

Selected Abstracts from Physical Review D

Abstracts of papers published in Physical Review D which may be of interest to our readers are printed here.

Energy-dependent solar neutrino flux depletion in the exact parity model and implications for SNO, SuperKamiokande, and BOREXINO. Raymond R. Volkas and Yvonne Y. Y. Wong, *School of Physics, Research Centre for High Energy Physics, The University of Melbourne, Parkville 3052 Australia.* (Received 26 March 1998; published 20 October 1998)

Energy-dependent solar neutrino flux reduction caused by the Mikheyev-Smirnov-Wolfenstein (MSW) effect is applied to the exact parity model. Several scenarios are possible, depending on the region of parameter space chosen. The interplay between intergenerational MSW transitions and vacuum “intragenerational” ordinary-mirror neutrino oscillations is discussed. Expectations for the ratio of charged to neutral current event rates at the Sudbury Neutrino Observatory (SNO) are estimated. The implications of the various scenarios for the boron neutrino energy spectrum and BOREXINO are briefly discussed. The consequences of MSW-induced solar neutrino depletion within the exact parity model differ in interesting ways from the standard $\nu_e \leftrightarrow \nu_{\mu,\tau}$ and $\nu_e \leftrightarrow \nu_s$ cases. The physical causes of these differences are determined. [S0556-2821(98)10821-4] [Phys. Rev. D **58**, 113001 (1998)]

Bremsstrahlung process $\nu_\tau \rightarrow \nu_e e^+ e^- \gamma$. H. Schmid and G. Raffelt, *Max-Planck-Institut für Physik (Werner-Heisenberg-Institut), Föhringer Ring 6, 80805 München, Germany; A. Leike, Ludwig-Maximilians-Universität, Sektion Physik, Theresienstrasse 37, 80333 München, Germany.* (Received 21 April 1998; published 29 October 1998)

The bremsstrahlung process $\nu_\tau \rightarrow \nu_e e^+ e^- \gamma$ is the dominant photon-producing decay of heavy τ neutrinos with $m_{\nu_\tau} > 2m_e$ so that this process is instrumental for supernova 1987A constraints on the properties of these particles, notably on their mixing amplitude with ν_e . We calculate the rate of the bremsstrahlung process as well as the photon spectrum and the angular distribution relative to the spin direction of the parent neutrino. We carefully pay attention to the difference between Dirac and Majorana neutrinos. [S0556-2821(98)05517-9] [Phys. Rev. D **58**, 113004 (1998)]

Study of the day-night effect for the Super-Kamiokande detector. III. The case of transitions into sterile neutrino. M. Maris, *OAT, Osservatorio Astronomico di Trieste, Trieste, Italy and Scuola Internazionale Superiore di Studi Avanzati, Trieste, Italy; S. T. Petcov, Scuola Internazionale Superiore di Studi Avanzati, Trieste, Italy and INFN-Sezione di Trieste, Trieste, Italy.* (Received 4 March 1998; published 3 November 1998)

Using the results of a high precision calculation of the solar neutrino survival probability for Earth crossing neutrinos in the case of the Mikheyev-Smirnov-Wolfenstein (MSW) $\nu_e \rightarrow \nu_s$ transition solu-

tion of the solar neutrino problem, we derive predictions for the one-year averaged day-night ($D-N$) asymmetries in the deformed recoil- e^- spectrum and in the energy-integrated event rate due to the solar neutrinos, to be measured with the Super-Kamiokande detector. The asymmetries are calculated for three event samples, produced by the solar ν_e crossing the Earth mantle only, the core, and the mantle only + the core (the full night sample), for a large set of representative values of the MSW transition parameters Δm^2 and $\sin^2 2\theta_V$ from the “conservative” $\nu_e \rightarrow \nu_s$ solution regions, obtained by taking into account the possible uncertainties in the predictions for the ^8B and ^7Be neutrino fluxes. The effects of the uncertainties in the value of the bulk matter density and in the chemical composition of the Earth core on the predictions for the $D-N$ asymmetries are investigated. The dependence of the $D-N$ effect related observables on the threshold recoil- e^- kinetic energy, $T_{e,th}$, is studied. It is shown, in particular, that for $\sin^2 2\theta_V \leq 0.030$, the one year average $D-N$ asymmetry in the sample of events due to the core-crossing neutrinos is larger than the asymmetry in the full night sample by a factor which, depending on the solution value of Δm^2 , can be $\sim (3-4)$ ($\Delta m^2 < 5 \times 10^{-6} \text{ eV}^2$) or $\sim (1.5-2.5)$ ($5 \times 10^{-6} \text{ eV}^2 \leq \Delta m^2 \leq 8 \times 10^{-6} \text{ eV}^2$). We find, however, that at small mixing angles $\sin^2 2\theta_V \leq 0.014$, the $D-N$ asymmetry in the case of solar $\nu_e \rightarrow \nu_s$ transitions is considerably smaller than if the transitions were into an active neutrino, $\nu_e \rightarrow \nu_{\mu(\tau)}$. In particular, a precision better than 1% in the measurement of any of the three one year averaged $D-N$ asymmetries considered by us would be required to test the small mixing angle nonadiabatic $\nu_e \rightarrow \nu_s$ solution at $\sin^2 2\theta_V \leq 0.01$. For $0.0075 \leq \sin^2 2\theta_V \leq 0.03$, the magnitude of the $D-N$ asymmetry in the sample of events due to the core-crossing neutrinos is very sensitive to the value of the electron number fraction in the Earth’s core, $Y_e(\text{core})$: a change of $Y_e(\text{core})$ from the standard value of 0.467 to the conservative upper limit of 0.50 can lead to an increase of the indicated asymmetry by a factor of $\sim (3-4)$. Iso- $(D-N)$ asymmetry contours in the Δm^2 - $\sin^2 2\theta_V$ plane for the Super-Kamiokande detector are derived in the region $\sin^2 2\theta_V \geq 10^{-4}$ for the three event samples studied for $T_{e,th} = 5 \text{ MeV}$ and 7.5 MeV , and in the case of the samples due to the core crossing and (only mantle crossing+core crossing) neutrinos—for $Y_e(\text{core}) = 0.467$ and 0.50 . The possibility to discriminate between the $\nu_e \rightarrow \nu_s$ and $\nu_e \rightarrow \nu_{\mu(\tau)}$ solutions of the solar neutrino problem by performing high precision $D-N$ asymmetry measurements is also discussed.

[S0556-2821(98)06819-2] [Phys. Rev. D **58**, 113008 (1998)]

Further considerations on the CP asymmetry in heavy majorana neutrino decays. Marion Flanz and Emmanuel A. Paschos, *Institut für Physik, Universität Dortmund, 44221 Dortmund, Germany.* (Received 5 June 1998; published 6 November 1998)

We work out the thermodynamic equations for the decays and scatterings of heavy Majorana neutrinos including the constraints from unitarity. The Boltzmann equations depend on the CP asym-

metry parameter which contains both a self-energy and a vertex correction. At thermal equilibrium there is no net lepton asymmetry due to the *CPT* theorem and the unitarity constraint. We show explicitly that deviations from thermal equilibrium create lepton asymmetry.

[S0556-2821(98)11121-9] [Phys. Rev. D **58**, 113009 (1998)]

Canonical ensemble of initial states leading to chiral fluctuations. Dénes Molnár, *Physics Department, University of Bergen, N-5007 Bergen, Allégaten 55, Norway and Physics Department, Columbia University, New York, New York 10027*; László P. Csernai and Zsolt I. Lázár, *Physics Department, University of Bergen, N-5007 Bergen, Allégaten 55, Norway*. (Received 26 November 1997; revised manuscript received 26 June 1998; published 29 October 1998)

In energetic heavy ion collisions, if a quark-gluon plasma is formed, its hadronization may lead to observable critical fluctuations, i.e., DCC formation. The strength and observability of these fluctuations depend on the initial state. Here we study the canonical ensemble of initial states of chiral fluctuations in heavy ion collisions and the probability to obtain observable domains of chiral condensates. [S0556-2821(98)10121-2] [Phys. Rev. D **58**, 114018 (1998)]

Twist four longitudinal structure function in light-front QCD. A. Harindranath, Rajen Kundu, and Asmita Mukherjee, *Saha Institute of Nuclear Physics, 1/AF, Bidhan Nagar, Calcutta 700064 India*; James P. Vary, *International Institute of Theoretical and Applied Physics, Iowa State University, Ames, Iowa 50011 and Physics Department, Iowa State University, Ames, Iowa 50011*. (Received 30 April 1998; published 30 October 1998)

To resolve various outstanding issues associated with the twist four longitudinal structure function $F_L^{\tau=4}(x)$ we perform an analysis based on the BJL expansion for the forward virtual photon-hadron Compton scattering amplitude and equal (light-front) time current algebra. Using the Fock space expansion for states and operators, we evaluate the twist four longitudinal structure function for dressed quark and gluon targets in perturbation theory. With the help of a new sum rule which we have derived recently we show that the quadratic and logarithmic divergences generated in the bare theory are related to the corresponding mass shifts in old-fashioned light-front perturbation theory. We present numerical results for the F_2 and F_L structure functions for the meson in two-dimensional QCD in the one pair approximation. We discuss the relevance of our results for the problem of the partitioning of the hadron mass in QCD. [S0556-2821(98)02721-0] [Phys. Rev. D **58**, 114022 (1998)]

Polarized parton densities in the nucleon. Elliot Leader, *Department of Physics, Birkbeck College, University of London, Malet Street, London WC1E 7HX, England*; Aleksander V. Sidorov, *Bogoliubov Theoretical Laboratory, Joint Institute for Nuclear Research, 141980 Dubna, Russia*; Dimiter B. Stamenov, *Institute for Nuclear Research and Nuclear Energy, Bulgarian Academy of Sciences, Boulevard Tsarigradsko Chaussee 72, Sofia 1784, Bulgaria*. (Received 6 July 1998; published 4 November 1998)

We present a critical assessment of what can be learned from the present data on inclusive polarized DIS. We examine critically some of the simplifying assumptions made in recent analyses and study in detail the question of the determination of the gluon, strange sea, and valence quark polarized densities. We have also carried out a new NLO QCD analysis of the world data. We find an excellent fit to the data and present our results for the polarized parton densities. [S0556-2821(98)08321-0] [Phys. Rev. D **58**, 114028 (1998)]

Shadowing in neutrino deep inelastic scattering and the determination of the strange quark distribution. C. Boros, *Department of Physics and Mathematical Physics, and Special Research Center for the Subatomic Structure of Matter, University of Adelaide, Adelaide 5005, Australia*; J. T. Londergan, *Department of Physics and Nuclear Theory Center, Indiana University, Bloomington, Indiana 47404*; A. W. Thomas, *Department of Physics and Mathematical Physics, and Special Research Center for the Subatomic Structure of Matter, University of Adelaide, Adelaide 5005, Australia*. (Received 27 April 1998; published 6 November 1998)

We discuss shadowing corrections to the structure function F_2 in neutrino deep-inelastic scattering on heavy nuclear targets. In particular, we examine the role played by shadowing in the comparison of the structure functions F_2 measured in neutrino and muon deep inelastic scattering. The importance of shadowing corrections in the determination of the strange quark distributions is explained. [S0556-2821(98)01323-X] [Phys. Rev. D **58**, 114030 (1998)]

Is nucleon spin structure inconsistent with the constituent quark model? Di Qing, Xiang-Song Chen, and Fan Wang, *Department of Physics and Center for Theoretical Physics, Nanjing University, Nanjing 210093, People's Republic of China*. (Received 23 February 1998; published 9 November 1998)

Proton spin structure discovered in polarized deep inelastic scattering is shown to be consistent with the valence-sea quark mixing constituent quark model. The relativistic correction and quark-antiquark pair creation (annihilation) terms inherently involved in the quark axial vector current suppress the quark spin contribution to the proton spin. The relativistic quark orbital angular momentum provides compensative terms to keep the proton spin $\frac{1}{2}$ untouched. The tensor charge of the proton is predicted to have a similar but smaller suppression. An explanation on why baryon magnetic moments can be parametrized by the naive quark model spin content as well as the spin structure discovered in polarized deep inelastic scattering is given. [S0556-2821(98)06421-2] [Phys. Rev. D **58**, 114032 (1998)]

Gerasimov-Drell-Hearn sum rule and the single-pion photoproduction multipole E_{0+} close to threshold. D. Drechsel and G. Krein, *Institut für Kernphysik, Universität Mainz, 55099 Mainz, Germany*. (Received 27 April 1998; published 6 November 1998)

The long-standing discrepancy between the Gerasimov-Drell-Hearn sum rule and the analysis of pion photoproduction multipoles is greatly diminished by use of s-wave multipoles that are in accord

with the predictions of chiral perturbation theory and describe the experimental data in the threshold region. The remaining difference may be due to contributions of channels with more pions and/or heavier mesons whose contributions to the sum rule remain to be investigated by a direct measurement of the photoabsorption cross sections. [S0556-2821(98)05721-X] [Phys. Rev. D **58**, 116009 (1998)]

Extensive investigation of pion-pion scattering in the quark potential model. Guo-Quan Zhao, Xiao-Gong Jing, and Jun-Chen Su, *Center for Theoretical Physics, Department of Physics, Jilin University, Changchun 130023, People's Republic of China.* (Received 20 October 1997; revised manuscript received 23 February 1998; published 6 November 1998)

The QCD-inspired constituent quark potential model is employed to derive the pion-pion interacting potential by means of the resonating group method. In the derivation, we start from the t-channel one-gluon exchange potential and the s-channel one-gluon exchange potential we derived previously in the approximation of order v^2/c^2 . Use of the derived pionic potential to calculate low-energy pion-pion elastic scattering phase shifts leads to results which are in reasonably good agreement with the present experimental data. [S0556-2821(98)05817-2] [Phys. Rev. D **58**, 117503 (1998)]

Rapid cooling of magnetized neutron stars. Debades Bandyopadhyay,¹ Somenath Chakrabarty,^{2,3} Prantick Dey,² and Subrata Pal,¹ ¹*Saha Institute of Nuclear Physics, 1/AF Bidhannagar, Calcutta 700 064, India* ²*Department of Physics, University of Kalyani, Kalyani 741235, India* ³*IUCAA, P.B. 4, Ganeshkhind, Pune 411007, India.* (Received 9 April 1998; published 4 November 1998)

The neutrino emissivities resulting from direct Urca processes in neutron stars are calculated in a relativistic Dirac-Hartree approach in the presence of a magnetic field. In a quark or a hyperon matter environment, the emissivity due to the nucleon direct Urca process is suppressed relative to that from pure nuclear matter due to the appearance of new degrees of freedom. In all the cases studied, the

magnetic field enhances emissivity compared to the field-free cases because of phase space modifications and a shift in the dynamical β -equilibrium condition. [S0556-2821(98)50622-4] [Phys. Rev. D **58**, 121301 (1998)]

Hadronic gas chiral phase transition within generalized chiral perturbation theory. J. R. Peláez, *Stanford Linear Accelerator Center, Stanford University, Stanford, California 94309.* (Received 1 July 1998; published 13 November 1998)

We study the temperature evolution of the $\langle \bar{q}q \rangle$ condensate below the chiral phase transition. The hadronic gas is described using a virial expansion within generalized chiral perturbation theory. In such a way, we can implement both the large or small chiral condensate scenarios and analyze the condensate dependence on the values of the lightest quark masses. [S0556-2821(98)02123-7] [Phys. Rev. D **59**, 014002 (1998)]

Single transverse-spin asymmetries in hadronic pion production. Jianwei Qiu, *Physics Department, Brookhaven National Laboratory, Upton, New York 11973-5000;* George Sterman, *Institute for Theoretical Physics, State University of New York, Stony Brook, New York 11794-3840.* (Received 5 June 1998; published 13 November 1998)

We analyze single transverse-spin asymmetries for hadronic pion production at large transverse momenta using QCD factorization. In the large x_F region, leading contributions to the asymmetries are naturally produced by twist-3 parton correlation functions that couple quark fields and gluon field strengths. With a simple model for these matrix elements, leading-order asymmetries calculated from QCD are consistent with data on pion production from Fermilab, and can be used to predict single-spin asymmetries at BNL RHIC. We argue that our perturbative calculation for the asymmetries is relevant to pion transverse momenta as low as a few GeV. [S0556-2821(98)07423-2] [Phys. Rev. D **59**, 014004 (1998)]