Selected Abstracts from Other Physical Review Journals

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Quark number susceptibilities of hot QCD up to $g^6 \ln g$. A. Vuorinen, *Department of Physical Sciences, Theoretical Physics Division, P.O. Box 64, FIN-00014 University of Helsinki, Finland.* (Received 23 December 2002; published 28 April 2003)

The pressure of hot QCD has recently been determined to the last perturbatively computable order $g^6 \ln g$ by Kajantie *et al.* using three-dimensional effective theories. A similar method is applied here to the pressure in the presence of small but non-vanishing quark chemical potentials, and the result is used to derive the quark number susceptibilities in the limit $\mu = 0$. The diagonal quark number susceptibility of QCD with n_f flavors of massless quarks is evaluated to order $g^6 \ln g$ and compared with recent lattice simulations. It is observed that the results qualitatively resemble the lattice ones, and that when combined with the fully perturbative but yet undetermined g^6 term they may well explain the behavior of the lattice data for a wide range of temperatures. [Phys. Rev. D **67**, 074032 (2003)]

Signatures of nucleon disappearance in large underground detectors. Yuri Kamyshkov, *Department of Physics, University of Tennessee, Knoxville, Tennessee 37996;* Edwin Kolbe, *Physics Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee 37831.* (Received 30 May 2002; revised manuscript received 31 December 2002; published 28 April 2003)

For neutrons bound inside nuclei, baryon instability can manifest itself as a decay into undetectable particles (e.g., $n \to \nu\nu\overline{\nu}$), i.e., as a disappearance of a neutron from its nuclear state. If electric charge is conserved, a similar disappearance is impossible for a proton. The existing experimental lifetime limit for neutron disappearance is 4–7 orders of magnitude lower than the lifetime limits with detectable nucleon decay products in the final state. In this paper we calculated the spectrum of nuclear de-excitations that would result from the disappearance of a neutron or two neutrons from ^{12}C. We found that some de-excitation modes have signatures that are advantageous for detection in the modern high-mass, low-background, and low-threshold underground detectors, where neutron disappearance would result in a characteristic sequence of time- and space-correlated events. Thus, in the KamLAND detector, a time-correlated triple coincidence of a prompt signal, a captured neutron, and a β^+ decay of the residual nucleus, all originating from the same point in the detector, will be a unique signal of neutron disappearance allowing searches for baryon instability with sensitivity 3–4 orders of magnitude beyond the present experimental limits. [Phys. Rev. D **67**, 076007 (2003)]

Chiral phase properties of finite size quark droplets in the Nambu–Jona-Lasinio model. O. Kiriyama and A. Hosaka, *Research Center for Nuclear Physics, Osaka University, Ibaraki 567-0047, Japan.* (Received 4 December 2002; published 21 April 2003)

Chiral phase properties of finite size hadronic systems are investigated within the Nambu–Jona-Lasinio model. Finite size effects are taken into account by making use of the multiple reflection expansion. We find that, for droplets with relatively small baryon numbers, chiral symmetry restoration is enhanced by the finite size effects. However the radius of the stable droplet does not change much, as compared to that without the multiple reflection expansion. [Phys. Rev. D **67**, 085010 (2003)]

Breaking rotational symmetry in two-flavor color superconductors. H. Müther and A. Sedrakian, *Institut für Theoretische Physik, Universität Tübingen, D-72076 Tübingen, Germany.* (Received 20 December 2002; published 28 April 2003)

The color superconductivity under flavor asymmetric conditions relevant to compact star phenomenology is studied within the Nambu–Jona-Lasinio model. We focus on the effect of the deformation of the Fermi surfaces on the pairing properties and the energy budget of the superconducting state. We find that at finite flavor asymmetries the color superconducting BCS state is unstable towards spontaneous quadrupole deformation of the Fermi surfaces of the *d* and *u* quarks into ellipsoidal form. The ground state of the phase with deformed Fermi surfaces corresponds to a superposition of prolate and oblate deformed Fermi ellipsoids of *d* and *u* quarks. [Phys. Rev. D **67**, 085024 (2003)]

Thermal field theory and generalized light front quantization. H. Arthur Weldon, *Department of Physics, West Virginia University, Morgantown, West Virginia 26506-6315.* (Received 24 December 2002; published 29 April 2003)

The dependence of thermal field theory on the surface of quantization and on the velocity of the heat bath is investigated by working in general coordinates that are arbitrary linear combinations of the Minkowski coordinates. In the general coordinates the metric tensor $g_{\overline{\mu\nu}}$ is nondiagonal. The Kubo-Martin-Schwinger condition requires periodicity in thermal correlation functions when the temporal variable changes by an amount $-i/(T\sqrt{g_{\overline{00}}})$. Light-front quantization fails since $g_{\overline{00}} = 0$; however, various related quantizations are possible. [Phys. Rev. D **67**, 085027 (2003)]

Paschos-Wolfenstein relationship for nuclei and the NuTeV $\sin^2\theta_W$ measurement. S. A. Kulagin, *Institute for Nuclear Research, 117312 Moscow, Russia.* (Received 25 January 2003; published 15 May 2003)

We discuss the nuclear effects in the Paschos-Wolfenstein relationship in the context of the extraction of the weak mixing angle. We point out that the neutron excess correction to the Paschos-Wolfenstein relationship for a neutron-rich target is negative and large on the scale of the experimental errors of a recent NuTeV measurement. We find a larger neutron excess correction to the Paschos-Wolfenstein relationship for the total cross sections than that discussed by the NuTeV Collaboration. The phenomenological applications of this observation are discussed in the context of the NuTeV deviation. The uncertainties in the neutron excess correction are estimated. The effects due to the Fermi motion, nuclear binding, and nuclear shadowing are also discussed in the context of the total cross sections. [Phys. Rev. D **67**, 091301 (2003)]

Implications of partially degenerate neutrinos at a high scale in light of KamLAND and WMAP results. Anjan S. Joshipura and Subhendra Mohanty, *Theoretical Physics Group, Physical Research Laboratory, Navrangpura, Ahmedabad 380 009, India.* (Received 3 March 2003; published 30 May 2003)

Electroweak radiative corrections can generate the neutrino $(\text{mass})^2$ difference required for the large mixing angle (LMA) solution to the solar neutrino problem if two of the neutrinos are assumed degenerate at high energy. We study this possibility and (i) derive restrictions on ranges of the high scale mixing matrix elements and (ii) obtain predictions for the low energy parameters required in order to get the LMA solution of the solar neutrino problem picked out by KamLAND. This solution is realized in the case of the standard model when the (degenerate) neutrino masses lie in the range $(0.7-2)$ eV. This is at odds with the cosmological limit $m_\nu < 0.23$ eV (at 95% C.L.) established recently using WMAP results. The LMA solution can be obtained in case of the MSSM electroweak corrections with a (almost) degenerate spectrum or with an inverted mass hierarchy for limited ranges in the high scale parameters. [Phys. Rev. D **67**, 091302 (2003)]

Kinematically complete measurement of the proton structure function F_2 in the resonance region and evaluation of its moments. M. Osipenko,[1,2] G. Ricco,[2] M. Taiuti,[2] M. Ripani,[2] S. Simula,[3] G. Adams,[4] E. Anciant,[5] M. Anghinolfi,[2] B. Asavapibhop,[7] G. Audit,[5] T. Auger,[5] H. Avakian,[8,9] H. Bagdasaryan,[10] J. P. Ball,[11] S. Barrow,[24] M. Battaglieri,[2] K. Beard,[31] M. Bektasoglu,[20] N. Bianchi,[9] A. S. Biselli,[4] S. Boiarinov,[8,35] P. Bosted,[7] S. Bouchigny,[12,8] R. Bradford,[17] D. Branford,[13] W. J. Briscoe,[14] W. K. Brooks,[8] V. D. Burkert,[8] J. R. Calarco,[15] D. S. Carman,[16] B. Carnahan,[18] A. Cazes,[19] C. Cetina,[14,17] L. Ciciani,[20] R. Clark,[17] P. L. Cole,[21,8] A. Coleman,[6] D. Cords,[8] P. Corvisiero,[2] D. Crabb,[22] H. Crannell,[18] J. P. Cummings,[4] E. De Sanctis,[9] P. V. Degtyarenko,[8] H. Denizli,[23] L. Dennis,[24] R. De Vita,[2] K. V. Dharmawardane,[20] C. Djalali,[19] G. E. Dodge,[20] J. J. Domingo,[8] D. Doughty,[25,8] P. 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We measured the inclusive electron-proton cross section in the nucleon resonance region ($W<2.5$ GeV) at momentum transfers Q^2 below 4.5 $(\mathrm{GeV}/c)^2$ with the CLAS detector. The large acceptance of CLAS allowed the measurement of the cross section in a large, contiguous two-dimensional range of Q^2 and x, making it possible to perform an integration of the data at fixed Q^2 over the significant x interval. From these data we extracted the structure function F_2 and, by including other world data, we studied the Q^2 evolution of its moments, $M_n(Q^2)$, in order to estimate higher twist contributions. The small statistical and systematic uncertainties of the CLAS data allow a precise extraction of the higher twists and will require significant improvements in theoretical predictions if a meaningful comparison with these new experimental results is to be made. [Phys. Rev. D **67**, 092001 (2003)]

Neutral-current atmospheric neutrino flux measurement using neutrino-proton elastic scattering in Super-Kamiokande. John F. Beacom, *NASA/Fermilab Astrophysics Center, Fermi National Accelerator Laboratory, Batavia, Illinois 60510-0500;* Sergio Palomares-Ruiz, *NASA/Fermilab Astrophysics Center, Fermi National Accelerator Laboratory, Batavia, Illinois 60510-0500, and Departamento de Física Teórica, Universidad de Valencia, 46100 Burjassot, Valencia, Spain.* (Received 9 January 2003; published 8 May 2003)

Recent results show that atmospheric ν_μ oscillate with $\delta m^2 \simeq 3 \times 10^{-3}$ eV^2 and $\sin^2 2\theta_{atm} \simeq 1$, and that conversion into ν_e is strongly disfavored. The Super-Kamiokande (SK) Collaboration, using a combination of three techniques, reports that their data favor $\nu_\mu \to \nu_\tau$ over $\nu_\mu \to \nu_{sterile}$. This distinction is extremely important for both four-neutrino models and cosmology. We propose that neutrino-proton elastic scattering ($\nu + p \to \nu + p$) in water Čerenkov detectors can also distinguish between active and sterile oscillations. This was not previously recognized as a useful channel since only about 2% of struck protons are above the Čerenkov threshold. Nevertheless, in the present SK data there should be about 40 identifiable events. We show that these events have unique particle identification characteristics, point in the direction of the incoming neutrinos, and correspond to a narrow range of neutrino energies (1–3 GeV, oscillating near the horizon). This channel will be particularly important in Hyper-Kamiokande, with ~40 times higher rate. Our results have other important applications. First, for a similarly small fraction of atmospheric neutrino quasielastic events, the proton is relativistic. This uniquely selects ν_μ (not $\bar{\nu}_\mu$) events, useful for understanding matter effects, and allows determination of the neutrino energy and direction, useful for the L/E dependence of oscillations. Second, using accelerator neutrinos, both elastic and quasielastic events with relativistic protons can be seen in the K2K 1-kton near detector and MiniBooNE. [Phys. Rev. D **67**, 093001 (2003)]

Combining the first KamLAND results with solar neutrino data. M. Maltoni,[1] T. Schwetz,[2] and J. W. F. Valle[1] [1]*AHEP Group, Instituto de Física Corpuscular–C.S.I.C./Universitat de València, Edificio de Institutos de Paterna, Apartado 22085, E-46071 València, Spain,* [2]*Theoretische Physik, Physik Department, Technische Universität München, James-Franck-Strasse, D–85748 Garching, Germany.* (Received 11 December 2002; revised manuscript received 7 February 2003; published 16 May 2003)

We consider the impact of the recent KamLAND data on neutrino oscillations, the first terrestrial neutrino experiment that can probe the solar neutrino anomaly. By combining the first 145.1 days of KamLAND data with the full sample of the latest solar neutrino data we find an enhanced rejection against non-large-mixing-angle (LMA) oscillations, allowed only at more than 4σ with respect to the LMA solution. Furthermore, the new data have a strong impact in narrowing down the allowed range of Δm^2 inside the LMA region. In contrast, our global analysis indicates that the new data have little impact on the location of the best fit point. In particular, the solar neutrino mixing remains significantly nonmaximal (3σ). [Phys. Rev. D **67**, 093003 (2003)]

Prospects of very long baseline neutrino oscillation experiments with the KEK-JAERI high intensity proton accelerator. Mayumi Aoki,[1] K. Hagiwara,[1] Y. Hayato,[2] T. Kobayashi,[2] T. Nakaya,[3] K. Nishikawa,[3] and N. Okamura[4] [1]*Theory Group, KEK, Tsukuba, Ibaraki 305-0801, Japan,* [2]*Institute of Particle and Nuclear Studies, High Energy Accelerator Research Org. (KEK), Tsukuba, Ibaraki 305-0801, Japan,* [3]*Department of Physics, Kyoto University, Kyoto 606-8502, Japan,* [4]*IPPAP, Physics Department, Virginia Tech., Blacksburg, Virginia 24061.* (Received 27 December 2001; revised manuscript received 19 February 2003; published 20 May 2003)

We study the physics potential of very long baseline neutrino-oscillation experiments with a high intensity proton accelerator which will be completed by the year 2007 in Tokai-village, as a joint project of KEK and JAERI (Japan Atomic Energy Research Institute). The 50 GeV proton synchrotron at J-PARC (Japan Proton Accelerator Research Complex) will deliver neutrino beams in the range of a few GeV with an intensity about two orders of magnitude higher than the present KEK beam for the K2K experiment. As a sequel to the proposed J-PARC–to–Super-Kamiokande experiment, we study the impact of experiments with a 100 kton-level detector and a baseline length of a few-thousand km. The pulsed narrow-band ν_μ beams allow us to measure the $\nu_\mu \to \nu_e$ transition probability and the ν_μ survival probability through counting experiments at a large water-Čerenkov detector. We study the sensitivity of such experiments to the neutrino mass hierarchy, the mass-squared differences, the three angles, and one CP phase of the three-generation lepton-flavor-mixing matrix. We find that experiments at a distance between 1000 and 2000 km can determine the sign of the larger mass-squared difference $(m_3^2 - m_1^2)$ if the mixing between ν_e and ν_3 (the heaviest-or-lightest neutrino) is not too small: $4|U_{e3}|^2(1 - |U_{e3}|^2) \gtrsim 0.03$. The CP phase can be constrained if the $|U_{e3}|$ element is sufficiently large: $4|U_{e3}|^2(1-|U_{e3}|^2) \gtrsim 0.06$, and if the smaller mass-squared difference $(m_2^2 - m_1^2)$ and the U_{e2} element are in the preferred range of the large-mixing-angle solution of the solar-neutrino deficit. The magnitude $|m_3^2 - m_1^2|$ and the matrix element $U_{\mu 3}$ can be precisely measured, but we find little sensitivity to $m_2^2 - m_1^2$ and the matrix element U_{e2}. [Phys. Rev. D **67**, 093004 (2003)]

Status of atmospheric neutrino $\nu_\mu \to \nu_\tau$ oscillations and decoherence after the first K2K spectral data. G. L. Fogli,[1] E. Lisi,[1] A. Marrone,[1] and D. Montanino[2] [1]*Dipartimento di Fisica and Sezione INFN di Bari, Via Amendola 173, 70126 Bari, Italy,* [2]*Dipartimento di Scienza dei Materiali and Sezione INFN di Lecce, Via Arnesano, 73100 Lecce, Italy.* (Received 17 March 2003; published 27 May 2003)

We review the status of $\nu_\mu \to \nu_\tau$ flavor transitions of atmospheric neutrinos in the 92 kton-year data sample collected in the first phase of the Super-Kamiokande (SK) experiment, in combination with the recent spectral data from the KEK-to-Kamioka (K2K) accelerator experiment (including 29 single-ring muon events). We consider a theoretical framework which embeds flavor oscillations plus hypothetical decoherence effects, and where both standard oscillations and pure decoherence represent limiting cases. It is found that standard oscillations provide the best description of the SK+K2K data, and that the associated mass-mixing parameters are determined at $\pm 1\sigma$ (and $N_{\mathrm{DF}}=1$) as $\Delta m^2=(2.6\pm 0.4)\times 10^{-3}$ eV^2 and $\sin^2 2\theta = 1.00^{+0.00}_{-0.05}$. As compared with standard oscillations, the case of pure decoherence is disfavored, although it cannot be ruled out yet. In the general case, additional decoherence effects in the $\nu_\mu \to \nu_\tau$ channel do not improve the fit to the SK and K2K data, and upper bounds can be placed on the associated decoherence parameter. Such indications, presently dominated by SK, could be strengthened by further K2K data, provided that the current spectral features are confirmed with higher statistics. A detailed description of the statistical analysis of SK and K2K data is also given, using the so-called ''pull'' approach to systematic uncertainties. [Phys. Rev. D **67**, 093006 (2003)]

Evolution of parton fragmentation functions at finite temperature. Jonathan A. Osborne, *Nuclear Science Division, Lawrence Berkeley Laboratory, Berkeley, California 94720;* Enke Wang, *Institute of Particle Physics, Huazhong Normal University, Wuhan 430079, China, and Nuclear Science Division, Lawrence Berkeley Laboratory, Berkeley, California 94720;* Xin-Nian Wang, *Nuclear Science Division, Lawrence Berkeley Laboratory, Berkeley, California 94720, and Department of Physics, Shandong University, Jinan 250100, China.* (Received 10 December 2002; published 30 May 2003)

The first order correction to the parton fragmentation functions in a thermal medium is derived in the leading logarithmic approximation in the framework of thermal field theory. The medium-modified evolution equations of the parton fragmentation functions are also derived. It is shown that all infrared divergences, both linear and logarithmic, in the real processes are canceled among themselves and by corresponding virtual corrections. The evolution of the quark number and the energy loss (or gain) induced by the thermal medium are investigated. [Phys. Rev. D **67**, 094022 (2003)]

Possible evidence of extended objects inside the proton. R. Petronzio, *Dip. di Fisica, Università di Roma "Tor Vergata" and INFN, Sezione di Roma II, Via della Ricerca Scientifica 1, I-00133 Roma, Italy;* S. Simula, *Istituto Nazionale di Fisica Nucleare, Sezione di Roma III, Via della Vasca Navale 84, I-00146, Roma, Italy;* G. Ricco, *Dip. di Fisica, Università di Genova and INFN, Sezione di Genova, Via Dodecanneso 33, I-16146, Genova, Italy.* (Received 23 January 2003; published 13 May 2003)

Recent experimental determinations of the Nachtmann moments of the inelastic structure function of the proton, $F_2^p(x,Q^2)$, obtained at Jefferson Lab, are analyzed for values of the squared four-momentum transfer Q^2 ranging from ≈ 0.1 to ≈ 2 $(\mathrm{GeV}/c)^2$. It is shown that such inelastic proton data exhibit a new type of scaling behavior and that the resulting scaling function can be interpreted as a constituent form factor consistent with the elastic nucleon data. These findings suggest that at low momentum transfer the inclusive proton structure function originates mainly from the elastic coupling with extended objects inside the proton. We obtain a constituent size of ≈ 0.2–0.3 fm. [Phys. Rev. D **67**, 094004 (2003)]

Deep inelastic scattering and "elastic" diffraction. Masaaki Kuroda, *Institute of Physics, Meiji-Gakuin University, Yokohama 244, Japan;* Dieter Schildknecht, *Fakultät für Physik, Universität Bielefeld, D-33501 Bielefeld, Germany.* (Received 20 January 2003; published 14 May 2003)

We examine the total cross section of virtual photons on protons, $\sigma_{\gamma^* p}(W^2,Q^2)$, at low $x \cong Q^2/W^2 \ll 1$ and its connection with ''elastic'' diffractive production $\gamma^*_{T,L} p \to X^{J=1}_{T,L} p$ in the two-gluon exchange dynamics for the virtual forward Compton scattering amplitude. Solely based on the generic structure of two-gluon exchange, we establish that the cross section is described by the (imaginary part of the) amplitude for forward scattering of $q\bar{q}$ vector states, $(q\bar{q})^{J=1}_{T,L} p \to (q\bar{q})^{J=1}_{T,L} p$. The generalized vector dominance picture is accordingly established to only rest on the two-gluon-exchange generic structure. This is explicitly seen by the sum rules that allow one to directly relate the total cross section to the cross section for elastic diffractive forward production, $\gamma^*_{T,L} p \to (q\bar{q})^{J=1}_{T,L} p$, of vector states. [Phys. Rev. D **67**, 094008 (2003)]

Transverse momentum in semi-inclusive polarized deep inelastic scattering and the spin-flavor structure of the proton. Steven D. Bass, *High Energy Physics Group, Institute for Experimental Physics and Institute for Theoretical Physics, Universität Innsbruck, Technikerstrasse 25, A 6020 Innsbruck, Austria.* (Received 21 October 2002; published 14 May 2003)

The nonvalence spin-flavor structure of the proton extracted from semi-inclusive measurements of polarized deep inelastic scattering depends strongly on the transverse momentum of the detected hadrons which are used to determine the individual polarized sea distributions. This physics may explain the recent HERMES observation of a positively polarized strange sea through semi-inclusive scattering, in contrast with the negative strange sea polarization deduced from inclusive polarized deep inelastic scattering. [Phys. Rev. D **67**, 097502 (2003)]

Neutrino opacities in neutron stars with kaon condensates. Takumi Muto, *Department of Physics, Chiba Institute of Technology, 2-1-1 Shibazono, Narashino, Chiba 275-0023, Japan;* Masatomi Yasuhira, *Yukawa Institute for Theoretical Physics, Kyoto 606-8502, Japan;* Toshitaka Tatsumi, *Department of Physics, Kyoto University, Kyoto 606-8502, Japan;* Naoki Iwamoto, *Department of Advanced Materials Science, Faculty of Engineering, Kagawa University, Takamatsu, Kagawa 761-0396, Japan, and Department of Physics and Astronomy, The University of Toledo, Toledo, Ohio 43606-3390.* (Received 14 January 2003; published 16 May 2003)

The neutrino mean free paths in hot neutron-star matter are obtained in the presence of kaon condensates. The kaon-induced neutrino absorption process, which is allowed only in the presence of kaon condensates, is considered for both nondegenerate and degenerate neutrinos. The neutrino mean free path due to this process is compared with that for neutrino-nucleon scattering. While the mean free path for the kaon-induced neutrino absorption process is shown to be shorter than for the ordinary two-nucleon absorption process by several orders of magnitude when the temperature is not very high, the neutrino-nucleon scattering process still has a dominant contribution to the neutrino opacity. Thus, the kaon-induced neutrino absorption process has a minor effect on the thermal and dynamical evolution of protoneutron stars. [Phys. Rev. D **67**, 103002 (2003)]