Selected Abstracts from Other Physical Review Journals

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Solar neutrino event spectra: Tuning SNO to equalize Super-Kamiokande. G. L. Fogli, E. Lisi, and A. Palazzo, *Dipartimento di Fisica and Sezione INFN di Bari, Via Amendola 173, I-70126 Bari, Italy;* F. L. Villante, *Dipartimento di Fisica and Sezione INFN di Ferrara, Via del Paradiso 12, I-44100 Ferrara, Italy.* (Received 5 March 2001; published 8 May 2001)

The Super-Kamiokande (SK) and the Sudbury Neutrino Observatory (SNO) experiments are monitoring the flux of ^{8}B solar neutrinos through the electron energy spectrum from the reactions $\nu_{e,\mu,\tau}+e^-\rightarrow\nu_{e,\mu,\tau}+e^-$ and $\nu_e+d\rightarrow p+p+e^-$, respectively. We show that the SK detector response to ^{8}B neutrinos in each bin of the electron energy spectrum (above 8 MeV) can be approximated, with good accuracy, by the SNO detector response in an appropriate electron energy range (above 5.1 MeV). For instance, the SK response in the bin $[10, 10.5]$ MeV is reproduced (''equalized'') within $\sim 2\%$ by the SNO response in the range $[7.1, 11.75]$ MeV. As a consequence, in the presence of active neutrino oscillations, the SK and SNO event rates in the corresponding energy ranges turn out to be linearly related, for any functional form of the oscillation probability. Such equalization is not spoiled by the possible contribution of hep neutrinos (within current phenomenological limits). In perspective, when the SK and the SNO spectra will both be measured with high accuracy, the SK-SNO equalization can be used to determine the *absolute* ^{8}B neutrino flux, and to cross-check the (non)observation of spectral deviations in SK *and* SNO. At present, as an exercise, we use the equalization to ''predict'' the SNO energy spectrum, on the basis of the current SK data. Finally, we briefly discuss some modifications or limitations of our results in the case of sterile ν oscillations and of relatively large Earth matter effects. [Phys. Rev. D **63**, 113016 (2001)]

Small, dense quark stars from perturbative QCD. Eduardo S. Fraga and Robert D. Pisarski, *Department of Physics, Brookhaven National Laboratory, Upton, New York 11973-5000;* Jürgen Schaffner-Bielich, *RIKEN BNL Research Center, Brookhaven National Laboratory, Upton, New York 11973-5000.* (Received 6 February 2001; published 25 May 2001)

As a model for nonideal behavior in the equation of state of QCD at high density, we consider cold quark matter in perturbation theory. To second order in the strong coupling constant α_s, the results depend sensitively on the choice of the renormalization mass scale. Certain choices of this scale correspond to a strongly first order chiral transition, and generate quark stars with maximum masses and radii approximately half that of ordinary neutron stars. At the center of these stars, quarks are essentially massless. [Phys. Rev. D **63**, 121702 (2001)]

Matter effect to *T* violation at a neutrino factory. Takahiro Miura, Eiichi Takasugi, and Yoshitaka Kuno, *Department of Physics, Osaka University, Toyonaka, Osaka 560-0043, Japan;* Masaki Yoshimura, *Department of Physics, Ritsumeikan University, Kusatsu, Shiga 525-8577, Japan.* (Received 15 February 2001; published 21 May 2001)

We analyze T violation in neutrino oscillations by using perturbation methods with respect to $\Delta m^2_{21}L/2E$ and $\delta a(x)L/2E$, where $\delta a(x)$ represents the matter density fluctuation from its average value. We find that the matter contribution to T violation arises from interference between $\Delta m^2_{21}L/2E$ and $\delta a(x)L/2E$. To second order, the symmetric and asymmetric matter density fluctuations give effects to the $\sin\delta$ (intrinsic) and the $\cos\delta$ (fake) parts of T violation. We give their analytic forms and analyze the matter contribution to the $\sin\delta$ and $\cos\delta$ terms. We find that, for $L=3000$ km, both the symmetric and asymmetric matter density fluctuations give negligible contributions to T violation and that thus the constant (average) matter density gives a good approximation. On the other hand, we argue that, for $L=7000$ km or longer, T violation turns out to become very small due to the cancellation between the first and second order terms. This shows that the constant (average) matter approximation is not valid. [Phys. Rev. D **64**, 013002 (2001)]

Photon-neutrino interactions in a magnetic field through the neutrino magnetic moment. Ashok Goyal, *Department of Physics and Astrophysics, University of Delhi, Delhi-110 007, India and InterUniversity Centre for Astronomy and Astrophysics, Ganeshkhind, Pune 411007, India.* (Received 21 November 2000; published 31 May 2001)

We study neutrino-photon processes such as $\gamma\gamma\rightarrow\nu\bar{\nu}$ in the presence of a uniform external magnetic field for the case when neutrinos can couple to the electromagnetic field directly through their dipole magnetic moment and obtain the stellar energy loss. The process would be of special relevance in astrophysical situations where standard left-handed neutrinos are trapped and the right-handed neutrinos produced through the spin flip interaction induced by the neutrino magnetic moment alone can freely stream out. [Phys. Rev. D **64**, 013005 (2001)]

Evolution of the neutrino state inside the Sun. Alexander Friedland, *Theoretical Physics Group, Ernest Orlando Lawrence Berkeley National Laboratory, University of California, Berkeley, California 94720 and School of Natural Sciences, Institute for Advanced Study, Einstein Drive, Princeton, New Jersey 08540.* (Received 2 November 2000; published 31 May 2001)

We reexamine the conventional physical description of the neutrino evolution inside the Sun. We point out that the traditional notion of resonance is a useful physical concept only in the limit of small values of the neutrino mixing angle, $\theta \ll 1$. For large values of θ, the resonance condition specifies neither the point of the maximal violation of adiabaticity in the nonadiabatic case, nor the point where the flavor conversion occurs at the maximal rate in the adiabatic case. The corresponding correct conditions, valid for all values of θ including $\theta > \pi/4$, are presented. The adiabaticity condition valid for all values of θ is also described. The results of accurate numerical computations of the level jumping probability in the Sun are presented. These calculations cover a wide range of Δm^2, from the vacuum oscillation region to the region where the standard exponential approximation is good. A convenient empirical parametrization of these results in terms of elementary functions is given. The matter effects in the so-called ''quasivacuum oscillation regime'' are discussed. Finally, it is shown how the known analytical results for the exponential, $1/x$, and linear matter distributions can be simply obtained from the formula for the hyperbolic tangent profile. A new expression for the jumping probability for the distribution $N_e \propto [\coth(x/l) \pm 1]$ is obtained. [Phys. Rev. D **64**, 013008 (2001)]

Three-flavor oscillation solutions for the solar neutrino problem. H. Schlattl, *Max-Planck-Institut für Astrophysik, Karl-Schwarzschild-Str. 1, 85741 Garching, Germany.* (Received 5 May 2000; revised manuscript received 6 February 2001; published 1 June 2001)

The good agreement of standard solar models with helioseismology and the combined analysis of the solar neutrino experiments suggest that the solution of the solar neutrino problem is located in particle physics rather than in astrophysics. The most promising solution is neutrino oscillations, which usually are analyzed within the reduced two-flavor scheme, because the solutions found therein reasonably well reproduce the recent data of Super-Kamiokande about the recoil-electron energy spectrum, zenith-angle and seasonal variations, and the event rate data of all the neutrino detectors. In this work, however, a survey of the complete parameter space of three-flavor oscillations is performed. Basically 8 three-flavor solutions could be identified, where the best one with $\Delta m^2_{12} = 2.7 \times 10^{-10}$ eV^2, $\Delta m^2_{13} = 1.0 \times 10^{-5}$ eV^2, $\Theta_{12} = 23°$, and $\Theta_{13} = 1.3°$ (denoted SVO) is slightly more probable than any two-flavor solution. However, as the greatest value for Δm^2_{23} of these three-flavor solutions is about 2.5×10^{-4} eV^2, none of these solutions is consistent with the results of the atmospheric neutrino problem where $\Delta m^2_{23} \gtrsim 10^{-3}$ eV^2. The relatively weak improvement of the fit using three-flavor instead of two-flavor oscillations, which appears to be due to an inconsistency of the different kinds of data, indicates that there are possibly still systematic errors in at least one data set or that the statistics is not yet sufficient. In addition, the abilities of SNO and Borexino to discriminate the various two- and three-flavor solutions are investigated. Only with very good statistics in these experiments can the correct solution to the solar neutrino problem be identified unambiguously. [Phys. Rev. D **64**, 013009 (2001)]

Remarks on flavor-neutrino propagators and oscillation formulas. Kanji Fujii and Chikage Habe, *Department of Physics, Faculty of Science, Hokkaido University, Sapporo 060-0810, Japan;* Tetsuo Yabuki, *Rakunou Gakuen University, Ebetsu 069-0836, Japan.* (Received 12 October 2000; published 4 June 2001)

We examine the general structure of the formulas of neutrino oscillations proposed by Blasone and Vitiello (BV). Reconstructing their formulas with the retarded propagators of the flavor-neutrino fields for the case of many flavors, we can get easily the formulas which satisfy the suitable boundary conditions and are independent of arbitrary mass parameters $\{\mu_\rho\}$, as obtained by BV for the case of two flavors. In this two-flavor case, our formulas reduce to those obtained by BV under a T-invariance condition. Furthermore, the reconstructed probabilities are shown to coincide with those derived with recourse to the mass Hilbert space $\mathcal{H}_m$ which is unitarily inequivalent to the flavor Hilbert space $\mathcal{H}_f$. Such a situation is not found in the corresponding construction in the manner of BV. Then the new factors in BV's formulas, which modify the usual oscillation formulas, are not the trace of the flavor Hilbert space construction, but come from Bogolyubov transformation among the operators of spin-$\frac{1}{2}$ neutrinos with different masses. [Phys. Rev. D **64**, 013011 (2001)]

Predicting neutron production from cosmic-ray muons. Y.-F. Wang, V. Balic, and G. Gratta, *Physics Department, Stanford University, Stanford, California 94305;* A. Fassò and S. Roesler, *Stanford Linear Accelerator Center, Stanford, California 94309;* A. Ferrari, *INFN, Sezione di Milano, Via Celoria 16, I-20133, Milano, Italy.* (Received 26 January 2001; published 5 June 2001)

Fast neutrons from cosmic-ray muons are an important background to underground low-energy experiments. The estimate of such a background is often hampered by the difficulty of measuring and calculating neutron production with sufficient accuracy. Indeed substantial disagreement exists between the different analytical calculations performed so far, while data reported by different experiments are not always consistent. We discuss a new unified approach to estimate the neutron yield, the energy spectrum, the multiplicity, and the angular distribution from cosmic muons using the Monte Carlo simulation package FLUKA and show that it gives a good description of most of the existing measurements once the appropriate corrections have been applied. [Phys. Rev. D **64**, 013012 (2001)]

Role of the Delta (1232) in deep inelastic scattering on polarized ^{3}He and extraction of the neutron spin structure function $g_1^n(x,Q^2)$. C. Boros and V. Guzey, *Special Research Centre for the Subatomic Structure of Matter (CSSM), Adelaide University, 5005, Australia;* M. Strikman, *The Pennsylvania State University, University Park, Pennsylvania 16802;* A. W. Thomas, *Special Research Centre for the Subatomic Structure of Matter (CSSM) and The Department of Physics and Mathematical Physics, Adelaide University, 5005, Australia.* (Received 28 November 2000; revised manuscript received 1 March 2001; published 4 June 2001)

We consider the effect of the transitions $n \to \Delta^0$ and $p \to \Delta^+$ in deep inelastic scattering on polarized ^{3}He on the extraction of the neutron spin structure function $g_1^n(x,Q^2)$. Making the natural assumption that these transitions are the dominant non-nucleonic contributions to the renormalization of the axial vector coupling constant in the $A=3$ system, we find that the effect of Δ increases $g_1^n(x,Q^2)$ by $15-30\,\%$ in the range $0.2 \leqslant x \leqslant 0.6$, where our considerations are applicable and the data for $g_1^n(x,Q^2)$ exist. [Phys. Rev. D **64**, 014025 (2001)]

Polarization properties of the charmed baryon Λ_c^+ in the $\Lambda_c^+ \to p + K^- + \pi^+ + \pi^0$ decay. A. Ya. Berdnikov, Ya. A. Berdnikov, A. N. Ivanov, V. F. Kosmach, M. D. Scadron, and N. I. Troitskaya, *Institut für Kernphysik, Technische Universität Wien, Wiedner Hauptstr. 8-10, A-1040 Vienna, Austria.* (Received 28 November 2000; revised manuscript received 15 March 2001; published 5 June 2001)

The polarization properties of the charmed Λ_c^+ baryon are investigated in the weak nonleptonic four-body $\Lambda_c^+ \to p + K^- + \pi^+ + \pi^0$ decay. The probability of this decay and the angular distribution of the probability are calculated in the effective quark model with chiral $U(3) \times U(3)$ symmetry incorporating heavy quark effective theory and the extended Nambu–Jona-Lasinio model with a linear realization of chiral $U(3) \times U(3)$ symmetry. The theoretical value of the probability of the decay $\Lambda_c^+ \to p + K^- + \pi^+ + \pi^0$ relative to the probability of the decay $\Lambda_c^+ \to p + K^- + \pi^+$ does not contain free parameters and fits experimental data well. The application of the obtained results to the analysis of the polarization of the Λ_c^+ produced in the processes of photo- and hadroproduction is discussed. [Phys. Rev. D **64**, 014027 (2001)]

QCD factorization for $B \to PP$. Dongsheng Du, *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;* Deshan Yang and Guohuai Zhu, *Institute of High Energy Physics, Chinese Academy of Sciences, P.O. Box 918(4), Beijing 100039, China.* (Received 13 October 2000; revised manuscript received 21 March 2001; published 11 June 2001)

In this work, we give a detailed discussion for QCD factorization involved in the complete chirally enhanced power corrections in the heavy quark limit for B decays to two light pseudoscalar mesons, and present some detailed calculations of radiative corrections at the order of α_s. We point out that the infrared finiteness of the vertex corrections in the chirally enhanced power corrections requires twist-3 light-cone distribution amplitudes (LCDAs) of the light pseudoscalar symmetric. However, even in the symmetric condition, there is also a logarithmic divergence from the end points of the twist-3 LCDAs in the hard spectator scattering. We point out that the decay amplitudes of $B \to PP$ predicted by QCD factorization are really free of the renormalization scale dependence, at least at the order of α_s. At last, we briefly compare the QCD factorization with the generalized factorization and PQCD method. [Phys. Rev. D **64**, 014036 (2001)]

Non-Gaussian correlations in the McLerran-Venugopalan model. C. S. Lam, *Department of Physics, McGill University, 3600 University Street, Montréal, Québec, Canada H3A 2T8;* Gregory Mahlon, *Department of Physics, McGill University, 3600 University Street, Montréal, Québec, Canada H3A 2T8 and Department of Physics, University of Arizona, 1118 East Fourth Street, Tucson, Arizona 85721.* (Received 1 March 2001; published 31 May 2001)

We argue that the statistical weight function $W[\rho]$ appearing in the McLerran-Venugopalan model of a large nucleus is intrinsically non-Gaussian, even if we neglect quantum corrections. Based on the picture where the nucleus of radius R consists of a collection of color-neutral nucleons, each of radius $a \ll R$, we show that to leading order in α_s and a/R only the Gaussian part of $W[\rho]$ enters into the final expression for the gluon number density. Thus, the existing results in the literature which assume a Gaussian weight remain valid. [Phys. Rev. D **64**, 016004 (2001)]

Pion production in nonequilibrium chiral perturbation theory. A. Gómez Nicola, *Departamento de Física Teórica II, Universidad Complutense, 28040 Madrid, Spain.* (Received 15 March 2001; published 12 June 2001)

We apply the formalism of chiral perturbation theory out of thermal equilibrium to describe explosive production of pions via the parametric resonance mechanism. To lowest order the Lagrangian is that of the nonlinear sigma model where the pion decay constant becomes a time-dependent function. This model allows for a consistent nonequilibrium formulation within the framework of the closed time path method, where one-loop effects can be systematically accounted for and renormalized. We work in the narrow resonance regime where there is only one resonant band. The pion distribution function is peaked around the resonant band where the number of pions grow exponentially in time. The present approach is limited to remain below the back-reaction time, although it accounts for nearly all the pion production during the typical plasma lifetime. Our results agree with the analysis performed in the $O(4)$ model. The space and time components $f_\pi^{s,t}(t)$ are also analyzed. To one loop $f_\pi^s \neq f_\pi^t$ unlike the equilibrium case and their final central values are lower than the initial ones. This effect can be interpreted in terms of a reheating of the plasma. [Phys. Rev. D **64**, 016011 (2001)]

Sterile neutrino hot, warm, and cold dark matter. Kevork Abazajian, George M. Fuller, and Mitesh Patel, *Department of Physics, University of California, San Diego, La Jolla, California 92093-0319.* (Received 30 January 2001; published 31 May 2001)

We calculate the incoherent resonant and non-resonant scattering production of sterile neutrinos in the early universe. We find ranges of sterile neutrino masses, vacuum mixing angles, and initial lepton numbers which allow these species to constitute viable hot, warm, and cold dark matter (HDM, WDM, CDM) candidates which meet observational constraints. The constraints considered here include energy loss in core collapse supernovae, energy density limits at big bang nucleosynthesis, and those stemming from sterile neutrino decay: limits from observed cosmic microwave background anisotropies, diffuse extragalactic background radiation, and ^{6}Li/D overproduction. Our calculations explicitly include matter effects, both effective mixing angle suppression and enhancement (MSW resonance), as well as quantum damping. We for the first time properly include all finite temperature effects, dilution resulting from the annihilation or disappearance of relativistic degrees of freedom, and the scattering-rate-enhancing effects of particle-antiparticle pairs (muons, tauons, quarks) at high temperature in the early universe. [Phys. Rev. D **64**, 023501 (2001)]

Stability of bound states in the light-front Yukawa model. M. Mangin-Brinet and J. Carbonell, *Institut des Sciences Nucléaires, 53, Avenue des Martyrs, 38026 Grenoble, France;* V. A. Karmanov, *Lebedev Physical Institute, Leninsky Pr. 53, 117924 Moscow, Russia.* (Received 13 February 2001; published 6 June 2001)

We show that in the system of two fermions interacting by scalar exchange, the solutions for $J^{\pi}=0^{+}$ bound states are stable without any cutoff regularization for a coupling constant below some critical value. [Phys. Rev. D **64**, 027701 (2001)]