

Selected Abstracts from Other Physical Review Journals

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Scaling limit of virtual states of triatomic systems. M. T. Yamashita,¹ T. Frederico,² A. Delfino,³ and Lauro Tomio⁴
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For a system with three identical atoms, the dependence of the s-wave virtual state energy on the weakly bound dimer and trimer binding energies is calculated in the form of a universal scaling function. The scaling function is obtained from a renormalizable three-body model with a pairwise Dirac- δ interaction. The threshold condition for the appearance of the trimer virtual state was also discussed. [Phys. Rev. A **66**, 052702 (2002)]

Phase transitions in neutron stars and gravitational wave emission. G. F. Marranghello and Cesar A. Z. Vasconcellos, *Instituto de Física, Universidade Federal do Rio Grande do Sul, Porto Alegre, Brazil*; J. A. de Freitas Pacheco, *Observatoire de la Côte d'Azur, Nice, France*. (Received 24 June 2002; published 30 September 2002)

We review the detectability of gravitational waves generated by oscillations excited during a phase transition from hadronic matter to deconfined quark-gluon matter in the core of a neutron star. Neutron star properties were computed using a Boguta-Bodmer based model and the MIT bag model. The maximum energy available to excite mechanical oscillations into the star is estimated by the energy difference between the configurations with and without a quark-gluon matter core. On basis of the planned sensitivity of present laser interferometers (VIRGO or LIGO I) and those of the next generation (LIGO II), the maximum volume to be probed by these experiments is determined. These results are used as an indication of the potential detectability of neutron stars as sources of gravitational waves. Our results indicate that the maximum distance probed by the detectors of the first generation is well beyond M31, whereas the second generation detectors will probably see phase transition events at distances two times longer, but certainly not yet attaining the Virgo cluster. [Phys. Rev. D **66**, 064027 (2002)]

Description of deconfinement at finite matter density in a generalized Nambu–Jona-Lasinio model. Hu Li and C. M. Shakin, *Department of Physics and Center for Nuclear Theory, Brooklyn College of the City University of New York, Brooklyn, New York 11210*. (Received 10 July 2002; published 18 October 2002)

Recent years have seen extensive applications of the Nambu–Jona-Lasinio (NJL) model in the study of matter at high density. There is a good deal of interest in the predictions of diquark condensation and color superconductivity, with suggested applications to the study of the properties of neutron stars. As the researchers in this field note, the NJL model does not describe confinement, so that one is limited to the study of the deconfined phase, which may set in at several times nuclear matter density. Recently, we have extended the NJL model to include a covariant confinement model. Our model may be used to study the properties of the full range of light mesons, including their radial excitations, in the 1–3 GeV energy domain. Most recently we have used our extended model to provide an excellent fit to the properties of the $\eta(547)$ and $\eta'(958)$ mesons and their radial excitations. The mixing angles and decay constants are given successfully in our model. In the present work our goal is to include a phenomenological model of deconfinement at finite matter density, using some analogy to what is known concerning “string breaking” and deconfinement at finite temperature. Various models may be used, but for this work we choose a specific model for the density dependence of the parameters of our confining interaction. We perform relativistic random-phase-approximation (RPA) calculations of the properties of the $\pi(138)$, $K(495)$, $f_0(980)$, $a_0(980)$, and $K_0^*(1430)$ mesons and their radial excitations. In the model chosen for this work, there are no mesonic states beyond about $2\rho_{NM}$, where ρ_{NM} is the density of nuclear matter. (The density for deconfinement in our model may be moved to higher values by the change of one of the parameters of the model.) This inability of the model to support bound hadronic states at large values of the density is taken as a signal of deconfinement. In addition to the density dependence of the confining interaction, we use the density-dependent quark mass values obtained in either the SU(2)- or SU(3)-flavor versions of the NJL model. We stress that other assumptions for the density dependence of the confinement potential, other than that used in this work, may be considered in future work, particularly if we are able to obtain further insight in the dynamics of deconfinement at finite matter density. [Phys. Rev. D **66**, 074016 (2002)]

Exploring the neutrino mass matrix at the M_R scale. Takahiro Miura, Tetsuo Shindou, and Eiichi Takasugi, *Department of Physics, Osaka University, Toyonaka, Osaka 560-0043, Japan*. (Received 25 June 2002; published 6 November 2002)

We discuss the neutrino mass matrix which predicts zero or small values of $|V_{13}|$ in the MSSM and find the inequality, $\sin^2 2\theta_{12} \leq \sin^2 2\theta_\odot$, where $\sin^2 2\theta_{12}$ is the mixing angle at the M_R scale and $\sin^2 2\theta_\odot$ is the value determined by the solar neutrino oscillation. This constraint says that the model which predicts a larger value of $\tan^2 \theta_{12}$ at M_R than the experimental value is excluded. In particular, the bimaximal mixing scheme at the M_R scale is excluded from the experimental value $\tan^2 \theta_\odot < 1$. In this model, $|V_{13}|$ and a Dirac phase at m_Z which are induced radiatively may not be small. [Phys. Rev. D **66**, 093002 (2002)]

Matter effects and CP violating neutrino oscillations with non-decoupling heavy neutrinos. B. Bekman, J. Gluza, J. Holeczek, J. Syska, and M. Zralek, *Institute of Physics, University of Silesia, Uniwersytecka 4, PL-40-007 Katowice, Poland*. (Received 3 July 2002; published 12 November 2002)

The evolution equation for active and sterile neutrinos propagating in a general anisotropic or polarized background environment is found and solved for a special case when heavy neutrinos do not decouple, resulting in nonunitary mixing among light neutrino states. Then new CP violating neutrino oscillation effects appear. In contrast with the standard unitary neutrino oscillations these effects can be visible even for two flavor neutrino transitions and even if one of the elements of the neutrino mixing matrix is equal to zero. They do not necessarily vanish with $\delta m^2 \rightarrow 0$ and they are different for various pairs of flavor neutrino transitions ($\nu_e \rightarrow \nu_\mu$), ($\nu_\mu \rightarrow \nu_\tau$), ($\nu_\tau \rightarrow \nu_e$). Neutrino oscillations in vacuum and Earth's matter are calculated for some fixed baseline experiments and a comparison between unitary and nonunitary oscillations are presented. It is shown, taking into account the present experimental constraints, that heavy neutrino states can affect CP and T asymmetries. This is especially true in the case of $\nu_\mu \rightarrow \nu_\tau$ oscillations. [Phys. Rev. D 66, 093004 (2002)]

Operator analysis of neutrinoless double beta decay. Kiwoon Choi, Kwang Sik Jeong, and Wan Young Song, *Department of Physics, Korea Advanced Institute of Science and Technology, Daejeon 305-701, Korea*. (Received 16 July 2002; published 22 November 2002)

We study the effective operators of the standard model fields which would yield an observable rate of neutrinoless double beta decay. We particularly focus on the possibility that neutrinoless double beta decay is dominantly induced by lepton-number-violating higher dimensional operators other than the Majorana neutrino mass. Our analysis can be applied to models in which neutrinoless double beta decay is induced either by strong dynamics or by quantum gravity effects at a fundamental scale near the TeV scale as well as the conventional models in which neutrinoless double beta decay is induced by perturbative renormalizable interactions. [Phys. Rev. D 66, 093007 (2002)]

Three-flavor solar neutrino oscillations with terrestrial neutrino constraints. G. L. Fogli, G. Lettera, E. Lisi, A. Marrone, A. Palazzo, and A. Rotunno, *Dipartimento di Fisica and Sezione INFN di Bari, Via Amendola 173, 70126 Bari, Italy*. (Received 12 August 2002; published 25 November 2002)

We present an updated analysis of the current solar neutrino data in terms of three-flavor oscillations, including the additional constraints coming from terrestrial neutrino oscillation searches at the CHOOZ (reactor), Super-Kamiokande (atmospheric), and KEK-to-Kamioka (accelerator) experiments. The best fit is reached for the subcase of two-family mixing, and the additional admixture with the third neutrino is severely limited. We discuss the relevant features of the globally allowed regions in the oscillation parameter space, as well as their impact on the amplitude of possible CP -violation effects at future accelerator experiments and on the reconstruction accuracy of the mass-mixing oscillation parameters at the KamLAND reactor experiment. [Phys. Rev. D 66, 093008 (2002)]

Confronting spin flavor solutions of the solar neutrino problem with current and future solar neutrino data. J. Barranco,¹ O. G. Miranda,¹ T. I. Rashba,² V. B. Semikoz,² and J. W. F. Valle³
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A global analysis of spin flavor precession (SFP) solutions to the solar neutrino problem is given, taking into account the impact of the full set of latest solar neutrino data, including the recent SNO data and the 1496-day Super-Kamiokande data. These are characterized by three effective parameters: $\Delta m_{SOL}^2 \equiv \Delta m^2$, the neutrino mixing angle $\theta_{SOL} \equiv \theta$, and the magnetic field parameter $\mu B_\perp$. For the last we adopt a self-consistent magnetohydrodynamics field profile in the convective zone and identify an optimum $B_\perp \sim 80$ kG strength for $\mu = 10^{-11} \mu_B$. We find that no low mass (LOW) quasi-vacuum or vacuum solutions are present at 3σ . In addition to the standard large mixing angle (LMA) oscillation solution, there are two SFP solutions, in the resonant (RSFP) and nonresonant (NRSFP) regimes. These two SFP solutions have a goodness of fit of 84% (RSFP) and 83% (NRSFP), slightly better than the LMA oscillation solution (78%). We discuss the role of solar antineutrino searches in the fit and present a table of best-fit parameters and χ^2_{min} values. Should the KamLAND experiment confirm the LMA solution, the SFP solutions may at best be present at a subleading level, leading to a constraint on $\mu B_\perp$. In the event the LMA is not the solution realized in nature, then experiments such as Borexino can help in distinguishing the LMA solution from the NRSFP solution and the simplest RSFP solution with no mixing. [Phys. Rev. D 66, 093009 (2002)]

Constraining the absolute neutrino mass scale and Majorana CP violating phases by future $0\nu\beta\beta$ decay experiments. H. Nunokawa, *Instituto de Física Teórica, Universidade Estadual Paulista, Rua Pamplona 145, 01405-900 São Paulo, Brazil*; W. J. C. Teves and R. Zukanovich Funchal, *Instituto de Física, Universidade de São Paulo C. P. 66.318, 05315-970 São Paulo, Brazil*. (Received 17 June 2002; published 27 November 2002)

Assuming that neutrinos are Majorana particles, in a three-generation framework, current and future neutrino oscillation experiments can determine six out of the nine parameters which fully describe the structure of the neutrino mass matrix. We try to clarify the interplay among the remaining parameters, the absolute neutrino mass scale and two CP violating Majorana phases, and how they can be accessed by future neutrinoless double beta ($0\nu\beta\beta$) decay experiments, for the normal as well as for the inverted order of the neutrino mass spectrum. Assuming the oscillation parameters to be in the range presently allowed by atmospheric, solar, reactor, and accelerator neutrino experiments, we quantitatively estimate the bounds on m_0 , the lightest neutrino mass, that can be inferred if the next generation $0\nu\beta\beta$ decay experiments can probe the effective Majorana mass (m_{ee}) down to ~ 1 meV. In this context we conclude that in the case that neutrinos are Majorana particles, (a) if $m_0 \gtrsim 300$ meV, i.e., within the range directly attainable by future laboratory experiments as well as astrophysical observations, then

$m_{ee} \gtrsim 30$ meV must be observed, (b) if $m_0 < 300$ meV, results from future $0\nu\beta\beta$ decay experiments combined with stringent bounds on the neutrino oscillation parameters, especially the solar ones, will place much stronger limits on the allowed values of m_0 than these direct experiments. For instance, if a positive signal is observed around $m_{ee} = 10$ meV, we estimate $3 \lesssim m_0/\text{meV} \lesssim 65$ at 95% C.L.; on the other hand, if no signal is observed down to $m_{ee} = 10$ meV, then $m_0 \lesssim 55$ meV at 95% C.L. [Phys. Rev. D **66**, 093010 (2002)]

Large neutrino mixing in a universal Yukawa coupling model with small violation. T. Teshima, T. Asai, and Y. Abe, *Department of Applied Physics, Chubu University, Kasugai 487-8501, Japan*. (Received 8 June 2002; published 27 November 2002)

We investigate the possibility that the universal Yukawa coupling (democratic mass matrix) with small violations of Dirac and Majorana neutrinos can induce the large mixing of neutrinos through the seesaw mechanism. The possibility can be produced by the condition that the violation parameters of Majorana neutrinos are sufficiently smaller than the violation parameters of Dirac neutrinos. The allowed regions of the violation parameters producing the observed neutrino mass hierarchy and large neutrino mixing are not so restricted at present in contrast with the violation parameters for the quark sector. In order to obtain the distinctive features in the violation parameters for the neutrino sector as a quark sector, one should take more precise data concerned with the neutrino, for example, mass values, mixing parameters of U_{MNS} , and CP violation phases. [Phys. Rev. D **66**, 093011 (2002)]

Parameter degeneracies in neutrino oscillation measurement of leptonic CP and T violation. Hisakazu Minakata, *Department of Physics, Tokyo Metropolitan University, 1-1 Minami-Osawa, Hachioji, Tokyo 192-0397, Japan*; Hiroshi Nunokawa, *Instituto de Física Teórica, Universidade Estadual Paulista, Rua Pamplona 145, 01405-900 São Paulo, SP Brazil*; Stephen Parke, *Theoretical Physics Department, Fermi National Accelerator Laboratory, P.O. Box 500, Batavia, Illinois 60510*. (Received 20 August 2002; published 27 November 2002)

The measurement of the mixing angle θ_{13} , sign of Δm_{13}^2 , and the CP or T violating phase δ is fraught with ambiguities in neutrino oscillation. In this paper we give an analytic treatment of the parameter degeneracies associated with measuring the $\nu_\mu \rightarrow \nu_e$ probability and its CP and/or T conjugates. For CP violation, we give explicit solutions to allow us to obtain the regions where there exist twofold and fourfold degeneracies. We calculate the fractional differences, $(\Delta\theta/\theta)$, between the allowed solutions which may be used to compare with the expected sensitivities of the experiments. For T violation we show that there is always a complete degeneracy between solutions with positive and negative Δm_{13}^2 which arises due to a symmetry and cannot be removed by observing one neutrino oscillation probability and its T conjugate. Thus there is always a fourfold parameter degeneracy apart from exceptional points. Explicit solutions are also given and the fractional differences are computed. The biprobability CP/T trajectory diagrams are extensively used to illuminate the nature of the degeneracies. [Phys. Rev. D **66**, 093012 (2002)]

Reanalysis of azimuthal spin asymmetries of meson electroproduction. Bo-Qiang Ma, *Department of Physics, Peking University, Beijing 100871, China, and CCAST (World Laboratory), P.O. Box 8730, Beijing 100080, China*; Ivan Schmidt, *Departamento de Física, Universidad Técnica Federico Santa María, Casilla 110-V, Valparaíso, Chile*; Jian-Jun Yang, *Departamento de Física, Universidad Técnica Federico Santa María, Casilla 110-V, Valparaíso, Chile, and Department of Physics, Nanjing Normal University, Nanjing 210097, China*. (Received 19 August 2002; published 6 November 2002)

The azimuthal spin asymmetries for pion production in semi-inclusive deep inelastic scattering of unpolarized charged lepton beams on longitudinally polarized nucleon targets are reanalyzed by taking into account an important sign correction to previous formulas. It is found that different approaches of distribution functions and fragmentation functions may lead to distinct predictions on the azimuthal asymmetries measured in the HERMES experiments; thus, the available data cannot be considered as a direct measurement of quark transversity distributions, although they still can serve to provide useful information on these distributions and on T -odd fragmentation functions. Predictions of the azimuthal spin asymmetries for kaon production are also presented, with different approaches of distribution and fragmentation functions. The unfavored fragmentation functions cannot be neglected for K^- and K_S^0 production in semi-inclusive deep inelastic processes. [Phys. Rev. D **66**, 094001 (2002)]

From QCD lattice calculations to the equation of state of quark matter. A. Peshier, *Institut für Theoretische Physik, Universität Giessen, 35392 Giessen, Germany*; B. Kämpfer, *Forschungszentrum Rossendorf, PF 510119, 01314 Dresden, Germany*; G. Soff, *Institut für Theoretische Physik, TU Dresden, 01062 Dresden, Germany*. (Received 5 July 2002; published 12 November 2002)

We describe two-flavor QCD lattice data for the pressure at a nonzero temperature and vanishing chemical potential within a quasiparticle model. Relying only on thermodynamic consistency, the model is extended to nonzero chemical potential. The results agree with lattice calculations in the region of a small chemical potential. [Phys. Rev. D **66**, 094003 (2002)]

Diffraction production and the total cross section in deep inelastic scattering. Masaaki Kuroda, *Institute of Physics, Meiji-Gakuin University, Yokohama 244, Japan*; Dieter Schildknecht, *Fakultät für Physik, Universität Bielefeld, D-33501 Bielefeld, Germany*. (Received 19 July 2002; published 18 November 2002)

We explore the consequences for diffractive production, $\gamma^*p \rightarrow Xp$, in deep inelastic scattering at low values of $x \equiv Q^2/W^2 \ll 1$ that follow from our recent representation of the total photoabsorption cross section, σ_{γ^*p} , in the generalized vector dominance or color dipole picture that is based on the generic structure of the two-gluon exchange from QCD. Sum rules are derived that relate the transverse and the longitudinal (virtual) photoabsorption cross section to diffractive forward production of $q\bar{q}$ states that carry photon quantum numbers ("elastic diffraction"). Agreement with experiment in the W^2 and Q^2 dependence is found for $M_X^2/Q^2 \ll 1$, where M_X is the mass of the produced system X . An additional component ("inelastic diffraction"), not actively contributing to the

forward Compton amplitude, is needed for diffractive production at high values of M_X . Our previous theoretical representation of the total photoabsorption cross section, $\sigma_{\gamma^*p} = \sigma_{\gamma^*p}(\eta)$, in terms of the scaling variable $\eta \equiv (Q^2 + m_0^2)/\Lambda^2(W^2)$ is extended to include the entire kinematic domain, $x \leq 0.1$ and all Q^2 with $Q^2 \geq 0$, where scaling in η holds experimentally. [Phys. Rev. D **66**, 094005 (2002)]

Color-neutral superconducting quark matter. Andrew W. Steiner, *Department of Physics and Astronomy, State University of Stony Brook, Stony Brook, New York 11794*; Sanjay Reddy, *Center for Theoretical Physics, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139*; Madappa Prakash, *Department of Physics and Astronomy, State University of Stony Brook, Stony Brook, New York 11794*. (Received 28 May 2002; published 21 November 2002)

We investigate the consequences of enforcing local color neutrality on the color superconducting phases of quark matter by utilizing the Nambu–Jona-Lasinio model supplemented by diquark and the 't Hooft six-fermion interactions. In neutrino free matter at zero temperature, color neutrality guarantees that the number densities of u , d , and s quarks in the color-flavor-locked (CFL) phase will be equal even with physical current quark masses. Electric charge neutrality follows as a consequence and without the presence of electrons. In contrast, electric charge neutrality in the less symmetric 2-flavor superconducting (2SC) phase with ud pairing requires more electrons than the normal quark phase. The free energy density cost of enforcing color and electric charge neutrality in the CFL phase is lower than that in the 2SC phase, which favors the formation of the CFL phase. With increasing temperature and neutrino content, an unlocking transition occurs from the CFL phase to the 2SC phase with the order of the transition depending on the temperature, the quark and lepton number chemical potentials. The astrophysical implications of this rich structure in the phase diagram, including estimates of the effects from Goldstone bosons in the CFL phase, are discussed. [Phys. Rev. D **66**, 094007 (2002)]

Collective modes in color superconductors. Masaharu Iwasaki, *Department of Physics, Kochi University, Kochi 780-8520, Japan*; Keiji Yamaguchi and Osamu Miyamura, *Department of Physics, Hiroshima University, Higashi-Hiroshima 739-3526, Japan*. (Received 30 July 2002; published 22 November 2002)

We investigate the fluctuation effects of a gap parameter in color superconductors. The fluctuation modes are described as the collective motion of a diquark field. One of the modes is a massless Nambu-Goldstone boson and the other is a diquark boson whose mass is twice the gap energy. It is also shown that in the normal phase the fluctuation mode becomes a precursory (soft) mode whose mass and decay width are calculated near the critical temperature. We discuss the temperature dependence of such quantities in detail. [Phys. Rev. D **66**, 094008 (2002)]

Dilepton production from the color glass condensate. François Gelis, *Laboratoire de Physique Théorique, Bâtiment 210, Université Paris XI, 91405 Orsay Cedex, France*; Jamal Jalilian-Marian, *Physics Department, Brookhaven National Laboratory, Upton, New York 11973*. (Received 20 August 2002; published 25 November 2002)

We consider dilepton production in high energy proton-nucleus (and very forward nucleus-nucleus) collisions. Treating the target nucleus as a color glass condensate and describing the projectile proton (nucleus) as a collection of quarks and gluons as in the parton model, we calculate the differential cross section for dilepton production in quark-nucleus scattering and show that it is very sensitive to the saturation scale characterizing the target nucleus. [Phys. Rev. D **66**, 094014 (2002)]

Probing neutrino properties with charged scalar lepton decays. M. Hirsch,¹ W. Porod,² J. C. Romão,³ and J. W. F. Valle¹
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Supersymmetry with bilinear R -parity violation provides a predictive framework for neutrino masses and mixings in agreement with current neutrino oscillation data. The model leads to striking signals at future colliders through the R -parity violating decays of the lightest supersymmetric particle (LSP). Here we study charged scalar lepton decays and demonstrate that if the scalar tau is the LSP (i) it will decay within the detector, despite the smallness of the neutrino masses, (ii) the relative ratio of branching ratios $\text{Br}(\tilde{\tau}_1 \rightarrow e \Sigma \nu_i) / \text{Br}(\tilde{\tau}_1 \rightarrow \mu \Sigma \nu_i)$ is predicted from the measured solar neutrino angle, and (iii) scalar muon and scalar electron decays will allow us to test the consistency of the model. Thus, bilinear R -parity breaking SUSY will be testable at future colliders also in the case where the LSP is not the neutralino. [Phys. Rev. D **66**, 095006 (2002)]

Role of lepton flavor violating muon decay in the seesaw model and LSND. M. Jamil Aslam and Riazuddin, *National Centre for Physics, Quaid-i-Azam University, Islamabad, Pakistan*. (Received 19 June 2002; published 15 November 2002)

The aim of this work is to study lepton flavor violation in a newly proposed seesaw model of neutrino mass and to see whether it could explain the Liquid Scintillation Neutrino Detector excess. The motivation of this seesaw model is that there is no new physics beyond the TeV scale. By studying $\mu \rightarrow 3e$ in this model, it is shown that the upper bound on the branching ratio requires a Higgs boson mass m_h of a new scalar doublet with the lepton number $L = -1$ needed in this model to be about 9 TeV. The predicted branching ratio for $\mu \rightarrow e \nu_1 \nu_1$ is too small to explain the LSND. [Phys. Rev. D **66**, 096005 (2002)]

Unitarity quadrangles of four neutrino mixing. Wan-lei Guo and Zhi-zhong Xing, *CCAST (World Laboratory), P.O. Box 8730, Beijing 100080, China*, and *Institute of High Energy Physics, Chinese Academy of Sciences, P.O. Box 918 (4), Beijing 100039, China*. (Received 1 September 2002; published 26 November 2002)

We present a classification of the unitarity quadrangles in the four-neutrino mixing scheme. We find that there are totally thirty-six distinct topologies among twelve different unitarity quadrangles.

Concise relations are established between the areas of those unitarity quadrangles and the rephasing invariants of CP and T violation. [Phys. Rev. D **66**, 097302 (2002)]