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.*

Neutrino spin-flips in curved space-time. M. Brüggen, *Institute of Astronomy, University of Cambridge, Madingley Road, Cambridge CB3 0HA, United Kingdom.* (Received 26 March 1998; published 15 September 1998)

The general relativistic effects on spin-flavor oscillations above the core of type II supernovae are investigated. The evolution equation is derived and the relative magnitudes of the terms in the Hamiltonian, which arise from the weak, electromagnetic and gravitational interaction, are compared. The effects on the resonance position and the adiabaticity are studied. Explicit calculations are presented for non-rotating and slowly rotating stars. [S0556-2821(98)00120-9] [Phys. Rev. D **58**, 083002 (1998)]

$\bar{d}/\bar{u}$ asymmetry and the origin of the nucleon sea. J. C. Peng,[6] G. T. Garvey,[6] T. C. Awes,[9] M. E. Beddo,[8] M. L. Brooks,[6] C. N. Brown,[3] J. D. Bush,[1] T. A. Carey,[6] T. H. Chang,[8] W. E. Cooper,[3] C. A. Gagliardi,[10] D. F. Geesaman,[2] E. A. Hawker,[10] X. C. He,[4] L. D. Isenhower,[1] S. B. Kaufman,[2] D. M. Kaplan,[5] P. N. Kirk,[7] D. D. Koetke,[11] G. Kyle,[8] D. M. Lee,[6] W. M. Lee,[4] M. J. Leitch,[6] N. Makins,[2] P. L. McGaughey,[6] J. M. Moss,[6] B. A. Mueller,[2] P. M. Nord,[11] B. K. Park,[6] V. Papavassiliou,[8] G. Petitt,[4] P. E. Reimer,[6] M. E. Sadler,[1] P. W. Stankus,[9] W. E. Sondheim,[6] T. N. Thompson,[6] R. S. Towell,[1] R. E. Tribble,[10] M. A. Vasiliev,[10] Y. C. Wang,[7] Z. F. Wang,[7] J. C. Webb,[8] J. L. Willis,[1] D. K. Wise,[1] and G. R. Young[9] (FNAL E866/NuSea Collaboration) [1]*Abilene Christian University, Abilene, Texas 79699* [2]*Argonne National Laboratory, Argonne, Illinois 60439* [3]*Fermi National Accelerator Laboratory, Batavia, Illinois 60510* [4]*Georgia State University, Atlanta, Georgia 30303* [5]*Illinois Institute of Technology, Chicago, Illinois 60616* [6]*Los Alamos National Laboratory, Los Alamos, New Mexico 87545* [7]*Louisiana State University, Baton Rouge, Louisiana 70803* [8]*New Mexico State University, Las Cruces, New Mexico 88003* [9]*Oak Ridge National Laboratory, Oak Ridge, Tennessee 37831* [10]*Texas A & M University, College Station, Texas 77843* [11]*Valparaiso University, Valparaiso, Indiana 46383.* (Received 10 April 1998; published 30 September 1998)

The Drell-Yan cross section ratios, $\sigma(p+d)/\sigma(p+p)$, measured in Fermilab E866, have led to the first determination of $\bar{d}(x)/\bar{u}(x)$, $\bar{d}(x)-\bar{u}(x)$, and the integral of $\bar{d}(x)-\bar{u}(x)$ for the proton over the range $0.02 \leqslant x \leqslant 0.345$. The E866 results are compared with predictions based on parton distribution functions and various theoretical models. The relationship between the E866 results and the NMC measurement of the Gottfried integral is discussed. The agreement between the E866 results and models employing virtual mesons indicates that these non-perturbative processes play an important role in the origin of the $\bar{d},\bar{u}$ asymmetry in the nucleon sea. [S0556-2821(98)02821-5] [Phys. Rev. D **58**, 092004 (1998)]

Muon ''depth-intensity'' relation measured by the LVD underground experiment and cosmic-ray muon spectrum at sea level. M. Aglietta,[16] B. Alpat,[13] E. D. Alyea,[7] P. Antonioli,[1] G. Badino,[16] G. Bari,[1] M. Basile,[1] V. S. Berezinsky,[10] F. Bersani,[1] M. Bertaina,[16] R. Bertoni,[16] G. Bonoli,[1] A. Bosco,[2] G. Bruni,[1] G. Cara Romeo,[1] C. Castagnoli,[16] A. Castellina,[16] A. Chiavassa,[16] J. A. Chinellato,[3] L. Cifarelli,[1] F. Cindolo,[1] G. Conforto,[17] A. Contin,[1] V. L. Dadykin,[10] A. De Silva,[2] M. Deutsch,[8] P. Dominici,[17] L. G. Dos Santos,[3] L. Emaldi,[1] R. I. Enikeev,[10] F. L. Fabbri,[4] W. Fulgione,[16] P. Galeotti,[16] C. Ghetti,[1] P. Ghia,[16] P. Giusti,[1] R. Granella,[16] F. Grianti,[1] G. Guidi,[17] E. S. Hafen,[8] P. Haridas,[8] G. Iacobucci,[1] N. Inoue,[14] E. Kemp,[3] F. F. Khalchukov,[10] E. V. Korolkova,[10] P. V. Korchaguin,[10] V. B. Korchaguin,[10] V. A. Kudryavtsev,[10] K. Lau,[6] M. Luvisetto,[1] G. Maccarone,[4] A. S. Malguin,[10] R. Mantovani,[17] T. Massam,[1] B. Mayes,[6] A. Megna,[17] C. Melagrana,[16] N. Mengotti Silva,[3] C. Morello,[16] J. Moromisato,[9] R. Nania,[1] G. Navarra,[16] L. Panaro,[16] L. Periale,[16] A. Pesci,[1] P. Picchi,[16] L. Pinsky,[6] I. A. Pless,[8] J. Pyrlik,[6] V. G. Ryasny,[10] O. G. Ryazhskaya,[10] O. Saavedra,[16] K. Saitoh,[15] S. Santini,[17] G. Sartorelli,[1] M. Selvi,[1] N. Taborgna,[5] V. P. Talochkin,[10] J. Tang,[8] G. C. Trinchero,[16] S. Tsuji,[11] A. Turtelli,[3] I. Uman,[13] P. Vallania,[16] G. Van Buren,[8] S. Vernetto,[16] F. Vetrano,[17] C. Vigorito,[16] E. von Goeler,[9] L. Votano,[4] T. Wada,[11] R. Weinstein,[6] M. Widgoff,[2] V. F. Yakushev,[10] I. Yamamoto,[12] G. T. Zatsepin,[10] and A. Zichichi[1] (LVD Collaboration) [1]*University of Bologna and INFN–Bologna, Bologna, Italy* [2]*Brown University, Providence, Rhode Island* [3]*University of Campinas, Campinas, Brazil* [4]*INFN-LNF, Frascati, Italy* [5]*INFN-LNGS, Assergi, Italy* [6]*University of Houston, Houston, Texas* [7]*Indiana University, Bloomington, Indiana* [8]*Massachusetts Institute of Technology, Cambridge, Massachusetts* [9]*Northeastern University, Boston, Massachusetts* [10]*Institute for Nuclear Research, Russian Academy of Sciences, Moscow, Russia* [11]*Okayama University, Okayama, Japan* [12]*Okayama University of Science, Okayama, Japan* [13]*University of Perugia and INFN–Perugia, Perugia, Italy* [14]*Saitama University, Saitama, Japan* [15]*Ashikaga Institute of Technology, Ashikaga, Japan* [16]*Institute of Cosmo-Geophysics, CNR, Torino, University of Torino and INFN–Torino, Torino, Italy* [17]*University of Urbino and INFN–Firenze, Firenze, Italy.* (Received 3 April 1998; published 1 October 1998)

We present an analysis of muon events with all muon multiplicities collected during 21804 h of operation of the first Large Volume Detector tower. The measured angular distribution of muon intensity has been converted to the ''depth–vertical-intensity'' relation in the depth range from 3 to 12 km w.e. The analysis of this relation allowed us to derive the power index γ of the primary all-nucleon spectrum: $\gamma = 2.78 \pm 0.05$. The ''depth–vertical-intensity'' relation has been converted to standard rock and the comparison with the

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data of other experiments has been done. We also present the derived vertical muon spectrum at sea level.
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Natural neutrino mass matrix. Masahisa Matsuda, *Department of Mathematical Physics, LTH, Lund University, S-22100, Lund, Sweden;* Morimitsu Tanimoto, *Science Education Laboratory, Ehime University, 790-77 Matsuyama, Japan.* (Received 13 November 1997; revised manuscript received 13 February 1998; published 17 September 1998)

The naturalness of the neutrino mass hierarchy and mixing is studied. First we select a few patterns from among 12 neutrino mixing patterns, which could form the natural neutrino mass matrix. Further we show that if the Dirac neutrino mass matrix is taken as the natural one in the quark sector, then only two mixing patterns without large mixing lead to the natural right-handed Majorana mass matrix. The rest of the chosen patterns with three degenerate mass solutions lead to the unnatural right-handed Majorana mass matrix in the seesaw mechanism. Notice, however, that for the chosen two natural patterns there could be a huge mass hierarchy such as $\mathcal{O}(10^4-10^6)$ in order to reproduce the inverse mass hierarchy of the light neutrinos. [S0556-2821(98)00819-4] [Phys. Rev. D **58**, 093002 (1998)]

Three neutrino Δm^2 scales and the singular seesaw mechanism. E. J. Chun, *Korea Institute for Advanced Study, 207-43 Cheongryangri-dong, Dongdaemun-gu, Seoul 130-012, Korea;* C. W. Kim, *Korea Institute for Advanced Study, 207-43 Cheongryangri-dong, Dongdaemun-gu, Seoul 130-012, Korea and Department of Physics & Astronomy, The Johns Hopkins University, Baltimore, Maryland 21218;* U. W. Lee, *Department of Physics, Mokpo National University, Chonnam 534-729, Korea.* (Received 2 February 1998; published 21 September 1998)

It is shown that the singular seesaw mechanism can simultaneously explain all the existing data supporting nonzero neutrino masses and mixing. The three mass-squared differences that are needed to accommodate the atmospheric neutrino data (through $\nu_\mu-\nu_s$ oscillation), the solar neutrino data via the MSW mechanism (through $\nu_e-\nu_\tau$ oscillation), and the positive result of $\nu_\mu-\nu_e$ oscillation from the LSND can be generated by this mechanism, whereas the vacuum oscillation solution to the solar neutrino problem is disfavored. We find that the electron and tau neutrino masses are of the order of 10^{-3} eV, and the muon neutrino and a sterile neutrino are almost maximally mixed to give a mass of the order of 1 eV. Two heavy sterile neutrinos have a mass of the order of 1 keV which can be obtained by the double seesaw mechanism with an intermediate mass scale $\sim 10^5$ GeV. A possible origin of such a scale is discussed. [S0556-2821(98)04917-0] [Phys. Rev. D **58**, 093003 (1998)]

Neutrino-antineutrino transitions. Paul Langacker and Jing Wang, *Department of Physics and Astronomy, University of Pennsylvania, Philadelphia, Pennsylvania 19104.* (Received 23 February 1998; published 22 September 1998)

We consider transitions between neutrinos and antineutrinos in laboratory experiments in five scenarios. These include the case in which the helicity flips, producing an antineutrino with normal weak interactions, and helicity preserving oscillations into an $SU(2)$ singlet state which only interacts by mixing or new interactions. The ratio of μ^+ and μ^- events for a high energy ν_μ beam from pion decay rescattered from a nucleon target and the ratio between e^+ and e^- events for a rescattered low energy ν_e beam are calculated in each case. The upper limit on the ratio is about $10^{-6}-10^{-10}$ for a high energy ν_μ beam and $10^{-6}-10^{-14}$ for a low energy ν_e beam, too small to observe in present experiments.
[S0556-2821(98)05615-X] [Phys. Rev. D **58**, 093004 (1998)]

Neutrino interactions at ultrahigh energies. Raj Gandhi, *Mehta Research Institute, Chhatnag Road, Jhusi, Allahabad 211019, India;* Chris Quigg, *Theoretical Physics Department, Fermi National Accelerator Laboratory, P.O. Box 500, Batavia, Illinois 60510;* 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 7 July 1998; published 30 September 1998)

We report new calculations of the cross sections for deeply inelastic neutrino-nucleon scattering at neutrino energies between 10^9 eV and 10^{21} eV. We compare with results in the literature and assess the reliability of our predictions. For completeness, we briefly review the cross sections for neutrino interactions with atomic electrons, emphasizing the role of the W-boson resonance in $\overline{\nu}_e e$ interactions for neutrino energies in the neighborhood of 6.3 PeV. Adopting model predictions for extraterrestrial neutrino fluxes from active galactic nuclei, gamma-ray bursters, and the collapse of topological defects, we estimate event rates in large-volume water Čerenkov detectors and large-area ground arrays.
[S0556-2821(98)08621-4] [Phys. Rev. D **58**, 093009 (1998)]

Mass signature of supernova ν_μ and ν_τ neutrinos in the Sudbury Neutrino Observatory. J. F. Beacom and P. Vogel, *Department of Physics, California Institute of Technology, Pasadena, California 91125.* (Received 9 June 1998; published 5 October 1998)

Core-collapse supernovae emit of order 10^{58} neutrinos and antineutrinos of all flavors over several seconds, with average energies of 10–25 MeV. In the Sudbury Neutrino Observatory (SNO), which begins operation this year, neutrinos and antineutrinos of all flavors can be detected by reactions which break up the deuteron. For a future Galactic supernova at a distance of 10 kpc, several hundred events will be observed in SNO. The ν_μ and ν_τ neutrinos and antineutrinos are of particular interest, as a test of the supernova mechanism. In addition, it is possible to measure or limit their masses by their delay (determined from neutral-current events) relative to the $\overline{\nu}_e$ neutrinos (determined from charged-current events). Numerical results are presented for such a future supernova as seen in SNO. Under reasonable assumptions, and in the presence of the expected counting statistics, a ν_μ or ν_τ mass down to about 30 eV can be simply and robustly determined. If zero delay is measured, then the mass limit is *independent* of the distance D. At present, this seems to be the best possibility for direct determination of a ν_μ or ν_τ mass within the cosmologically interesting range. We also

show how to separately study the supernova and neutrino physics, and how changes in the assumed supernova parameters would affect the mass sensitivity. [S0556-2821(98)00821-2] [Phys. Rev. D **58**, 093012 (1998)]

Problems with extracting m_s from flavor breaking in hadronic τ decays. Kim Maltman, *Department of Mathematics and Statistics, York University, 4700 Keele St., Toronto, Ontario, Canada M3J 1P3 and Special Research Center for the Subatomic Structure of Matter, University of Adelaide, Australia 5005.* (Received 22 April 1998; published 7 October 1998)

A numerical error is pointed out in the existing expression for the $\mathcal{O}(\alpha_s^2)$ longitudinal component of the squared-mass ($D=2$) contribution to the hadronic τ decay rate. The corrected version is found to be such that, to $\mathcal{O}(\alpha_s^2)$, each term in the resulting series is larger than the previous one, hence ruling out the direct use of flavor breaking in hadronic τ decays as a means of extracting the strange quark mass. An alternate approach, in which one uses the model spectral functions previously developed for the strangeness-changing scalar channel (and employed in alternate sum rule analyses of m_s) as input to the τ decay analysis, is shown to provide mutual consistency checks for the two different methods. The results for m_s implied by τ decay data and the existing model spectral function are also presented. [S0556-2821(98)03921-6] [Phys. Rev. D **58**, 093015 (1998)]

Variations on four-neutrino oscillations. V. Barger, *Department of Physics, University of Wisconsin, Madison, Wisconsin 53706;* S. Pakvasa, *Department of Physics and Astronomy, University of Hawaii, Manoa, Hawaii 96822;* T. J. Weiler, *Department of Physics and Astronomy, Vanderbilt University, Nashville, Tennessee 37235;* K. Whisnant, *Department of Physics and Astronomy, Iowa State University, Ames, Iowa 50011.* (Received 11 June 1998; published 7 October 1998)

We make a model-independent analysis of all available data that indicate neutrino oscillations. Using probability diagrams, we confirm that a mass spectrum with two nearly degenerate pairs of neutrinos separated by a mass gap of $\simeq 1$ eV is preferred over a spectrum with one mass eigenstate separated from the others. We derive some new relations among the four-neutrino mixing matrix elements. We design four-neutrino mass matrices with three active neutrinos and one sterile neutrino that naturally incorporate maximal oscillations of atmospheric ν_μ and explain the solar neutrino and LSND results. The models allow either a large or small angle MSW or vacuum oscillation description of the solar neutrino deficit. The models predict (i) oscillations of either $\nu_e \to \nu_\tau$ or $\nu_e \to \nu_s$ in long-baseline experiments at $L/E \gg 1$ km/GeV, with amplitude determined by the LSND oscillation amplitude and argument given by the atmospheric δm^2, and (ii) the equality of the ν_e disappearance probability, the ν_μ disappearance probability, and the LSND $\nu_\mu \to \nu_e$ appearance probability in short-baseline experiments. [S0556-2821(98)06921-5] [Phys. Rev. D **58**, 093016 (1998)]

Anomaly induced domain formation of disoriented chiral condensates. Masayuki Asakawa, *Department of Physics, School of Science, Nagoya University, Nagoya, 464-8602, Japan and Institute for Nuclear Theory, University of Washington, Seattle, Washington 98195-1550;* Hisakazu Minakata, *Department of Physics, Tokyo Metropolitan University, Minami-Osawa, Hachioji, Tokyo 192-0397, Japan;* Berndt Müller, *Department of Physics, Duke University, Durham, North Carolina 27708-0305.* (Received 4 May 1998; published 23 September 1998)

We discuss the effect of the chiral anomaly as a possible mechanism for triggering the formation of domains of disoriented chiral condensate (DCC) in relativistic heavy ion collisions. The anomalous $\pi^0 \to 2\gamma$ coupling and the strong, Lorentz contracted electromagnetic fields of the heavy ions combine to produce the ''anomaly kick'' to the field configuration of the neutral pion field. We implement the effect of the anomaly kick in our numerical simulation of the linear sigma model in a schematic way which preserves its characteristic features: the effect is coherent over a large region of space but is opposite in sign above and below the ion scattering plane. We demonstrate by detailed simulations with longitudinal expansion that the DCC domain formation is dramatically enhanced by the anomaly kick in spite of its small absolute magnitude. We examine the behavior of various physical quantities such as pion fields, the axial vector currents, and their correlation functions. Our results also provide useful insight into the mechanism and properties of DCC domain formation, in general. Finally, we discuss some experimental observables which can signal the anomaly induced formation of DCC. [S0556-2821(98)05617-3] [Phys. Rev. D **58**, 094011 (1998)]

***x*-dependent polarized parton distributions.** Lionel E. Gordon, *Thomas Jefferson National Lab, Newport News, Virginia 23606; Hampton University, Hampton, Virginia 23668; and Argonne National Lab, Argonne, Illinois 60439;* Mehrdad Goshtasbpour, *Shahid Beheshti University, Tehran, Iran and Center For Theoretical Physics and Mathematics, AEOI, Tehran, Iran;* Gordon P. Ramsey, *Loyola University, Chicago, Illinois 60626 and Argonne National Lab, Argonne, Illinois 60439.* (Received 20 March 1998; published 28 September 1998)

Using QCD motivated and phenomenological considerations, we construct x dependent polarized parton distributions, which evolve under GLAP evolution, satisfy DIS data and are within positivity constraints. Each flavor is done separately and the overall set can be used to predict polarization asymmetries for various processes. We perform our NLO analysis strictly in x space. Small-x results and other physical considerations are discussed.
[S0556-2821(98)05819-6] [Phys. Rev. D **58**, 094017 (1998)]

Bloom-Gilman duality in the resonance spin structure functions. Carl E. Carlson, *Physics Department, College of William and Mary, Williamsburg, Virginia 23187-8795;* Nimai C. Mukhopadhyay, *Department of Physics, Applied Physics, and Astronomy, Rensselaer Polytechnic Institute, Troy, New York 12180-3590.* (Received 19 March 1998; published 5 October 1998)

We investigate the relations between the spin structure functions in the scaling and resonance regions. We examine the possible duality between the two, and draw inferences for the behavior of the asymmetry A_1 at large x. Finally, we point out the importance of

additional polarized structure function data in the resonance region for observing lingering effects of single quark interactions in a region where final state interactions are large.
[S0556-2821(98)03521-8] [Phys. Rev. D **58**, 094029 (1998)]

Unified description of light- and strange-baryon spectra. L. Ya. Glozman,[1] W. Plessas,[1] K. Varga,[2,3] and R. F. Wagenbrunn,[1] [1]*Institute for Theoretical Physics, University of Graz, A-8010 Graz, Austria* [2]*Institute of Nuclear Research, Hungarian Academy of Sciences, H-4001 Debrecen, Hungary* [3]*RIKEN, Hirosawa 2-1, Wako, Saitama 35101, Japan.* (Received 26 June 1997; published 6 October 1998)

We present a chiral constituent-quark model for light and strange baryons providing a unified description of their ground states and excitation spectra. The model relies on constituent quarks and Goldstone bosons arising as effective degrees of freedom of low-energy QCD from the spontaneous breaking of chiral symmetry. The spectra of the three-quark systems are obtained from a precise variational solution of a Schrödinger-type equation with a semirelativistic Hamiltonian. The theoretical predictions are found to be in close agreement with experiment. [S0556-2821(98)02619-8] [Phys. Rev. D **58**, 094030 (1998)]

Cross section fluctuations of a photon projectile in the generalized vector meson dominance model. L. Frankfurt, *School of Physics and Astronomy, Raymond and Beverly Sackler Faculty of Exact Sciences, Tel Aviv University, 69978 Tel Aviv, Israel and Institute of Nuclear Physics, St. Petersburg, Russia;* V. Guzey, *Department of Physics, The Pennsylvania State University, University Park, Pennsylvania 16802;* M. Strikman, *Department of Physics, The Pennsylvania State University, University Park, Pennsylvania 16802 and Institute of Nuclear Physics, St. Petersburg, Russia.* (Received 16 December 1997; published 7 October 1998)

We explain that the generalized vector meson dominance (GVMD) models successful in the theoretical description of photoproduction and electroproduction in high energy processes effectively implement color coherent phenomena expected in QCD. Within a model, which reproduces Bjorken scaling and nuclear shadowing for deep inelastic processes, we calculate $P_\gamma(\sigma,Q^2)$, the probability for a photon to interact with a target with the cross section σ. We find that within the GVMD model the virtual photon has two main components: the ''hard'' one with a small cross section of the order of $1/Q^2$ and the high probability and the ''soft'' one with a typical hadronic cross section with the probability suppressed by the factor of $1/Q^2$. Thus the GVDM model produces $P_\gamma(\sigma,Q^2)$ similar to that within the parton model and suggests the interplay between hard and soft QCD at $Q^2>1$ GeV^2. We study the limit $\sigma\to 0$ and show that $P_\gamma(\sigma,Q^2)\propto 1/\sigma$ in both the GVMD model and QCD. Thus similarly to the parton model the GVMD model predicts the color transparency phenomenon. This is an indirect indication that Bjorken scaling, color transparency and shadowing in nuclei in DIS are closely related.
[S0556-2821(98)06221-3] [Phys. Rev. D **58**, 094039 (1998)]

QCD sum rules at finite temperature. S. Mallik and Krishnendu Mukherjee, *Saha Institute of Nuclear Physics, 1/AF, Bidhannagar, Calcutta 700064, India.* (Received 17 November 1997; revised manuscript received 29 May 1998; published 6 October 1998)

We derive thermal QCD sum rules for the correlation function of two vector currents in the rho-meson channel. It takes into account the leading non-perturbative corrections from the additional operators, which appear due to the breakdown of Lorentz invariance at finite temperature. The mixing of the new operators has a drastic effect on their coefficients. The thermal average of all the operators can be related to that of the quark condensate and the energy density. The sum rules then yield the temperature dependence of the parameters of the ρ meson, namely its mass and coupling to the vector current. Our result is that these parameters are practically independent of temperature at least up to a temperature of 125 MeV. [S0556-2821(98)04921-2] [Phys. Rev. D **58**, 096011 (1998)]

Direct CP violation in $\Lambda_b\to n(\Lambda)\pi^+\pi^-$ decays via ρ-ω mixing. X.-H. Guo, *Department of Physics and Mathematical Physics, and Special Research Center for the Subatomic Structure of Matter, University of Adelaide, SA 5005, Australia and Institute of High Energy Physics, Academia Sinica, Beijing 100039, China;* A. W. Thomas, *Department of Physics and Mathematical Physics, and Special Research Center for the Subatomic Structure of Matter, University of Adelaide, SA 5005, Australia.* (Received 14 May 1998; published 7 October 1998)

We study direct CP violation in the bottom baryon decays $\Lambda_b\to f\rho^0(\omega)\to f\pi^+\pi^-$ ($f=n$ or Λ). It is found that in these decays via ρ-ω mixing the CP violation could be very large when the invariant mass of the $\pi^+\pi^-$ pair is in the vicinity of the ω resonance. With a typical value $N_c=2$ in the factorization approach, the maximum CP-violating asymmetries are more than 50% and 68% for $\Lambda_b\to n\pi^+\pi^-$ and $\Lambda_b\to\Lambda\pi^+\pi^-$, respectively. With the aid of heavy quark symmetry and phenomenological models for the hadronic wave functions of Λ_b, Λ and the neutron, we estimate the branching ratios of $\Lambda_b\to n(\Lambda)\rho^0$. [S0556-2821(98)06419-4] [Phys. Rev. D **58**, 096013 (1998)]

Where do we stand with solar neutrino oscillations? J. N. Bahcall, *School of Natural Sciences, Institute for Advanced Study, Princeton, New Jersey 08540;* P. I. Krastev, *University of Wisconsin, Madison, Wisconsin 53706;* A. Yu. Smirnov, *ICTP, Trieste, Italy.* (Received 6 July 1998; published 7 October 1998)

We determine parameters for MSW and vacuum oscillations (active and sterile neutrinos) that are allowed by separate, and collective, imposition of the constraints from total event rates in the chlorine, GALLEX, SAGE, and SuperKamiokande experiments (504 days), the SuperKamiokande energy spectrum, and the SuperKamiokande zenith-angle dependence. The small mixing angle MSW solution is acceptable at 7% C.L. (8% for sterile ν's) and the vacuum solution is acceptable at 6% C.L. The best-fit global MSW solution for active neutrinos is $\Delta m^2=5\times10^{-6}$ eV^2, $\sin^2 2\theta=5.5\times10^{-3}$ (and for sterile neutrinos $\Delta m^2=4\times10^{-6}$ eV^2, $\sin^2 2\theta=7\times10^{-3}$). For vacuum oscillations, the best-fit solution is $\Delta m^2=6.5\times10^{-11}$ eV^2, $\sin^2 2\theta=0.75$. An arbitrary combination of undistorted (no oscillations) pp, ^{7}Be, ^{8}B, and CNO neutrino fluxes is inconsistent with the combined data sets at the 3.5σ C.L., indepen-

dent of astrophysical considerations. We use improved calculations of solar model fluxes, neutrino absorption cross sections and energy spectra, and a detailed evaluation of regeneration effects. [S0556-2821(98)08521-X] [Phys. Rev. D **58**, 096016 (1998)]

Electromagnetic form factors in the J/ψ mass region: The case in favor of additional resonances. N. N. Achasov and A. A. Kozhevnikov, *Laboratory of Theoretical Physics, S. L. Sobolev Institute for Mathematics, 630090, Novosibirsk 90, Russian Federation.* (Received 15 January 1998; published 30 September 1998)

Using the results of our recent analysis of e^+e^- annihilation, we plot the curves for the diagonal and transition form factors of light hadrons in the timelike region up to the production threshold of an open charm quantum number. The comparison with existing data on the decays of J/ψ into such hadrons shows that some new resonance structures may be present in the mass range between 2 GeV and the J/ψ mass. Searching them may help in a better understanding of the mass spectrum in both simple and more sophisticated quark models, and in revealing the details of the three-gluon mechanism of the OZI rule breaking in $K\overline{K}$ channel.
[S0556-2821(98)05019-X] [Phys. Rev. D **58**, 097502 (1998)]

Relic neutrino asymmetries and big bang nucleosynthesis in a four neutrino model. N. F. Bell, R. Foot, and R. R. Volkas, *School of Physics, Research Centre for High Energy Physics, The University of Melbourne, Parkville 3052 Australia.* (Received 27 April 1998; published 8 October 1998)

Oscillations between ordinary and sterile neutrinos can generate large neutrino asymmetries in the early universe. These asymmetries can significantly affect big bang nucleosynthesis (BBN) through modification of nuclear reaction rates. We study this phenomenon within a model consisting of the three ordinary neutrinos plus one sterile neutrino that can be motivated by the neutrino anomalies and the dark matter problem. We calculate how the lepton asymmetries produced, evolve at temperatures where they impact on BBN. The effect of the asymmetries on primordial helium production is determined, leading to an effective number of neutrino flavors during BBN of either about 2.7 or 3.1 depending on the sign of the lepton asymmetry. [S0556-2821(98)09720-3] [Phys. Rev. D **58**, 105010 (1998)]

Spin asymmetries A_1 and structure functions g_1 of the proton and the deuteron from polarized high energy muon scattering. B. Adeva,[18] T. Akdogan,[2] E. Arik,[2] A. Arvidson,[21] B. Badelek,[21,23] G. Bardin,[17] G. Baum,[1] P. Berglund,[8] L. Betev,[13] I. G. Bird,[17] R. Birsa,[20] P. Björkholm,[21] N. de Botton,[17] M. Boutemeur,[24] F. Bradamante,[20] A. Bravar,[11] A. Bressan,[20] S. Bültmann,[1] E. Burtin,[17] C. Cavata,[17] D. Crabb,[22] J. Cranshaw,[20] T. Çuhadar,[2,15] S. Dalla Torre,[20] R. van Dantzig,[15] B. Derro,[4] A. Deshpande,[24] S. Dhawan,[24] C. Dulya,[15,4] A. Dyring,[21] S. Eichblatt, J. C. Faivre,[17] D. Fasching,[16] F. Feinstein,[17] C. Fernandez,[18,9] S. Forthmann,[7] B. Frois,[17] A. Gallas,[18] J. A. Garzon,[18,9] H. Gilly,[6] M. Giorgi,[20] E. von Goeler, S. Goertz,[3] I. A. Golutvin,[10] G. Gracia,[18] N. de Groot,[15] M. Grosse Perdekamp,[24] K. Haft,[13] D. von Harrach,[11] T. Hasegawa,[14] P. Hautle,[5] N. Hayashi,[14] C. A. Heusch,[5] N. Horikawa,[14] V. W. Hughes,[24] G. Igo,[4] S. Ishimoto,[14] T. Iwata,[14] E. M. Kabuß,[11] T. Kageya,[14] A. Karev,[10] H. J. Kessler,[6] T. J. Ketel,[15] J. Kiryluk,[23] I. Kiryushin,[10] A. Kishi,[14] Yu. Kisselev,[10] L. Klostermann,[15] D. Krämer,[1] V. Krivokhijine,[10] W. Kröger,[5] V. Kukhtin,[10] K. Kurek,[23] J. Kyynäräinen,[1,8] M. Lamanna,[20] U. Landgraf,[6] J. M. Le Goff,[17] F. Lehar,[17] A. de Lesquen,[17] J. Lichtenstadt,[19] T. Lindqvist,[21] M. Litmaath,[15] M. Lowe, A. Magnon,[17] G. K. Mallot,[11] F. Marie,[17] A. Martin,[20] J. Martino,[17] T. Matsuda,[14] B. Mayes,[9] J. S. McCarthy,[22] K. Medved,[10] W. Meyer,[3] G. van Middelkoop,[15] D. Miller,[16] Y. Miyachi,[14] K. Mori,[14] J. Moromisato, A. Nagaitsev,[10] J. Nassalski,[23] L. Naumann,[5] T. O. Niinikoski,[5] J. E. J. Oberski,[15] A. Ogawa,[14] C. Ozben,[2] H. Pereira,[17] F. Perrot-Kunne,[17] D. Peshekhonov,[10] R. Piegia,[5] L. Pinsky,[9] S. Platchkov,[17] M. Plo,[18] D. Pose,[10] H. Postma,[15] J. Pretz,[11] R. Puntaferro,[20] T. Pussieux,[17] G. Rädel,[5] A. Rijllart,[5] G. Reicherz,[3] J. Roberts, S. Rock,[5] M. Rodriguez,[21] E. Rondio,[23,5] L. Ropelewski,[23] I. Sabo,[19] J. Saborido,[18] A. Sandacz,[23] I. Savin,[10] P. Schiavon,[20] A. Schiller,[7] K. P. Schüler,[24] R. Seitz,[11] Y. Semertzidis,[5] S. Sergeev,[10] P. Shanahan,[16] E. P. Sichtermann,[15] F. Simeoni,[20] G. I. Smirnov,[10] A. Staude,[13] A. Steinmetz,[11,13] U. Stiegler,[5] H. Stuhrmann,[7] M. Szleper,[23] F. Tessarotto,[20] D. Thers,[17] W. Tlaczala,[23] A. Tripet,[1] G. Unel,[2] M. Velasco,[16] J. Vogt,[13] R. Voss,[5] C. Whitten,[4] R. Windmolders,[12] R. Willumeit,[7] W. Wislicki,[23] A. Witzmann,[6] J. Ylöstalo,[8] A. M. Zanetti,[20] K. Zaremba,[23] N. I. Zamiatin,[10] and J. Zhao,[7] [1]*University of Bielefeld, Physics Department, D-33501 Bielefeld, Germany* [2]*Bogaziçi University and Istanbul Technical University, Istanbul, Turkey* [3]*University of Bochum, Physics Department, D-44780 Bochum, Germany* [4]*University of California, Department of Physics, Los Angeles, California 90024* [5]*CERN, 1211 Geneva 23, Switzerland* [6]*University of Freiburg, Physics Department, D-79104 Freiburg, Germany* [7]*GKSS, D-21494 Geesthacht, Germany* [8]*Helsinki University of Technology, Low Temperature Laboratory and Institute of Particle Physics Technology, Espoo, Finland* [9]*University of Houston, Department of Physics, Houston, Texas 77204-5506* [10]*JINR, Dubna, RU-141980 Dubna, Russia* [11]*University of Mainz, Institute for Nuclear Physics, D-55099 Mainz, Germany* [12]*University of Mons, Faculty of Science, 7000 Mons, Belgium* [13]*University of Munich, Physics Department, D-80799 Munich, Germany* [14]*Nagoya University, CIRSE and Department of Physics, Furo-Cho, Chikusa-Ku, 464 Nagoya, Japan* [15]*NIKHEF, Delft University of Technology, FOM and Free University, 1009 AJ Amsterdam, The Netherlands* [16]*Northwestern University, Department of Physics, Evanston, Illinois 60208* [17]*CEA Saclay, DAPNIA, 91191 Gif-sur-Yvette, France* [18]*University of Santiago, Department of Particle Physics, 15706 Santiago de Compostela, Spain* [19]*Tel Aviv University, School of Physics, 69978 Tel Aviv, Israel* [20]*INFN Trieste and University of Trieste, Department of Physics, 34127 Trieste, Italy* [21]*Uppsala University, Department of Radiation Sciences, 75121 Uppsala, Sweden* [22]*University of Virginia, Department of Physics, Charlottesville, Virginia 22901* [23]*Soltan Institute for Nuclear Studies and Warsaw University, 00681 Warsaw, Poland* [24]*Yale University, Department of Physics, New Haven, Connecticut 06511.* (Received 18 May 1998; published 19 October 1998)

We present the final results of the spin asymmetries A_1 and the spin structure functions g_1 of the proton and the deuteron in the kinematic range $0.0008<x<0.7$ and $0.2<Q^2<100\ \mathrm{GeV}^2$. For the determination of A_1, in addition to the usual method which employs inclusive scattering events and includes a large radiative background at low x, we use a new method which minimizes the radiative background by selecting events with at least one hadron as

well as a muon in the final state. We find that this hadron method gives smaller errors for $x<0.02$, so it is combined with the usual method to provide the optimal set of results.
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Next-to-leading order QCD analysis of the spin structure function g_1. B. Adeva,[18] T. Akdogan,[2] E. Arik,[2] B. Badelek,[21,23] G. Bardin,[17] G. Baum,[1] P. Berglund,[8] L. Betev,[13] R. Birsa,[20] N. de Botton,[17] F. Bradamante,[20] A. Bravar,[11] A. Bressan,[20] S. Bültmann,[1] E. Burtin,[17] C. Cavata,[17] D. Crabb,[22] J. Cranshaw,[20] T. Çuhadai,[2,15] S. Dalla Torre,[20] R. van Dantzig,[15] B. Derro,[4] A. Deshpande,[24] S. Dhawan,[24] C. Dulya,[15,4] S. Eichblatt, D. Fasching,[16] F. Feinstein,[17] C. Fernandez,[18,9] S. Forthmann,[7] B. Frois,[17] A. Gallas,[18] J. A. Garzon,[18,9] H. Gilly,[6] M. Giorgi,[20] E. von Goeler, S. Goertz,[3] G. Gracia,[18] N. de Groot,[15] M. Grosse Perdekamp,[24] K. Haft,[13] D. von Harrach,[11] T. Hasegawa,[14] P. Hautle,[5] N. Hayashi,[14] C. A. Heusch,[5] N. Horikawa,[14] V. W. Hughes,[24] G. Igo,[4] S. Ishimoto,[14] T. Iwata,[14] E. M. Kabuß,[11] T. Kageya,[14] A. Karev,[10] H. J. Kessler,[6] T. J. Ketel,[15] J. Kiryluk,[23] Yu. Kisselev,[10] D. Krämer,[1] V. Krivokhijine,[10] W. Kröger,[5] V. Kukhtin,[10] K. Kurek,[23] J. Kyynäräinen,[1,8] M. Lamanna,[20] U. Landgraf,[6] J. M. Le Goff,[17] F. Lehar,[17] A. de Lesquen,[17] J. Lichtenstadt,[19] M. Litmaath,[15] A. Magnon,[17] G. K. Mallot,[11] F. Marie,[17] A. Martin,[20] J. Martino,[17] T. Matsuda,[14] B. Mayes,[9] J. S. McCarthy,[22] K. Medved,[10] W. Meyer,[3] G. van Middelkoop,[15] D. Miller,[16] Y. Miyachi,[14] K. Mori,[14] J. Moromisato, J. Nassalski,[23] L. Naumann,[5] T. O. Niinikoski,[5] J. E. J. Oberski,[15] A. Ogawa,[14] C. Ozben,[2] H. Pereira,[17] F. Perrot-Kunne,[17] D. Peshekhonov,[10] R. Piegaia,[5] L. Pinsky,[9] S. Platchkov,[17] M. Plo,[18] D. Pose,[10] H. Postma,[15] J. Pretz,[11] R. Puntaferro,[20] T. Pussieux,[17] G. Rädel,[5] A. Rijllart,[5] G. Reicherz,[3] J. Roberts, M. Rodriguez,[21] E. Rondio,[23,5] I. Sabo,[19] J. Saborido,[18] A. Sandacz,[23] I. Savin,[10] P. Schiavon,[20] A. Schiller,[7] E. P. Sichtermann,[15] F. Simeoni,[20] G. I. Smirnov,[10] A. Staude,[13] A. Steinmetz,[11,13] U. Stiegler,[5] H. Stuhrmann,[7] M. Szleper,[23] F. Tessarotto,[20] D. Thers,[17] W. Tlaczala,[23] A. Tripet,[1] G. Unel,[2] M. Velasco,[16] J. Vogt,[13] R. Voss,[5] C. Whitten,[4] R. Windmolders,[12] R. Willumeit,[7] W. Wislicki,[23] A. Witzmann,[6] J. Ylöstalo,[8] A. M. Zanetti,[20] K. Zaremba,[23] J. Zhao,[7] [1]*University of Bielefeld, Physics Department, D-33501 Bielefeld, Germany* [2]*Bogaziçi University and Istanbul Technical University, Istanbul, Turkey* [3]*University of Bochum, Physics Department, D-44780 Bochum, Germany* [4]*University of California, Department of Physics, Los Angeles, California 90024* [5]*CERN, 1211 Geneva 23, Switzerland* [6]*University of Freiburg, Physics Department, D-79104 Freiburg, Germany* [7]*GKSS, D-21494 Geesthacht, Germany* [8]*Helsinki University of Technology, Low Temperature Laboratory and Institute of Particle Physics Technology, Espoo, Finland* [9]*University of Houston, Department of Physics, Houston, Texas 77204-5506* [10]*JINR, Dubna, RU-141980 Dubna, Russia* [11]*University of Mainz, Institute for Nuclear Physics, D-55099 Mainz, Germany* [12]*University of Mons, Faculty of Science, 7000 Mons, Belgium* [13]*University of Munich, Physics Department, D-80799 Munich, Germany* [14]*Nagoya University, CIRSE and Department of Physics, Furo-Cho, Chikusa-Ku, 464 Nagoya, Japan* [15]*NIKHEF, Delft University of Technology, FOM and Free University, 1009 AJ Amsterdam, The Netherlands* [16]*Northwestern University, Department of Physics, Evanston, Illinois 60208* [17]*CEA Saclay, DAPNIA, 91191 Gif-sur-Yvette, France* [18]*University of Santiago, Department of Particle Physics, 15706 Santiago de Compostela, Spain* [19]*Tel Aviv University, School of Physics, 69978 Tel Aviv, Israel* [20]*INFN Trieste and University of Trieste, Department of Physics, 34127 Trieste, Italy* [21]*Uppsala University, Department of Radiation Sciences, 75121 Uppsala, Sweden* [22]*University of Virginia, Department of Physics, Charlottesville, Virginia 22901* [23]*Soltan Institute for Nuclear Studies and Warsaw University, 00681 Warsaw, Poland* [24]*Yale University, Department of Physics, New Haven, Connecticut 06511.* (Received 18 May 1998; published 19 October 1998)

We present a next-to-leading order QCD analysis of the presently available data on the spin structure function g_1 including the final data from the Spin Muon Collaboration. We present results for the first moments of the proton, deuteron, and neutron structure functions, and determine singlet and nonsinglet parton distributions in two factorization schemes. We also test the Bjorken sum rule and find agreement with the theoretical prediction at the level of 10%.
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Diffractive exclusive photon production in DIS at DESY HERA. L. L. Frankfurt, *Physics Department, Tel Aviv University, Tel Aviv, Israel* A. Freund and M. Strikman, *Department of Physics, Penn State University, University Park, Pennsylvania 16802.* (Received 30 January 1998; published 13 October 1998)

We demonstrate that perturbative QCD allows one to calculate the absolute cross section of diffractive exclusive production of photons at large Q^2 at DESY HERA, while the aligned jet model allows one to estimate the cross section for intermediate $Q^2 \sim 2$ GeV^2. Furthermore, we find that the imaginary part of the amplitude for the production of real photons is larger than the imaginary part of the corresponding DIS amplitude by about a factor of 2, leading to the prediction of a significant counting rate for the current generation of experiments at HERA. We also find a large azimuthal angle asymmetry in ep scattering for HERA kinematics which allows one to directly measure the real part of the DVCS amplitude and hence the nondiagonal parton distributions.
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Pions in nuclei and manifestations of supersymmetry in neutrinoless double beta decay. Amand Faessler, *Institute für Theoretische Physik der Universität Tübingen, Auf der Morgenstelle 14, D-72076 Tübingen, Germany;* Sergey Kovalenko, *Institute für Theoretische Physik der Universität Tübingen, Auf der Morgenstelle 14, D-72076 Tübingen, Germany and Joint Institute for Nuclear Research, 141980 Dubna, Russia;* Fedor Šimkovic, *Department of Nuclear Physics, Comenius University, Mlynská dolina F1, 84215 Bratislava, Slovakia.* (Received 30 March 1998; published 13 October 1998)

We examine the pion realization of the short-ranged supersymmetric (SUSY) mechanism of neutrinoless double beta decay ($0\nu\beta\beta$ decay). It originates from the R-parity violating quark-lepton interactions of the SUSY extensions of the standard model of the electroweak interactions. We argue that pions are dominant SUSY mediators in $0\nu\beta\beta$ decay. The corresponding nuclear matrix elements

for potentially $0\nu\beta\beta$-decaying isotopes are calculated within the proton-neutron renormalized quasiparticle random-phase approximation (pn-RQRPA). We define those isotopes which are most sensitive to the SUSY signal and provide an outlook on the present experimental situation with the $0\nu\beta\beta$-decay searches for SUSY. Upper limits on the R-parity violating first-generation Yukawa coupling λ'_{111} are derived from various $0\nu\beta\beta$ experiments.
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