Selected Abstracts from Other Physical Review Journals

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Commutators of lepton mass matrices, *CP* violation, and matter effects in medium-baseline neutrino experiments. Zhi-zhong Xing, *Theory Division, Institute of High Energy Physics, P.O. Box 918, Beijing 100039, China and Sektion Physik, Universität München, Theresienstrasse 37A, 80333 München, Germany.* (Received 26 September 2000; published 12 March 2001)

We introduce the commutators of lepton mass matrices to describe the phenomenon of lepton flavor mixing, and establish their relations to the effective Hamiltonians responsible for the propagation of neutrinos. The determinants of those commutators are invariant under matter effects, leading to an instructive relationship between the universal CP-violating parameters in vacuum and in matter. In the scenario of low-energy (100 MeV $\leqslant E \leqslant$ 1 GeV) and medium-baseline (100 km $\leqslant L \leqslant$ 400 km) neutrino experiments, we illustrate the features of lepton flavor mixing and CP violation. The terrestrial matter effects on CP- and T-violating asymmetries in $\nu_e \leftrightarrow \nu_\mu$ and $\overline{\nu_e} \leftrightarrow \overline{\nu_\mu}$ neutrino oscillations are also discussed. We demonstrate that a relatively pure signal of leptonic CP violation at the percent level can be established from such medium-baseline experiments with low-energy neutrino beams. [Phys. Rev. D **63**, 073012 (2001)]

Superfluid phases of quark matter: Ginzburg-Landau theory and color neutrality. Kei Iida, *Department of Physics, University of Illinois at Urbana-Champaign, 1110 West Green Street, Urbana, Illinois 61801-3080 and Department of Physics, University of Tokyo, 7-3-1 Hongo, Bunkyo, Tokyo 113-0033, Japan;* Gordon Baym, *Department of Physics, University of Illinois at Urbana-Champaign, 1110 West Green Street, Urbana, Illinois 61801-3080.* (Received 26 October 2000; published 13 March 2001)

We systematically apply Ginzburg-Landau theory to determine BCS pairing in a strongly coupled uniform superfluid of three-flavor massless quarks in flavor equilibrium. We elucidate the phase diagram near the critical temperature in the space of the parameters characterizing the thermodynamic-potential terms of fourth order in the pairing gap. Within the color and flavor antisymmetric channel with zero total angular momentum, the phase diagram contains an isoscalar, color-antitriplet phase and a color-flavor-locked phase, reached by a second order phase transition from the normal state, as well as states reached by a first order phase transition. We complement the general Ginzburg-Landau approach by deriving the high-density asymptotic form of the Ginzburg-Landau free energy from the finite temperature weak-coupling gap equation. The dynamically screened, long-range color magnetic interactions are explicitly taken into account in solving the gap equation. We find that in the limit of weak coupling, the isoscalar, color-antitriplet phase has higher free energy near the transition temperature than the color-flavor locked phase. In view of the fact that deconfined quark matter must be color charge neutral, we incorporate the constraint of overall color neutrality into the general Ginzburg-Landau theory and the gap equation. This constraint yields a disparity in the chemical potential between colors and reduces the size of the pairing gap, in the presence of the anisotropy of the order parameters in color space. In comparison with the case in which there are no chemical potential differences between colors and hence the superfluid generally has nonzero net color charge, we find that while the constraint of color neutrality has only negligible effects on the gap in the weak coupling regime, it appreciably destabilizes the isoscalar, color-antitriplet phase in the strong coupling regime without affecting the color-flavor-locked phase. [Phys. Rev. D **63**, 074018 (2001)]

Analytical description of quasivacuum oscillations of solar neutrinos. E. Lisi,[1] A. Marrone,[1] D. Montanino,[2] A. Palazzo,[1] and S. T. Petcov,[3,4] [1]*Dipartimento di Fisica and Sezione INFN di Bari, Via Amendola 173, I-70126 Bari, Italy* [2]*Dipartimento di Scienza dei Materiali dell'Università di Lecce, Via Arnesano, I-73100 Lecce, Italy* [3]*Scuola Internazionale Superiore di Studi Avanzati, Via Beirut 4, I-34014 Trieste, Italy* [4]*Istituto Nazionale di Fisica Nucleare, Sezione di Trieste, Via Valerio 2, I-34127 Trieste, Italy.* (Received 29 November 2000; published 2 April 2001)

We propose a simple prescription to calculate the solar neutrino survival probability P_{ee} in the quasivacuum oscillation (QVO) regime. Such a prescription is obtained by matching perturbative and exact analytical results, which effectively take into account the density distribution in the Sun as provided by the standard solar model. The resulting analytical recipe for the calculation of P_{ee} is shown to reach its highest accuracy ($|\Delta P_{ee}| \leqslant 2.6 \times 10^{-2}$ in the whole QVO range) when the familiar prescription of choosing the solar density scale parameter r_0 at the Mikheyev-Smirnov-Wolfenstein (MSW) resonance point is replaced by a new one, namely, when r_0 is chosen at the point of ''maximal violation of adiabaticity'' (MVA) along the neutrino trajectory in the Sun. The MVA prescription admits a smooth transition from the QVO regime to the MSW transition one. We discuss in detail the phase acquired by neutrinos in the Sun, and show that it might be of relevance for the studies of relatively short time scale variations of the fluxes of the solar ν lines in the future real-time solar neutrino experiments. Finally, we elucidate the role of matter effects in the convective zone of the Sun. [Phys. Rev. D **63**, 093002 (2001)]

Oscillation probability of GeV solar neutrinos of all active species. André de Gouvêa, *CERN, Theory Division, CH-1211 Geneva 23, Switzerland.* (Received 11 July 2000; published 5 April 2001)

In this paper, I address the oscillation probability of $O(\mathrm{GeV})$ neutrinos of all active flavors produced inside the Sun and detected at the Earth. Flavors other than electron-type neutrinos may be produced, for example, by the annihilation of WIMPs which may be trapped inside the Sun. In the GeV energy regime, matter effects are important both for the ''1-3'' system and the ''1-2'' system, and for different neutrino mass hierarchies. A numerical scan of the multidimensional three-flavor parameter space is performed, ''inspired'' by the current experimental situation. One important result is that, in the three-flavor oscillation case, $P_{\alpha\beta} \neq P_{\beta\alpha}$ for a significant portion of the parameter space, even if there is no CP-violating phase in the neutrino mixing matrix. Furthermore, $P_{\mu\mu}$ has a significantly different behavior from $P_{\tau\tau}$, which may affect expectations for the number of events detected at large neutrino telescopes. [Phys. Rev. D **63**, 093003 (2001)]

Moments of the proton F_2 structure function at low Q^2. C. S. Armstrong,[1] R. Ent,[1] C. E. Keppel,[1,2] S. Liuti,[3,4] G. Niculescu,[5] and I. Niculescu,[1,6] [1]*Thomas Jefferson National Accelerator Facility, Newport News, Virginia 23606* [2]*Hampton University, Hampton, Virginia 23668* [3]*University of Virginia, Charlottesville, Virginia 22901* [4]*INFN Sezione di Roma Tre, Roma, Italy* [5]*Ohio University, Athens, Ohio 45071* [6]*The George Washington University, Washington, D.C. 20052.* (Received 5 July 2000; published 30 March 2001)

We investigate the Q^2 dependence of inclusive electron-proton scattering F_2 structure function data in both the nucleon resonance region and the deep inelastic region, at momentum transfers below 5 $(\mathrm{GeV}/c)^2$. From these data we construct moments of F_2, down to momentum transfers of $Q^2 \approx 0.1$ $(\mathrm{GeV}/c)^2$. The second moment is only slowly varying with Q^2 down to $Q^2 \approx 1$ $(\mathrm{GeV}/c)^2$, which is a reflection of duality. Below Q^2 of 1 $(\mathrm{GeV}/c)^2$, the Q^2 dependence of the moments is predominantly governed by the elastic contribution, whereas the inelastic channels still seem governed by local duality. [Phys. Rev. D **63**, 094008 (2001)]

Singlet g_2 structure function in the next-to-leading order. A. V. Belitsky,[1] Xiangdong Ji,[2] Wei Lu,[2] and Jonathan Osborne,[2] [1]*C. N. Yang Institute for Theoretical Physics, State University of New York at Stony Brook, Stony Brook, New York 11794-3840* [2]*Department of Physics, University of Maryland, College Park, Maryland 20742.* (Received 11 August 2000; published 3 April 2001)

Following a previous study of the one-loop factorization of the nonsinglet g_2 structure function of the nucleon, we present in this paper the next-to-leading order coefficient functions in the singlet sector. To obtain the result, the partonic processes of virtual Compton scattering off two and three on-shell gluons are calculated. A key step in achieving the correct factorization is to separate the correct twist-two contribution. The Burkardt-Cottingham sum rule is nominally satisfied at this order. [Phys. Rev. D **63**, 094012 (2001)]

Modified Wandzura-Wilczek relation with the Nachtmann variable. Xiaotong Song, *Institute of Nuclear and Particle Physics, Department of Physics, University of Virginia, P.O. Box 400714, Charlottesville, Virginia 22904-4714.* (Received 16 December 2000; published 9 April 2001)

If one retains M^2/Q^2 terms in the kinematics, the Nachtmann variable ξ seems to be more appropriate to describe deep inelastic lepton-nucleon scattering. Up to the first power of M^2/Q^2, a modified Wandzura-Wilczek relation with respect to ξ was derived. Kinematical correction factors are given as functions of ξ and Q^2. A comparison of the modified $g_2^{WW}(\xi)$ and the original $g_2^{WW}(x)$ with the most recent g_2 data is shown. [Phys. Rev. D **63**, 094019 (2001)]

Update of the direct detection of dark matter and the role of the nuclear spin. V. A. Bednyakov, *Laboratory of Nuclear Problems, Joint Institute for Nuclear Research, 141980 Dubna, Russia;* H. V. Klapdor-Kleingrothaus, *Max-Planck-Institut für Kernphysik, Postfach 103980, D-69029, Heidelberg, Germany.* (Received 21 November 2000; published 4 April 2001)

We update our exploration of the minimal supersymmetric standard model (MSSM) parameter space at the weak scale where new accelerator and cosmological constraints are respected. The dependence of weakly interacting massive particle nucleon cross sections on parameters of the MSSM, uncertainties of the nucleon structure and other theoretical assumptions such as universality and coannihilation are considered. In particular, we find that the coannihilation does not have a significant effect on our analysis in certain regions which are allowed even with coannihilation. The new cosmological constraint on the relic neutralino density used in the form $0.1 < \Omega_\chi h_0^2 < 0.3$ also does not significantly affect the regions of allowed neutralino-nucleon cross sections. We notice that for nuclear targets with spin the spin-dependent interaction may determine the lower bound for the direct detection rate when the cross section of the scalar interaction drops below about 10^{-12} pb. [Phys. Rev. D **63**, 095005 (2001)]

Shadowing of gluons in perturbative QCD: A comparison of different models. Jamal Jalilian-Marian, *Physics Department, University of Arizona, Tucson, Arizona 85721;* Xin-Nian Wang, *Nuclear Science Division, MS 70-319, Lawrence Berkeley National Laboratory, Berkeley, California 94720.* (Received 31 May 2000; published 29 March 2001)

We investigate the different perturbative QCD-based models for nuclear shadowing of gluons. We show that, in the kinematic region appropriate to the BNL relativistic heavy ion collider experiment, all models give similar estimates for the magnitude of gluon shadowing. At scales relevant to CERN large hadron collider (LHC), there is a sizable difference between the predictions of the different models. However, the uncertainties in gluon shadowing coming from a different parametrization of the gluon distribution in nucleons, are larger than those due to different perturbative QCD models of gluon shadowing. We also investigate the effect of initial nonperturbative shadowing on the magnitude of perturbative shadowing and show that the magnitudes of perturbative and nonperturbative shadowing are comparable at RHIC but perturbative shadowing

dominates over nonperturbative shadowing at smaller values of x reached at LHC. [Phys. Rev. D **63**, 096001 (2001)]

Resumming the large-N approximation for time evolving quantum systems. Bogdan Mihaila 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 14 September 2000; published 2 April 2001)

In this paper we discuss two methods of resumming the leading and next to leading order in $1/N$ diagrams for the quartic $O(N)$ model. These two approaches have the property that they preserve both boundedness and positivity for expectation values of operators in our numerical simulations. These approximations can be understood either in terms of a truncation to the infinitely coupled Schwinger-Dyson hierarchy of equations, or by choosing a particular two-particle irreducible vacuum energy graph in the effective action of the Cornwall-Jackiw-Tomboulis formalism. We confine our discussion to the case of quantum mechanics where the Lagrangian is $L(x,\dot{x})=(\frac{1}{2})\Sigma_{i=1}^{N}\dot{x}_i^2-(g/8N)[\Sigma_{i=1}^{N}x_i^2-r_0^2]^2$. The key to these approximations is to treat both the x propagator and the x^2 propagator on similar footing which leads to a theory whose graphs have the same topology as QED with the x^2 propagator playing the role of the photon. The bare vertex approximation is obtained by replacing the exact vertex function by the bare one in the exact Schwinger-Dyson equations for the one and two point functions. The second approximation, which we call the dynamic Debye screening approximation, makes the further approximation of replacing the exact x^2 propagator by its value at leading order in the $1/N$ expansion. These two approximations are compared with exact numerical simulations for the quantum roll problem. The bare vertex approximation captures the physics at large and modest N better than the dynamic Debye screening approximation. [Phys. Rev. D **63**, 096003 (2001)]

Generalized Gerasimov-Drell-Hearn sum rule for the proton-neutron difference in chiral perturbation theory. Volker D. Burkert, *Thomas Jefferson National Accelerator Facility, Newport News, Virginia 23606.* (Received 15 December 2000; published 10 April 2001)

Applications of the chiral expansion to generalize the Gerasimov-Drell-Hearn sum rule for finite Q^2 are discussed. The observation of several authors that the corrections to the leading order contributions are large and limit the applicability to a very small range in Q^2 are only valid when considering the generalization of the sum rule for protons and neutrons separately. When using the proton-neutron difference, the chiral expansion may be valid to considerably higher Q^2 where hadronic degrees of freedom at large distances may connect up with quark and gluon degrees of freedom. This could mark the first time that nucleon structure is described by fundamental theory from large to small distances. [Phys. Rev. D **63**, 097904 (2001)]

Zenith angle distributions at Super-Kamiokande and SNO and the solution of the solar neutrino problem. M. C. Gonzalez-Garcia and Carlos Peña-Garay, *Instituto de Física Corpuscular, Universitat de València – C.S.I.C., Edificio Institutos de Paterna, Apt 2085, 46071 València, Spain;* Alexei Yu. Smirnov, *International Center for Theoretical Physics, 34100 Trieste, Italy and Institute for Nuclear Research, Russian Academy of Sciences, Moscow 117312, Russia.* (Received 28 December 2000; published 20 April 2001)

We have performed a detailed study of the zenith angle dependence of the regeneration factor and distributions of events at SNO and SK for different solutions of the solar neutrino problem. In particular, we discuss the oscillatory behavior and the synchronization effect in the distribution for the LMA solution, the parametric peak for the LOW solution, etc. A physical interpretation of the effects is given. We suggest a new binning of events which emphasizes the distinctive features of the zenith angle distributions for the different solutions. We also find the correlations between the integrated day-night asymmetry and the rates of events in different zenith angle bins. The study of these correlations strengthens the identification power of the analysis. [Phys. Rev. D **63**, 113004 (2001)]

$\bar{d}$-$\bar{u}$ asymmetry and semi-inclusive production of pions in deep inelastic scattering. A. Szczurek,[1] V. Uleshchenko,[1,2] and J. Speth,[3] [1]*Institute of Nuclear Physics, PL-31-342 Cracow, Poland* [2]*Institute for Nuclear Research, 03-028 Kiev, Ukraine* [3]*Institut für Kernphysik, KFA, Jülich, Germany.* (Received 5 October, 2000; published 18 April 2001)

We investigate ambiguities in the extraction of the $\bar{d}$-$\bar{u}$ asymmetry from semi-inclusive production of pions in deep inelastic scattering. The role of several effects beyond the quark-parton model that lead to $N_p^{\pi^+}\neq N_n^{\pi^+}$ and $N_p^{\pi^-}\neq N_n^{\pi^-}$ and may therefore cloud such an extraction is studied. The results are discussed in the context of the recent HERMES data. We find that the interaction of the resolved photon with the nucleon significantly modifies the observed $\bar{d}$-$\bar{u}$ asymmetry. The exclusive elastic production of ρ mesons plays a similar role for the large-z data sample. Our estimate shows a rather small effect of the spectator mechanism. Nuclear effects in the deuteron also look potentially important but are difficult to estimate quantitatively. Throughout the paper we make in addition several general remarks concerning semi-inclusive and exclusive production of mesons. [Phys. Rev. D **63**, 114005 (2001)]

Experimental and theoretical results for weak charge current backward proton production. C. E. Carlson, *Physics Department, College of William and Mary, Williamsburg, Virginia 23187;* J. Hanlon, *Fermi National Accelerator Laboratory, Batavia, Illinois 60510;* K. E. Lassila, *Department of Physics and Astronomy, Iowa State University, Ames, Iowa 50011.* (Received 9 February 1999; published 20 April 2001)

In this paper, we study deuteron breakup by high energy neutrinos. We present previously unpublished data on neutrino induced backward protons from deuteron targets; we calculate the contributions from both the two-nucleon ($2N$) and six-quark ($6q$) deuteron components, which depend upon the overall normalization of the part that is $6q$; and, we suggest other signatures for distinguishing the $2N$ and $6q$ clusters. We conclude that the $6q$ cluster naturally contributes to the high momentum backward proton spectrum just in the region where the standard $2N$ models lie below the data, and the absolute size of the far backward data is nicely explained if the amount of $6q$ is one or a few percent by normalization of the deuteron. [Phys. Rev. D **63**, 117301 (2001)]