baseline neutrino experiments in the  $(3+1)$  and  $(3+2)$  sterile neutrino oscillation hypotheses.** M. Sorel, J. M. Conrad, and M. H. Shaevitz, *Department of Physics, Columbia University, New York, New York 10027, USA.* (Received 21 April 2004; published 12 October 2004)

We investigate adding two sterile neutrinos to resolve the apparent tension existing between short-baseline neutrino oscillation results and CPT-conserving, four-neutrino oscillation models. For both  $(3+1)$  and  $(3+2)$  models, the level of statistical compatibility between the combined dataset from the null short-baseline ex-

periments Bugey, CHOOZ, CCFR84, CDHS, KARMEN, and NOMAD, on the one hand; and the LSND dataset, on the other, is computed. A combined analysis of all seven short-baseline experiments, including LSND, is also performed, to obtain the favored regions in neutrino mass and mixing parameter space for both models. Finally, four statistical tests to compare the  $(3+1)$  and the  $(3+2)$  hypotheses are discussed. All tests show that  $(3+2)$  models fit the existing short-baseline data significantly better than  $(3+1)$  models. [Phys. Rev. D **70**, 073004 (2004)]

**Prospects of accelerator and reactor neutrino oscillation experiments for the coming ten years.** P. Huber,<sup>1,2</sup> M. Lindner,<sup>1</sup> M. Rolinec,<sup>1</sup> T. Schwetz<sup>1</sup> and W. Winter,<sup>1</sup> *Physik-Department, Technische Universität München, James-Frank-Strasse, D-85748 Garching, Germany*<sup>2</sup> *Max-Planck-Institut für Physik, Postfach 401212, D-80805 München, Germany.* (Received 17 March 2004; revised 3 May 2004; published 27 October 2004)

We analyze the physics potential of long-baseline neutrino oscillation experiments planned for the coming ten years, where the main focus is the sensitivity limit to the small mixing angle  $\theta_{13}$ . The discussed experiments include the conventional beam experiments MINOS, ICARUS, and OPERA, which are under construction, the planned superbeam experiments J-PARC to Super-Kamiokande and NuMI off-axis, as well as new reactor experiments with near and far detectors, represented by the Double-Chooz project. We perform a complete numerical simulation including systematics, correlations, and degeneracies on an equal footing for all experiments using the GLOBES software. After discussing the improvement of our knowledge on the atmospheric parameters  $\theta_{23}$  and  $\Delta m_{31}^2$  by these experiments, we investigate the potential to determine  $\theta_{13}$  within the next ten years in detail. Furthermore, we show that under optimistic assumptions and for  $\theta_{13}$  close to the current bound, even the next generation of experiments might provide some information on the Dirac  $CP$  phase and the type of the neutrino mass hierarchy. [Phys. Rev. D **70**, 073014 (2004)]

**Quark-mass dependence of  $T_c$  in QCD: Working up from  $m=0$  or down from  $m=\infty$ ?** Adrian Dumitru, Dirk Röder, and Jörg Ruppert, *Institut für Theoretische Physik, J. W. Goethe Universität, Postfach 11 19 32, D-60054 Frankfurt am Main, Germany.* (Received 11 November 2003; revised 27 July 2004; published 11 October 2004)

We analyze the dependence of the QCD transition temperature on the quark (or pion) mass. We find that a linear sigma model, which links the transition to chiral symmetry restoration, predicts a much stronger dependence of  $T_c$  on  $m_\pi$  than seen in present lattice data

for  $m_\pi \geq 0.4$  GeV. On the other hand, working down from  $m_\pi = \infty$ , an effective Lagrangian for the Polyakov loop requires only small explicit symmetry breaking,  $b_1 \sim \exp(-m_\pi)$ , to describe  $T_c(m_\pi)$  in the above mass range. Physically, this is a consequence of the flat potential (large correlation length) for the Polyakov loop in the three-color pure gauge theory at  $T_c$ . We quantitatively estimate the end point of the line of first-order deconfining phase transitions:  $m_\pi \approx 4.2\sqrt{\sigma} \approx 1.8$  GeV and  $T_c \approx 240$  MeV for three flavors and three colors. [Phys. Rev. D **70**, 074001 (2004)]

**Neutron electric dipole moment in the instanton vacuum: Quenched versus unquenched simulations.** P. Faccioli,<sup>1</sup> D. Guadagnoli,<sup>2</sup> and S. Simula,<sup>3</sup> <sup>1</sup>*E. C. T.\*, Strada delle Tabarelle 286, I-38050 Trento, and INFN, Sezione Collegata di Trento, Trento, Italy;* <sup>2</sup>*Dipartimento di Fisica, Università di Roma "La Sapienza", and INFN, Sezione di Roma, P.le A. Moro 2, I-00185 Rome, Italy;* <sup>3</sup>*INFN, Sezione di Roma Tre, Via della Vasca Navale 84, I-00146, Roma, Italy.* (Received 7 July 2004; published 14 October 2004)

We investigate the role played by the fermionic determinant in the evaluation of the  $CP$ -violating neutron electric dipole moment (EDM) adopting the Instanton Liquid Model. Significant differences between quenched and unquenched calculations are found. In the case of unquenched simulations the neutron EDM decreases linearly with the quark mass and is expected to vanish in the chiral limit. On the contrary, within the quenched approximation, the neutron EDM increases as the quark mass decreases and is expected to diverge as  $1/m^N_f$  in the chiral limit. We argue that such a qualitatively different behavior is a parameter-free, semiclassical prediction and occurs because the neutron EDM is sensitive to the topological structure of the vacuum. The present analysis suggests that quenched and unquenched lattice QCD simulations of the neutron EDM as well as of other observables governed by topology might show up important differences in the quark mass dependence for  $m_q \lesssim \Lambda_{QCD}$ . [Phys. Rev. D **70**, 074017 (2004)]

**Quantum anomalies in dense matter.** D. T. Son<sup>1</sup> and Ariel R. Zhitnitsky,<sup>2</sup> <sup>1</sup>*Institute for Nuclear Theory, University of Washington, Seattle, Washington 98195-1550, USA;* <sup>2</sup>*Department of Physics and Astronomy, University of British Columbia, Vancouver, BC, Canada, V6T 1Z1.* (Received 19 June 2004; published 15 October 2004)

We consider the effects of quantum anomalies involving the baryon current for high-density matter. In the effective Lagrangian, the anomaly terms describe the interaction of three light fields: the electromagnetic photons  $A_\mu$ , neutral light Nambu-Goldstone bosons ( $\pi$ ,  $\eta$ ,  $\eta'$ ), and the superfluid phonon. The anomaly induced interactions lead to a number of interesting phenomena which may have phenomenological consequences observable in neutron stars. [Phys. Rev. D **70**, 074018 (2004)]

**Generalized parton distributions and color transparency phenomena.** S. Liuti and S. K. Taneja, *University of Virginia, Charlottesville, Virginia 22904-4714, USA.* (Received 2 June 2004; published 15 October 2004)

We study the structure of generalized parton distributions in impact parameter space with the aim of determining the size and the role of small transverse separation components in the quark wave function. We analyze the relation between transverse momentum components and transverse separations. Wave functions with large transverse momentum components can simultaneously reproduce the behavior of the Dirac form factor at large momentum transfer and of the deep inelastic structure functions at Bjorken  $x \rightarrow 1$ . The presence of large momentum components does not ensure, however, the dominance of small transverse distances at large  $x$ . We suggest that experiments measuring the attenuation of hadrons in the nuclear medium, or the onset of color transparency, can provide an alternative source of information on generalized parton distributions by mapping out the behavior of the transverse components of the wave function. [Phys. Rev. D **70**, 074019 (2004)]

**Phenomenological constraints on the Jaffe-Wilczek model of pentaquarks.** Thomas D. Cohen, *Department of Physics, University of Maryland, College Park, Maryland 20742-4111, USA.* (Received 18 February 2004; published: 21 October 2004)

A model recently introduced by Jaffe and Wilczek based on the quarks being dynamically bound into diquarks has been used to predict that the recently observed exotic baryons (pentaquarks) fall into a nearly ideally mixed combination of the 8 and  $\bar{10}$  representations of  $SU(3)$  flavor. The model predicts two states with nucleon quantum numbers which have tentatively been identified with the  $N^*(1440)$  and the  $N^*(1710)$ . This paper examines the viability of this model by focusing on the decay width of the nucleon members of the multiplet. An inequality relating the partial widths of these nucleon states in the  $\pi^+$  nucleon channel to the width of the  $\theta^+$  is derived for this model assuming ideal mixing and that the only significant exact  $SU(3)$  symmetry violations are the result of ideal mixing, threshold effects, and the masses of pseudo-Goldstone bosons. This inequality is badly violated if the states in the multiplet are the  $N^*(1440)$  and the  $N^*(1710)$  and if the recent bounds extracted for the  $\theta^+$  width are reliable. Thus, the model appears to require a scenario with the existence of at least one presently unknown resonance with nucleon quantum numbers. [Phys. Rev. D **70**, 074023 (2004)]

**NLO QCD procedure of the semi-inclusive deep inelastic scattering data analysis with respect to the light quark polarized sea.** A. N. Sissakian, O. Yu. Shevchenko, and O. N. Ivanov, *Joint Institute for Nuclear Research, 141980 Dubna, Russia.* (Received 21 January 2004; revised 4 May 2004; published 27 October 2004)

The semi-inclusive deep inelastic scattering (SIDIS) process is considered. A theoretical procedure is proposed allowing the direct extraction from the SIDIS data of the first moments of the polarized valence distributions and of the first moment difference of the light sea quark polarized distributions in the next to leading QCD order. The validity of the procedure is confirmed by the respective simulations. [Phys. Rev. D **70**, 074032 (2004)]

**Representation mixing and exotic baryons in the Skyrme model.** Hyun Kyu Lee<sup>1,2</sup> and Ha Young Park,<sup>1</sup> <sup>1</sup>*Department of Physics, Hanyang University, Seoul 133-791, Korea;* <sup>2</sup>*Theoretical Physics Institute, Department of Physics, University of Alberta, Alberta, Canada T6G2J1.* (Received 9 June 2004; revised 9 July 2004; published 29 October 2004)

We study the effect of representation mixing in the SU(3) Skyrme model by diagonalizing exactly the representation-dependent part. It is observed that even without the next-to-leading-order symmetry breaking terms the low-lying baryon masses as well as the recently discovered  $\Theta^+$  and  $\Xi_{10}$  can be fairly well reproduced within 3% accuracy. It is also demonstrated that the mixing effect is not negligible in decay processes of  $\{\overline{10}\}$ . In particular the effect of mixing with  $\{27\}$  is found to be quite large. These results are compatible with the second-order perturbation scheme. The decay widths are found to be sensitive to the mass values. The decay widths of  $\{\overline{10}\}$  are estimated to be smaller than those of  $\{10\}$  by an order of magnitude due to the destructive interference between operators, although the kinematic factors are comparable. [Phys. Rev. D **70**, 074033 (2004)]

**Static quark-antiquark free energy and the running coupling at finite temperature.** O. Kaczmarek and F. Zantow, *Fakultät für Physik, Universität Bielefeld, P. O. Box 100131, D-33501 Bielefeld, Germany.* P. Petreczky, *Physics Department, Brookhaven National Laboratory, Upton, New York 11973 USA.* (Received 30 June 2004; published 12 October 2004)

We analyze the free energy of a static quark-antiquark pair in quenched QCD at short and large distances. From this we deduce running couplings,  $g^2(r, T)$ , and determine the length scale that separates at high temperature the short distance perturbative regime from the large distance nonperturbative regime in the QCD plasma phase. Ambiguities in the definition of a coupling beyond the perturbative regime are discussed in their relation to phenomenological considerations on heavy quark bound states in the quark gluon plasma. Our analysis suggests that it is more appropriate to characterize the nonperturbative properties of the QCD plasma phase close to  $T_c$  in terms remnants of the confinement part of the QCD force rather than a strong Coulombic force. [Phys. Rev. D **70**, 074505 (2004)]

**Study of pentaquarks on the lattice with overlap fermions.** N. Mathur<sup>1</sup>, F. X. Lee<sup>2,3</sup>, A. Alexandru<sup>1</sup>, C. Bennhold<sup>2</sup>, Y. Chen<sup>4</sup>, S. J. Dong<sup>1</sup>, T. Draper<sup>1</sup>, I. Horváth<sup>1</sup>, K. F. Liu<sup>1</sup>, S. Tamhankar<sup>1</sup>, and J. B. Zhang<sup>5</sup>, <sup>1</sup>*Department of Physics & Astronomy, University of Kentucky, Lexington, Kentucky 40506, USA;* <sup>2</sup>*Center for Nuclear Studies, Department of Physics, The George Washington University, Washington, D.C. 20052, USA;* <sup>3</sup>*Jefferson Lab, 12000 Jefferson Avenue, Newport News, Virginia 23606, USA;* <sup>4</sup>*Institute of High En-*

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We present a quenched lattice QCD calculation of spin-1/2 five-quark states with  $uudd\bar{s}$  quark content for both positive and negative parities. We do not observe any bound pentaquark state in these channels for either  $I=0$  or  $I=1$ . The states we found are consistent with  $KN$  scattering states which are checked to exhibit the expected volume dependence of the spectral weight. The results are based on overlap-fermion propagators on two lattices,  $12^3 \times 28$  and  $16^3 \times 28$ , with the same lattice spacing of 0.2 fm, and pion mass as low as  $\sim 180$  MeV. [Phys. Rev. D **70**, 074508 (2004)]

**Lepton flavor violation without supersymmetry.** V. Cirigliano, A. Kurylov, M. J. Ramsey-Musolf, and P. Vogel, *Kellogg Radiation Laboratory, California Institute of Technology, Pasadena, California 91125, USA.* (Received 29 April 2004; published 11 October 2004)

We study the lepton flavor-violating (LFV) processes  $\mu \rightarrow e \gamma$ ,  $\mu \rightarrow 3e$ , and  $\mu \rightarrow e$  conversion in nuclei in the left-right symmetric model without supersymmetry and perform the first complete computation of the LFV branching ratios  $B(\mu \rightarrow f)$  to leading nontrivial order in the ratio of left- and right-handed symmetry-breaking scales. To this order,  $B(\mu \rightarrow e \gamma)$  and  $B(\mu \rightarrow e)$  are governed by the same combination of LFV violating couplings, and their ratio is naturally of order unity. We also find  $B(\mu \rightarrow 3e)/B(\mu \rightarrow e) \sim 100$  under slightly stronger assumptions. Existing limits on the branching ratios already substantially constrain mass splittings and/or mixings in the heavy neutrino sector. When combined with future collider studies and precision electroweak measurements, improved limits on LFV processes will test the viability of low-scale, nonsupersymmetric LFV scenarios. [Phys. Rev. D **70**, 075007 (2004)]

**Lorentz violation and short-baseline neutrino experiments.** V. Alan Kostelecký and Matthew Mewes, *Physics Department, Indiana University, Bloomington, Indiana 47405, USA.* (Received 23 June 2004; published 14 October 2004)

A general discussion is given of signals for broken Lorentz symmetry in short-baseline neutrino experiments. Among the effects that Lorentz violation can introduce are a dependence on energy differing from that of the usual massive-neutrino solution and a dependence on the direction of neutrino propagation. Using the published result of the Liquid Scintillator Neutrino Detector experiment, analysis of the effects of broken Lorentz symmetry yields an estimated nonzero value  $(3 \pm 1) \times 10^{-19}$  GeV for a combination of coefficients for Lorentz violation. This lies in the range expected for effects originating from the Planck scale in an underlying unified theory. [Phys. Rev. D **70**, 076002 (2004)]

**Critical view to “IGEX  $^{76}\text{Ge}$  neutrinoless double-beta decay experiment: Prospects for next generation experiments”.** H. V. Klapdor-Kleingrothaus<sup>1</sup>, A. Dietz<sup>1</sup>, and I. V. Krivosheina<sup>1,2</sup>, <sup>1</sup>Max-Planck-Institut für Kernphysik, Postfach 10 39 80, D-69029 Heidelberg, Germany; <sup>2</sup>Radiophysical-Research Institute, Nishnii-Novgorod, Russia. (Received 27 June 2002; published 28 October 2004)

Recently, a paper entitled “The IGEX  $^{76}\text{Ge}$  neutrinoless double-beta decay experiment: Prospects for next generation experiments” has been published [Phys. Rev. D **65**, 092007 (2002)]. In view of the recently reported evidence for neutrinoless double-beta decay [Mod. Phys. Lett. A **16**, 2409 (2001); Found. Phys. **31**, 1181 (2002); Phys. Lett. B **586**, 198 (2004).], it is particularly unfortunate that the IGEX paper is rather incomplete in its presentation. We would like to point out in this Comment that and why it would be highly desirable to make more details about the experimental conditions and the analysis of IGEX available. We list some of the main points, which require further explanation. We also point to an arithmetic mistake in the analysis of the IGEX data, the consequence of which are too high half-life limits given in that paper. [Phys. Rev. D **70**, 078301 (2004)]

**The IGEX experiment reexamined: A response to the critique of Klapdor-Kleingrothaus, Dietz, and Krivosheina.** C. E. Aalseth<sup>1</sup>, F. T. Avignone III<sup>2</sup>, R. L. Brodzinski<sup>1</sup>, S. Cebrian<sup>3</sup>, E. Garcia<sup>3</sup>, D. Gonzales<sup>3</sup>, W. K. Hensley<sup>1</sup>, I. G. Irastorza<sup>3</sup>, I. V. Kirpichnikov<sup>4</sup>, A. A. Klimenko<sup>5</sup>, H. S. Miley<sup>1</sup>, A. Morales<sup>3</sup>, J. Morales<sup>3</sup>, A. Ortiz de Solorzano<sup>3</sup>, S. B. Osetrov<sup>5</sup>, V. S. Pogosov<sup>6</sup>, J. Puimedo<sup>3</sup>, J. H. Reeves<sup>1,2</sup>, M. L. Sarsa<sup>3</sup>, A. A. Smolnikov<sup>5</sup>, A. S. Starostin<sup>4</sup>, A. G. Tamanyan<sup>6</sup>, A. A. Vasenko<sup>4</sup>, S. I. Vasiliev<sup>5</sup>, and J. A. Villar<sup>3</sup>, <sup>1</sup>Pacific Northwest National Laboratory, Richland, Washington 99352, USA; <sup>2</sup>University of South Carolina, Columbia, South Carolina 29208, USA; <sup>3</sup>University of Zaragoza, 50009 Zaragoza, Spain; <sup>4</sup>Institute for Theoretical and Experimental Physics, 117259 Moscow, Russia; <sup>5</sup>Institute for Nuclear Research, Baksan Neutrino Observatory, 361309 Neutrino, Russia; <sup>6</sup>Yerevan Physical Institute, 375036 Yerevan, Armenia. (Received 28 April 2004; published 28 October 2004)

This paper is a response to the preceding Comment by Klapdor-Kleingrothaus, Dietz, and Krivosheina. The criticisms are confronted, and the questions raised are answered. We demonstrate that the lower limit quoted by IGEX,  $T_{1/2}^{0\nu}(^{76}\text{Ge}) \geq 1.57 \times 10^{25}$ , is correct and that there was no “arithmetical error” as claimed in the “Critical View” article. [Phys. Rev. D **70**, 078302 (2004)]

**$K^-$ -meson condensation and phase transition from nuclear matter to color-flavor-locked matter.** Xiao-Bing Zhang and Xue-Qian Li, *Department of Physics, Nankai University, Tianjin 300071, China.* (Received 23 June 2004; published 10 September 2004)

We investigate effects of discontinuous  $K^-$ -meson condensation on the phase transition from nuclear matter to color-flavor-locked quark matter. Two specific scenarios (one is a first-order transition via mixing of opposite-charged phases, whereas the other is a coexisting phase of the nuclear matter with  $K^-$ -meson condensation and the color-flavor-locked matter) are examined. It is found that the presence of electrically neutral color-flavor-locked matter is preceded by the coexisting phase in the sense of the hadron-quark continuity, once  $K^-$ -meson condensation occurs in a neutron star environment. [Phys. Rev. D **70**, 054010 (2004)]

**Linking the quark meson model with QCD at high temperature.** Jens Braun and Hans-Jürgen Pirner, *Institut für Theoretische Physik, Universität Heidelberg, Philosophenweg 19, 69120 Heidelberg, Germany.* Kai Schwenzer, *Department of Physics, North Carolina State University, Raleigh, North Carolina 27695, USA.* (Received 25 May 2004; published 22 October 2004)

We model the transition of a system of quarks and gluons at high energies to a system of quarks and mesons at low energies in a consistent renormalization group approach. Flow equations interpolate between the physics of the high-temperature degrees of freedom and the low-temperature dynamics at a scale of 1 GeV. We also discuss the dependence of the equation of state on baryon density and compare our results with recent lattice gauge simulations. [Phys. Rev. D **70**, 085016 (2004)]