

Selected Abstracts from Physical Review D

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Limits on active-sterile neutrino mixing and the primordial deuterium abundance. Christian Y. Cardall and George M. Fuller, *Department of Physics, University of California, San Diego, La Jolla, California 92093-0319.* (Received 20 March 1996)

Studies of limits on active-sterile neutrino mixing derived from big bang nucleosynthesis (BBN) considerations are extended to consider the dependence of these constraints on the primordial deuterium abundance. This study is motivated by recent measurements of D/H in quasar absorption systems, which at present yield discordant results. Limits on active-sterile mixing are somewhat relaxed for high D/H ($\approx 2 \times 10^{-4}$). For low D/H ($\approx 2 \times 10^{-5}$), no active-sterile neutrino mixing is allowed by currently popular upper limits on the primordial ^4He abundance Y . For such low primordial D/H values, the observational inference of active-sterile neutrino mixing by upcoming solar neutrino experiments would imply that Y has been systematically underestimated, unless there is new physics not included in standard BBN. [S0556-2821(96)50314-0] [Phys. Rev. D **54**, 1260 (1996)]

Superfluidity and neutron star crust matter. Ø. Elgarøy,¹ L. Engvik,¹ E. Osnes,¹ F. V. De Blasio,² M. Hjorth-Jensen,² and G. Lazzari.^{2,3} ¹*Department of Physics, University of Oslo, N-0316 Oslo, Norway* ²*European Centre for Theoretical Studies in Nuclear Physics and Related Areas, Trento, Italy* ³*Dipartimento di Fisica, Università di Milano, I-20133 Milano, Italy.* (Received 25 March 1996)

In this work we study the properties of neutron star crusts, where matter is expected to consist of nuclei surrounded by superfluid neutrons and a homogeneous background of relativistic electrons. Using a modern meson-exchange potential in the framework of a local-density approximation we calculate the neutronic specific heat accounting for various nuclear shapes. We find that a realistic nucleon-nucleon potential leads to an increase in the neutronic specific heat with respect to what is obtained with more phenomenological effective forces. The increase is largest for the nonspherical phase of the neutron star crust. The implications for the thermal history of young neutron stars are discussed. [S0556-2821(96)06014-6] [Phys. Rev. D **54**, 1848 (1996)]

Short-baseline neutrino oscillations and neutrinoless double- β decay in the framework of three neutrino mixing and a mass hierarchy. S. M. Bilenky,¹ A. Bottino,² C. Giunti,² and C. W. Kim,³ ¹*Joint Institute for Nuclear Research, Dubna, Russia and SISSA-ISAS, Trieste, Italy* ²*INFN, Sezione di Torino and Dipartimento di Fisica Teorica, Università di Torino, Via P. Giuria 1, 10125 Torino, Italy* ³*Department of Physics and Astronomy, The Johns Hopkins University, Baltimore, Maryland 21218.* (Received 5 February 1996)

We have analyzed the results of the latest terrestrial neutrino oscillation experiments in the framework of a model with mixing of three massive neutrinos and a neutrino mass hierarchy ($m_1 \ll m_2 \ll m_3$). In this model, oscillations of the terrestrial neutrinos are characterized by three parameters, $\Delta m^2 \equiv m_3^2 - m_1^2$ and the squared moduli of the two mixing matrix elements U_{e3} and $U_{\mu 3}$. Using the results of disappearance experiments and solar neutrino experiments, it is shown that only two regions of possible values of $|U_{e3}|^2$ and $|U_{\mu 3}|^2$ are allowed: (I) $|U_{e3}|^2$ and $|U_{\mu 3}|^2$ are both small and (II) $|U_{e3}|^2$ is small and $|U_{\mu 3}|^2$ is large. If the mixing parameters are in region I, $\nu_\mu \leftrightarrow \nu_e$ oscillations are suppressed. In this case the LSND indication in favor of $\nu_\mu \leftrightarrow \nu_e$ oscillations is not compatible with the negative results of all other experiments. If the mixing parameters are in region II, $\nu_e \leftrightarrow \nu_\tau$ oscillations are strongly suppressed. If massive neutrinos are Majorana particles, our analysis shows that neutrinoless double- β decay could be observed in the experiments of the next generation only if the mixing parameters are in region I. [S0556-2821(96)02415-0]

Polarized structure function g_2 in the c.m. bag model. X. Song, *Institute of Nuclear and Particle Physics, Department of Physics, University of Virginia, Charlottesville, Virginia 22901.* (Received 1 November 1995)

The spin-dependent structure functions $g_1(x)$, $g_2(x)$, $g_2^{WW}(x)$, and $\bar{g}_2(x)$ and their moments are studied in the c.m. bag model. The results show the following: (i) $\int_0^1 g_2(x) dx = 0$, i.e., the Burkhardt-Cottingham sum rule holds; hence, $g_2(x)$ must have at least one nontrivial zero in addition to $x=0$ and $x=1$. (ii) $\int_0^1 x^2 g_2(x) dx$ is negative for the proton, neutron, and deuteron. (iii) $\int_0^1 x^2 g_2(x) dx$ is about one order of magnitude smaller than $\int_0^1 x^2 g_1(x) dx$; hence, the twist-3 matrix element is approximately equal to the twist-2 matrix element. The results are compared with most recent data and predictions from the MIT bag model, lattice QCD, and QCD sum rules. [S0556-2821(96)03113-X] [Phys. Rev. D **54**, 1955 (1996)]

Simple description of $\pi\pi$ scattering to 1 GeV. Masayasu Harada, *Department of Physics, Syracuse University, Syracuse, New York 13244-1130;* Francesco Sannino, *Department of Physics, Syracuse University, Syracuse, New York 13244-1130 and Dipartimento di Scienze Fisiche, Mostra d'Oltremare Pad. 19, 80125 Napoli, Italia;* Joseph Schechter, *Department of Physics, Syracuse University, Syracuse, New York 13244-1130.* (Received 16 November 1995)

Motivated by the $1/N_c$ expansion, we present a simple model of $\pi\pi$ scattering as a sum of a *current-algebra* contact term and resonant pole exchanges. The model preserves crossing symmetry as well as unitarity up to 1.2 GeV. Key features include chiral dynamics, vector meson dominance, a broad low energy scalar (σ) meson, and a *Ramsauer-Townsend* mechanism for the understanding of the 980 MeV region. We discuss in detail the *regularization* (corre-

sponding to rescattering effects) necessary to make all these nice features work. [S0556-2821(96)00615-7] [Phys. Rev. D **54**, 1991 (1996)]

Relations between the Sudbury Neutrino Observatory and the Super Kamiokande solar neutrino rates. Waikwok Kwong and S. P. Rosen, *Department of Physics, University of Texas at Arlington, Arlington, Texas 76019-0059*. (Received 13 February 1996)

We develop a model-independent method for analyzing the SNO and Super Kamiokande solar neutrino experiments simultaneously, and for establishing relations between them. Representing the rates for the two experiments by a point in a two-dimensional rate-space diagram, we determine the regions of the diagram corresponding to different solutions of the solar neutrino problem. We can then use the method to ascertain which theoretical hypotheses are consistent with the observed rates. [S0556-2821(96)04815-1] [Phys. Rev. D **54**, 2043 (1996)]

Matter-enhanced three-flavor oscillations and the solar neutrino problem. G. L. Fogli, *Dipartimento di Fisica and Sezione INFN, Bari, Italy*; E. Lisi, *Institute for Advanced Study, Princeton, New Jersey 08540 and Dipartimento di Fisica and Sezione INFN, Bari, Italy*; D. Montanino, *Dipartimento di Fisica and Sezione INFN, Bari, Italy*. (Received 25 March 1996)

We present a systematic analysis of the three-flavor Mikheyev-Smirnov-Wolfenstein (MSW) oscillation solutions to the solar neutrino problem, in the hypothesis that the two independent neutrino square mass differences, δm^2 and m^2 , are well separated: $\delta m^2 \ll m^2$. At zeroth order in $\delta m^2/m^2$, the relevant variables for solar neutrinos are δm^2 and two mixing angles ω and ϕ . We introduce new graphical representations of the parameter space $(\delta m^2, \omega, \phi)$ that prove useful both to analyze the properties of the electron-neutrino survival probability and to present the results of the analysis of solar neutrino data. We make a detailed comparison between the theoretical predictions of the Bahcall-Pinsonneault standard solar model and the current experimental results on solar neutrino rates, and discuss thoroughly the MSW solutions found by spanning the whole three-flavor space $(\delta m^2, \omega, \phi)$. The allowed regions can be radically different from the usual "small mixing" and "large mixing" solutions, characteristic of the usual two-generation MSW approach. We also discuss the link between these results and the independent information on neutrino masses and mixings coming from accelerator and reactor oscillation searches. [S0556-2821(96)03415-7] [Phys. Rev. D **54**, 2048 (1996)]

F/D ratio in hyperon β decays and the spin distribution in the nucleon. X. Song, P. K. Kabir, and J. S. McCarthy, *Institute of Nuclear and Particle Physics, Department of Physics, University of Virginia, Charlottesville, Virginia 22901*. (Received 22 February 1996)

It is shown that hyperon β decay data can be well accommodated within the framework of Cabibbo's SU(3) symmetric description if one allows for a small SU(3) symmetry breaking proportional to the mass difference between strange and nonstrange quarks. The F/D

ratio does not depend sensitively on the exact form of the symmetry breaking, and the best fits are close to the value previously used in the analysis of deep inelastic scattering of electrons or muons on polarized nucleons. The total quark helicity and strange quark polarization in the nucleon are discussed. [S0556-2821(96)02315-6] [Phys. Rev. D **54**, 2108 (1996)]

Can the SU(3) chiral quark soliton model describe the nucleon properties better than the SU(2) model? M. Wakamatsu, *Department of Physics, Faculty of Science, Osaka University, Toyonaka, Osaka 560, Japan*. (Received 4 December 1995)

A comparative analysis of the $\pi N \sigma$ term is carried out within the flavor SU(2) as well as the SU(3) versions of the chiral quark soliton model. The validity of the latter model relies upon the approximate degeneracy of the strange and nonstrange quark masses, since its basic dynamical assumption, i.e., the SU(3) symmetric collective quantization and the subsequent perturbative treatment of the strange quark mass, is justified only on such a condition. We argue that a relatively large admixture of the $s\bar{s}$ component in the nucleon is a characteristic feature of this SU(3) symmetric rotation, but it simultaneously predicts a considerably small $\pi N \sigma$ term as compared with the prediction of the SU(2) model, which is interpreted as indicating a limitation of the SU(3) collective coordinate approach to the physics of the strangeness content of the nucleon. [S0556-2821(96)00415-8] [Phys. Rev. D **54**, 2161 (1996)]

Time evolution of the chiral phase transition during a spherical expansion. Melissa A. Lampert and John F. Dawson, *Department of Physics, University of New Hampshire, Durham, New Hampshire 03824*; Fred Cooper, *Theoretical Division, Los Alamos National Laboratory, Los Alamos, New Mexico 87545*. (Received 11 March 1996)

We examine the nonequilibrium time evolution of the hadronic plasma produced in a relativistic heavy ion collision, assuming a spherical expansion into the vacuum. We study the O(4) linear σ model to leading order in a large- N expansion. Starting at a temperature above the phase transition, the system expands and cools, finally settling into the broken symmetry vacuum state. We consider the proper time evolution of the effective pion mass, the order parameter $\langle \sigma \rangle$, and the particle number distribution. We examine several different initial conditions and look for instabilities (exponentially growing long wavelength modes) which can lead to the formation of disoriented chiral condensates (DCC's). We find that instabilities exist for proper times which are less than 3 fm/c. We also show that an experimental signature of domain growth is an increase in the low momentum spectrum of outgoing pions when compared to an expansion in thermal equilibrium. In comparison to particle production during a longitudinal expansion, we find that in a spherical expansion the system reaches the "out" regime much faster and more particles get produced. However the size of the unstable region, which is related to the domain size of DCC's, is not enhanced. [S0556-2821(96)02215-1] [Phys. Rev. D **54**, 2213 (1996)]

Sidewise dispersion relations and the structure of the nucleon vertex. R. M. Davidson and G. I. Poulis, *National Institute for Nuclear Physics and High-Energy Physics (NIKHEF), P.O. Box*

41882, NL-1009 DB Amsterdam, The Netherlands. (Received 21 March 1996)

We reexamine sidewise dispersion relations as a method to relate the nucleon off-shell form factor to observable quantities, namely, the meson-nucleon scattering phase shifts. It is shown how for meson-nucleon scattering a redefinition of the intermediate fields leaves the scattering amplitude invariant, but changes the behavior of the off-shell form factor as expressed through dispersion relations, thus, showing representation dependence. We also employ a coupled-channel, unitary model to test the validity of approximations concerning the influence of inelastic channels in the sidewise dispersion relation method. [S0556-2821(96)02615-X] [Phys. Rev. D **54**, 2228 (1996)]

Analytic calculation of prompt photon plus associated heavy flavor at next-to-leading order in QCD. Edmond L. Berger and L. E. Gordon, *High Energy Physics Division, Argonne National Laboratory, Argonne, Illinois 60439*. (Received 18 December 1995)

Contributions through second order, $O(\alpha_s^2)$, in perturbative quantum chromodynamics are calculated analytically for inclusive associated production of a prompt photon and a charm quark at large values of transverse momentum in high energy hadron-hadron collisions. Seven partonic subprocesses contribute at order α_s^2 . We find important corrections to the lowest order, $O(\alpha_s)$, subprocess $cg \rightarrow \gamma c$. We demonstrate to what extent data from $p + p \rightarrow \gamma + c + X$ may serve to measure the charm quark density in the nucleon. [S0556-2821(96)01015-6] [Phys. Rev. D **54**, 2279 (1996)]