

Selected Abstracts from Other Physical Review Journals

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Neutrino emission from Goldstone modes in dense quark matter. Prashanth Jaikumar and Madappa Prakash, *Department of Physics & Astronomy, SUNY at Stony Brook, New York 11794*; Thomas Schäfer, *Department of Physics & Astronomy, SUNY at Stony Brook, New York 11794, Department of Physics, Duke University, Durham, North Carolina 27708, and Riken-BNL Research Center, Brookhaven National Laboratory, Upton, New York 11973*. (Received 6 March 2002; published 12 September 2002)

We calculate neutrino emissivities from the decay and scattering of Goldstone bosons in the color-flavor-locked (CFL) phase of quarks at high baryon density. Interactions in the CFL phase are described by an effective low-energy theory. For temperatures in the tens of keV range, relevant to the long-term cooling of neutron stars, the emissivities involving Goldstone bosons dominate over those involving quarks, because gaps in the CFL phase are ~ 100 MeV while the masses of Goldstone modes are on the order of 10 MeV. For the same reason, the specific heat of the CFL phase is also dominated by the Goldstone modes. Notwithstanding this, both the emissivity and the specific heat from the massive modes remain rather small, because of their extremely small number densities. The values of the emissivity and the specific heat imply that the time scale for the cooling of the CFL core is $\sim 10^{26}$ yr, which makes the CFL phase invisible as the exterior layers of normal matter surrounding the core will continue to cool through significantly more rapid processes. If the CFL phase appears during the evolution of a protoneutron star, neutrino interactions with Goldstone bosons are expected to be significantly more important since temperatures are high enough (~ 20 – 40 MeV) to admit large number densities of Goldstone modes. [Phys. Rev. D **66**, 063003 (2002)]

Ultrahigh-energy neutrino fluxes and their constraints. Oleg E. Kalashev,¹ Vadim A. Kuzmin,¹ Dmitry V. Semikoz,^{1,2} and Günter Sigl³ ¹*Institute for Nuclear Research of the Academy of Sciences of Russia, Moscow 117312, Russia*, ²*Max-Planck-Institut für Physik (Werner-Heisenberg-Institut), Föhringer Ring 6, 80805 München, Germany*, ³*GRECO, Institut d'Astrophysique de Paris, C.N.R.S., 98 bis boulevard Arago, F-75014 Paris, France*. (Received 12 May 2002; published 12 September 2002)

Applying our recently developed propagation code we review extragalactic neutrino fluxes above 10^{14} eV in various scenarios and how they are constrained by current data. We specifically identify scenarios in which the cosmogenic neutrino flux above $\sim 10^{18}$ eV, produced by pion production of ultrahigh energy cosmic rays outside their sources, is considerably higher than the “Waxman-Bahcall bound.” This is easy to achieve for sources with hard injection spectra and luminosities that were higher in the past. Such fluxes would significantly increase the chances to detect ultra-

high energy neutrinos with experiments currently under construction or in the proposal stage. [Phys. Rev. D **66**, 063004 (2002)]

High-energy neutrino fluxes from supermassive dark matter. Patrick Crotty, *Department of Physics, University of Chicago, Chicago, Illinois 60637*. (Received 12 May 2002; published 16 September 2002)

We calculate the fluxes and energy spectra of high-energy ($E > 50$ GeV) neutrinos from the annihilations of supermassive ($10^8 \text{ GeV} < M < 10^{16} \text{ GeV}$), strongly interacting dark matter particles in the core of the Sun. We take all significant aspects of neutrino propagation through matter into account, as well as oscillations in matter and vacuum. We also calculate the resulting event rates in an idealized 1 km^3 ice detector. We find that the signal should be well above background and easily observed by next-generation neutrino detectors such as IceCube. [Phys. Rev. D **66**, 063504 (2002)]

General analysis with trilinear and bilinear R -parity violating couplings in the light of recent SNO data. Asmaa Abada, *Laboratoire de Physique Théorique, Université de Paris XI, Bâtiment 210, 91405 Orsay Cedex, France*; Gautam Bhattacharyya, *Laboratoire de Physique Théorique, Université de Paris XI, Bâtiment 210, 91405 Orsay Cedex, France* and Saha Institute of Nuclear Physics, 1/AF Bidhan Nagar, Kolkata 700064, India; Marta Losada, *Centro de Investigaciones, Universidad Antonio Nariño, Cll. 58A No. 37-94, Santa Fe de Bogotá, Colombia*. (Received 6 August 2002; published 11 October 2002)

We analyze an extension of the minimal supersymmetric standard model including the dominant trilinear and bilinear R -parity violating contributions. We take the trilinear terms from the superpotential and the bilinear terms from the superpotential as well as the scalar potential. We compute the neutrino masses induced by those couplings and determine the allowed ranges of the R -parity violating parameters that are consistent with the latest SNO results, atmospheric data and the CHOOZ constraint. We also estimate the effective mass for neutrinoless double beta decay in such scenarios. [Phys. Rev. D **66**, 071701 (2002)]

Collider signatures of neutrino masses and mixing from R -parity violation. Eung Jin Chun,¹ Dong-Won Jung,² Sin Kyu Kang,^{3,4} and Jong Dae Park² ¹*Korea Institute for Advanced Study, P.O. Box 201, Cheongryangri, Seoul 130-650, Korea*, ²*Department of Physics, Seoul National University, Seoul 151-747, Korea*, ³*Institute for Basic Science, Korea University, Seoul 136-701, Korea*, ⁴*Graduate School of Science, Hiroshima University, Higashi-*

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R -parity violation in the supersymmetric standard model can be the source of neutrino masses and mixing. We analyze the neutrino mass matrix coming from either bilinear or trilinear R -parity violation and its collider signatures, assuming that the atmospheric and solar neutrino data are explained by three active neutrino oscillations. Taking the gauge mediated supersymmetry breaking mechanism, we show that the lightest neutralino decays well inside the detector and the model could be tested by observing its branching ratios in future colliders. In the bilinear model where only the small solar neutrino mixing angle can be accommodated, the relation $10^3 \text{BR}(\nu e^\pm \tau^\mp) \sim \text{BR}(\nu \mu^\pm \tau^\mp) \approx \text{BR}(\nu \tau^\pm \tau^\mp)$ serves as a robust test of the model. The large mixing angle solution can be realized in the trilinear model which predicts $\text{BR}(\nu e^\pm \tau^\mp) \sim \text{BR}(\nu \mu^\pm \tau^\mp) \sim \text{BR}(\nu \tau^\pm \tau^\mp)$. In either case, the relation $\text{BR}(e jj) \ll \text{BR}(\mu jj) \sim \text{BR}(\tau jj)$ should hold to be consistent with the atmospheric neutrino and CHOOZ experiments. [Phys. Rev. D **66**, 073003 (2002)]

Neutrino oscillations due to nonuniversal gauge interactions in the weak sector. Ehab Malkawi, *Department of Physics, Jordan University of Science & Technology, Irbid 22110, Jordan.* (Received 13 July 2002; published 17 October 2002)

We discuss the structure of the neutrino mass matrix as derived from a nonuniversal electroweak gauge interaction model. We discuss two interesting patterns of neutrino masses. The first pattern is hierarchal which fits the large mixing angle or low probability, low mass solution of solar neutrino data. The second pattern gives rise to an inverted mass spectrum which fits the currently not preferred small mixing angle solution. The mechanism for generating a light sterile neutrino mass is interesting and is briefly discussed. [Phys. Rev. D **66**, 073004 (2002)]

Exact formulas and simple CP dependence of neutrino oscillation probabilities in matter with constant density. Keiichi Kimura, *Department of Physics, Nagoya University, Nagoya, 464-8602, Japan;* Akira Takamura, *Department of Physics, Nagoya University, Nagoya, 464-8602, Japan and Department of Mathematics, Toyota National College of Technology Eisei-cho 2-1, Toyota-shi, 471-8525, Japan;* Hidekazu Yokomakura, *Department of Physics, Nagoya University, Nagoya, 464-8602, Japan.* (Received 16 June 2002; published 29 October 2002)

We investigate neutrino oscillations in constant matter within the context of the standard three neutrino scenario. We derive an exact and simple formula for the oscillation probability applicable to all channels. In the standard parametrization, the probability for the $\nu_e \rightarrow \nu_\mu$ transition can be written in the form $P(\nu_e \rightarrow \nu_\mu) = A_{e\mu} \cos \delta + B_{e\mu} \sin \delta + C_{e\mu}$ without any approximation using the CP phase δ . For the $\nu_\mu \rightarrow \nu_\tau$ transition, the linear term of $\cos 2\delta$ is added and the probability can be written in the form $P(\nu_\mu \rightarrow \nu_\tau) = A_{\mu\tau} \cos \delta + B_{\mu\tau} \sin \delta + C_{\mu\tau} + D_{\mu\tau} \cos 2\delta$. We give the CP dependences of the probability for other channels. We show that the probability for each channel in matter has the same form with respect to δ as in vacuum. It means that matter effects just modify the coefficients A , B , C , and D . We also give the exact expression of the

coefficients for each channel. Furthermore, we show that our results with respect to CP dependences are reproduced from the effective mixing angles and the effective CP phase calculated by Zaglauer and Schwarzer. Through the calculation, a new identity is obtained by dividing the Naumov-Harrison-Scott identity by the Toshev identity. [Phys. Rev. D **66**, 073005 (2002)]

Saturation and Wilson line distribution. C. S. Lam, *Department of Physics, McGill University, 3600 University St., Montréal, Québec, Canada H3A 2T8;* Gregory Mahlon, *Department of Physics, Penn State Mont Alto, 1 Campus Drive, Mont Alto, Pennsylvania 17237;* Wei Zhu, *Department of Physics, East China Normal University, Shanghai 200062, China.* (Received 3 July 2002; published 11 October 2002)

We introduce a Wilson line distribution function $\bar{W}_\tau(v)$ to study gluon saturation at small Feynman x_F , or large $\tau = \ln(1/x_F)$. This new distribution can be obtained from the distribution $W_\tau(\alpha)$ of the color glass condensate model and the Jalilian-Marian-Iancu-McLerran-Weigert-Leonidov-Kovner (JIMWLK) renormalization group equation. $\bar{W}_\tau(v)$ is physically more relevant, and mathematically simpler to deal with because of unitarity of the Wilson line v . A JIMWLK equation is derived for $\bar{W}_\tau(v)$; its properties are studied. These properties are used to complete Mueller's derivation of the JIMWLK equation, though for $\bar{W}_\tau(v)$ and not $W_\tau(\alpha)$. They are used to derive a generalized Balitsky-Kovchegov equation for higher multipole amplitudes. They are also used to compute the unintegrated gluon distribution at $x_F=0$, yielding a completely flat spectrum in transverse momentum squared $\mathbf{k}^2$, with a known height. This is similar but not identical to the mean field result at small $\mathbf{k}^2$. [Phys. Rev. D **66**, 074005 (2002)]

QCD thermal phase transition in the presence of a small chemical potential. C. R. Allton,^{1,2} S. Ejiri,¹ S. J. Hands,^{1,3} O. Kaczmarek,⁴ F. Karsch,^{3,4} E. Laermann,⁴ Ch. Schmidt,⁴ and L. Scorzato¹ ¹*Department of Physics, University of Wales Swansea, Singleton Park, Swansea SA2 8PP, United Kingdom,* ²*Department of Mathematics, University of Queensland, Brisbane 4072, Australia,* ³*Institute for Theoretical Physics, University of California, Santa Barbara, California 93106-4030,* ⁴*Fakultät für Physik, Universität Bielefeld, D-33615 Bielefeld, Germany.* (Received 9 April 2002; published 29 October 2002)

We propose a new method to investigate the thermal properties of QCD with a small quark chemical potential μ . Derivatives of quark and gluonic observables with respect to μ are computed at $\mu=0$ for two flavors of $p4$ improved staggered fermions with $ma=0.1, 0.2$ on a $16^3 \times 4$ lattice, and used to calculate the leading order Taylor expansion in μ of the location of the pseudocritical point about $\mu=0$. This expansion should be well behaved for the small values of $\mu_q/T_c \sim 0.1$ relevant for BNL RHIC phenomenology, and predicts a critical curve $T_c(\mu)$ in reasonable agreement with estimates obtained using exact reweighting. In addition, we contrast the case of isoscalar and isovector chemical potentials, quantify the effect of $\mu \neq 0$ on the equation of state, and comment on the complex phase

of the fermion determinant in QCD with $\mu \neq 0$. [Phys. Rev. D **66**, 074507 (2002)]

Lepton flavor violation in the supersymmetric grand unified models with a lopsided mass matrix. Xiao-Jun Bi, *Department of Physics, Tsinghua University, Beijing 100084, People's Republic of China*; Yuan-Ben Dai, *Institute of Theoretical Physics, Academia Sinica, P. O. Box 2735, Beijing 100080, People's Republic of China*. (Received 10 April 2002; published 18 October 2002)

The tiny neutrino masses measured in neutrino oscillation experiments can be naturally explained via a supersymmetric seesaw mechanism. If supersymmetry breaking is mediated by gravity, such seesaw models may predict observable lepton flavor violating effects. In this work, we investigate the lepton flavor violating process $\mu \rightarrow e \gamma$ in supersymmetric seesaw models with a “lopsided” charged lepton mass matrix. Constraints set by the muon anomalous magnetic moment are taken into account. We find that such models generally predict a branching ratio for $\mu \rightarrow e \gamma$ far above the current experimental limit. Thus this process strongly constrains models of this type. Such restrictions suggest a novel form for the charged lepton mass matrix, featuring a “lopsided” structure for elements between both the 2-3 and the 1-3 generations. This structure produces a very small 1-3 mixing and a large 1-2 mixing in the charged lepton sector, leading naturally to a small $\text{Br}(\mu \rightarrow e \gamma)$ and to the large mixing angle solution for the solar neutrino problem. [Phys. Rev. D **66**, 076006 (2002)]

Universality of the coupling of neutrinos to Z. Eduard Massó, *Grup de Física Teòrica and Institut de Física d'Altes Energies, Universitat Autònoma de Barcelona, 08193 Bellaterra, Barcelona, Spain*. (Received 16 July 2002; published 23 October 2002)

We employ an effective Lagrangian approach and use CERN LEP data to place severe bounds on universality violations of the couplings of ν_e , ν_μ , and ν_τ to the Z boson. Our results justify the assumption of universality in these couplings that is usually made, such as, for example, in the analysis of solar neutrinos detected at SNO. [Phys. Rev. D **66**, 077301 (2002)]

Secondary neutrinos from tau neutrino interactions in Earth. Sharada Iyer Dutta, *Department of Physics, SUNY Stony Brook, Stony Brook, New York 11794*; Mary Hall Reno, *Department of Physics and Astronomy, University of Iowa, Iowa City, Iowa 52242*; Ina Sarcevic, *Department of Physics, University of Arizona, Tucson, Arizona 85721*. (Received 2 August 2002; published 29 October 2002)

The energy dependence of “secondary” neutrinos from the process $(\nu_\tau \rightarrow \tau \rightarrow \bar{\nu}_\mu \rightarrow \bar{\mu})$ for two input tau neutrino fluxes ($F_\nu^0 \sim E_\nu^{-1}$ and E_ν^{-2}), assumed to have been produced via neutrino oscillations from extragalactic sources, is evaluated to assess the impact of secondary neutrinos on upward muon rates in a km^3 detector. We show that the secondary fluxes are considerably suppressed for the steeper flux, and even for fluxes $\sim E_\nu^{-1}$ the secondary flux will be difficult to observe experimentally. [Phys. Rev. D **66**, 077302 (2002)]

Responses of quark condensates to the chemical potential. O. Miyamura,¹ S. Choe,² Y. Liu,¹ T. Takaishi,³ and A. Nakamura⁴
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The responses of quark condensates to the chemical potential, as a function of temperature T and chemical potential μ , are calculated within the Nambu–Jona-Lasinio (NJL) model. We compare our results with those from the recent lattice QCD simulations [QCD-TARO Collaboration, S. Choe *et al.*, Nucl. Phys. B (Proc. Suppl.) **106**, 462 (2002)]. The NJL model and lattice calculations show qualitatively similar behavior, and they will be complementary ways to study hadrons at finite density. The behavior above T_c requires more elaborated analyses. [Phys. Rev. D **66**, 077502 (2002)]