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.*

Spin structure of the proton from polarized inclusive deep-inelastic muon-proton scattering. D. Adams,[17] B. Adeva,[19] E. Arik,[2] A. Arvidson,[22] B. Badelek,[22,24] M. K. Ballintijn,[14] G. Bardin,[18] G. Baum,[1] P. Berglund,[7] L. Betev,[12] I. G. Bird,[18] R. Birsa,[21] P. Björkholm,[22] B. E. Bonner,[17] N. de Botton,[18] M. Boutemeur,[25] F. Bradamante,[21] A. Bravar,[10] A. Bressan,[21] S. Bültmann,[1] E. Burtin,[18] C. Cavata,[18] D. Crabb,[23] J. Cranshaw,[17] T. Çuhadar,[2] S. Dalla Torre,[21] R. van Dantzig,[14] B. Derro,[3] A. Deshpande,[25] S. Dhawan,[25] C. Dulya,[3] A. Dyring,[22] S. Eichblatt,[17] J. C. Faivre,[18] D. Fasching,[16] F. Feinstein,[18] C. Fernandez,[19,8] B. Frois,[18] A. Gallas,[19] J. A. Garzon,[19,8] T. Gaussiran,[17] M. Giorgi,[21] E. von Goeler,[15] G. Gracia,[19] N. de Groot,[14] M. Grosse Perdekamp,[3] E. Gülmez,[2] D. von Harrach,[10] T. Hasegawa,[13] P. Hautle,[4] N. Hayashi,[13] C. A. Heusch,[4] N. Horikawa,[13] V. W. Hughes,[25] G. Igo,[3] S. Ishimoto,[13] T. Iwata,[13] E. M. Kabuß,[10] A. Karev,[9] H. J. Kessler,[5] T. J. Ketel,[14] A. Kishi,[13] Yu. Kisselev,[9] L. Klostermann,[14] D. Krämer,[1] V. Krivokhijine,[9] W. Kröger,[4] K. Kurek,[24] J. Kyynäräinen,[4,7] M. Lamanna,[21] U. Landgraf,[5] T. Layda,[4] J. M. Le Goff,[18] F. Lehar,[18] A. de Lesquen,[18] J. Lichtenstadt,[20] T. Lindqvist,[22] M. Litmaath,[14] M. Lowe,[17] A. Magnon,[18] G. K. Mallot,[10] F. Marie,[18] A. Martin,[21] J. Martino,[18] T. Matsuda,[13] B. Mayes,[8] J. S. McCarthy,[23] K. Medved,[9] G. van Middelkoop,[14] D. Miller,[16] K. Mori,[13] J. Moromisato,[15] A. Nagaitsev,[9] J. Nassalski,[24] L. Naumann,[4] T. O. Niinikoski,[4] J. E. J. Oberski,[14] A. Ogawa,[13] C. Ozben,[2] D. P. Parks,[8] A. Penzo,[21] F. Perrot-Kunne,[18] D. Peshekhonov,[9] R. Piegaia,[25] L. Pinsky,[8] S. Platchkov,[18] M. Plo,[19] D. Pose,[9] H. Postma,[14] J. Pretz,[10] T. Pussieux,[18] J. Pyrlik,[8] I. Reyhancan,[2] A. Rijllart,[4] J. B. Roberts,[17] S. Rock,[4] M. Rodriguez,[22] E. Rondio,[24] A. Rosado,[12] I. Sabo,[20] J. Saborido,[19] A. Sandacz,[24] I. Savin,[9] P. Schiavon,[21] K. P. Schüler,[25] R. Segel,[16] R. Seitz,[10] Y. Semertzidis,[4] F. Sever,[14] P. Shanahan,[16] E. P. Sichtermann,[14] F. Simeoni,[21] G. I. Smirnov,[9] A. Staude,[12] A. Steinmetz,[10] U. Stiegler,[4] H. Stuhrmann,[6] M. Szleper,[24] K. M. Teichert,[12] F. Tessarotto,[21] W. Tlaczala,[24] S. Trentalange,[3] G. Unel,[2] M. Velasco,[16] J. Vogt,[12] R. Voss,[4] R. Weinstein,[8] C. Whitten,[3] R. Windmolders,[11] R. Willumeit,[6] W. Wislicki,[24] A. Witzmann,[5] A. M. Zanetti,[21] K. Zaremba,[24] and J. Zhao[6] (Spin Muon Collaboration)[1]*University of Bielefeld, Physics Department, 33501 Bielefeld, Germany* [2]*Bogaziçi University and Istanbul Technical University, Istanbul, Turkey* [3]*University of California, Department of Physics, Los Angeles, California 90024* [4]*CERN, 1211 Geneva 23, Switzerland* [5]*University of Freiburg, Physics Department, 79104 Freiburg, Germany* [6]*GKSS, 21494 Geesthacht, Germany* [7]*Helsinki University of Technology, Low Temperature Laboratory and Institute of Particle Physics Technology, Espoo, Finland* [8]*University of Houston, Department of Physics, and Institute for Beam Particle Dynamics, Houston, Texas 77204* [9]*JINR, Dubna, RU-141980 Dubna, Russia* [10]*University of Mainz, Institute for Nuclear Physics, 55099 Mainz, Germany* [11]*University of Mons, Faculty of Science, 7000 Mons, Belgium* [12]*University of Munich, Physics Department, 80799 Munich, Germany* [13]*Nagoya University, CIRSE and Department of Physics, Furo-Cho, Chikusa-Ku, 464 Nagoya, Japan* [14]*NIKHEF, Delft University of Technology, FOM and Free University, 1009 AJ Amsterdam, The Netherlands* [15]*Northeastern University, Department of Physics, Boston, Massachusetts 02115* [16]*Northwestern University, Department of Physics, Evanston, Illinois 60208* [17]*Rice University, Bonner Laboratory, Houston, Texas 77251-1892* [18]*C.E.A. Saclay, DAPNIA, 91191 Gif-sur-Yvette, France* [19]*University of Santiago, Department of Particle Physics, 15706 Santiago de Compostela, Spain* [20]*Tel Aviv University, School of Physics, 69978 Tel Aviv, Israel* [21]*INFN Trieste and University of Trieste, Department of Physics, 34127 Trieste, Italy* [22]*Uppsala University, Department of Radiation Sciences, 75121 Uppsala, Sweden* [23]*University of Virginia, Department of Physics, Charlottesville, Virginia 22901* [24]*Soltan Institute for Nuclear Studies and Warsaw University, 00681 Warsaw, Poland* [25]*Yale University, Department of Physics, New Haven, Connecticut 06511.* (Received 11 February 1997)

We have measured the spin-dependent structure function g_1^p in inclusive deep-inelastic scattering of polarized muons off polarized protons, in the kinematic range $0.003<x<0.7$ and $1\ \mathrm{GeV}^2<Q^2<60\ \mathrm{GeV}^2$. A next-to-leading order QCD analysis is used to evolve the measured $g_1^p(x,Q^2)$ to a fixed Q_0^2. The first moment of g_1^p at $Q_0^2=10\ \mathrm{GeV}^2$ is $\Gamma_1^p=0.136\pm0.013$ (stat) ±0.009 (syst) ±0.005 (evol). This result is below the prediction of the Ellis-Jaffe sum rule by more than two standard deviations. The singlet axial charge a_0 is found to be 0.28 ± 0.16. In the Adler-Bardeen factorization scheme, $\Delta g\simeq 2$ is required to bring $\Delta\Sigma$ in agreement with the quark-parton model. A combined analysis of all available proton, deuteron, and ^{3}He data confirms the Bjorken sum rule. [S0556-2821(97)05521-5] [Phys. Rev. D **56**, 5330 (1997)]

Solving the Bethe-Salpeter equation for bound states of scalar theories in Minkowski space. Kensuke Kusaka, *Department of Physics, Tokyo Metropolitan University, Minami-Osawa 1-1, Hachioji-shi, Tokyo 192-03, Japan;* Ken Simpson, *Department of Physics and Mathematical Physics, University of Adelaide, South Australia 5005, Australia;* Anthony G. Williams, *Department of Physics and Mathematical Physics, University of Adelaide, South Australia 5005, Australia and Special Research Centre for the Subatomic Structure of Matter, University of Adelaide, South Australia 5005, Australia.* (Received 14 May 1997)

We apply the perturbation theory integral representation to solve for the bound state Bethe-Salpeter (BS) vertex for an *arbitrary* scattering kernel, without the need for any Wick rotation. The results derived are applicable to any scalar field theory (without derivative coupling). It is shown that solving directly for the BS vertex, rather than the BS amplitude, has several major advantages, notably its relative simplicity and superior numerical accuracy. In order to illustrate the generality of the approach we obtain numerical solutions using this formalism for a number of scattering kernels, including cases where the Wick rotation is not possible. [S0556-2821(97)01520-8] [Phys. Rev. D **56**, 5071 (1997)]

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Order 1/N corrections to the time-dependent Hartree approximation for a system of $N+1$ oscillators. Bogdan Mihaila and John F. Dawson, *Department of Physics, University of New Hampshire, Durham, New Hampshire 03824;* Fred Cooper, *Theoretical Division, MS B285, Los Alamos National Laboratory, Los Alamos, New Mexico 87545.* (Received 20 May 1997)

We solve numerically to order $1/N$ the time evolution of a quantum dynamical system of N oscillators of mass m coupled quadratically to a massless dynamic variable. We use Schwinger's closed time path formalism to derive the equations. We compare two methods which differ by terms of order $1/N^2$. The first method is a direct perturbation theory in $1/N$ using the path integral. The second solves exactly the theory defined by the effective action to order $1/N$. We compare the results of both methods as a function of N. At $N=1$, where we expect the expansion to be quite innacurate, we compare our results to an exact numerical solution of the Schrödinger equation. In this case we find that when the two methods disagree they also diverge from the exact answer. We also find at $N=1$ that the $1/N$ corrected evolutions track the exact answer for the expectation values much longer than the mean field ($N=\infty$) result. [S0556-2821(97)02921-4] [Phys. Rev. D **56**, 5400 (1997)]

***CP* violation and baryogenesis due to heavy Majorana neutrinos.** Apostolos Pilaftsis, *Max-Planck-Institut für Physik, Föhringer Ring 6, 80805 Munich, Germany.* (Received 28 May 1997)

We analyze the scenario of baryogenesis through leptogenesis induced by the out-of-equilibrium decays of heavy Majorana neutrinos and pay special attention to CP violation. Extending a recently proposed resummation formalism for two-fermion mixing to decay amplitudes, we calculate the resonant phenomenon of CP violation due to the mixing of two nearly degenerate heavy Majorana neutrinos. Solving numerically the relevant Boltzmann equations, we find that the isosinglet Majorana mass may range from 1 TeV up to the grand unification scale, depending on the mechanism of CP violation and/or the flavor structure of the neutrino mass matrix assumed. Finite temperature effects and possible constraints from the electric dipole moment of electron and other low-energy experiments are briefly discussed. [S0556-2821(97)04121-0] [Phys. Rev. D **56**, 5431 (1997)]

Study of off-forward parton distributions. Xiangdong Ji and W. Melnitchouk, *Department of Physics, University of Maryland, College Park, Maryland 20742;* X. Song, *Department of Physics, University of Virginia, Charlottesville, Virginia 22901.* (Received 28 February 1997)

An extensive theoretical analysis of off-forward parton distributions (OFPDs) is presented. The OFPDs and the form factors of the quark energy-momentum tensor are estimated at a low energy scale using a bag model. Relations among the second moments of OFPDs, the form factors, and the fraction of the nucleon spin carried by quarks are discussed. [S0556-2821(97)01121-1] [Phys. Rev. D **56**, 5511 (1997)]

Nonforward parton distributions. A. V. Radyushkin, *Physics Department, Old Dominion University, Norfolk, Virginia 23529 and Jefferson Lab, Newport News, Virginia 23606.* (Received 22 May 1997)

Applications of perturbative QCD to deeply virtual Compton scattering and hard exclusive electroproduction processes require a generalization of usual parton distributions for the case when long-distance information is accumulated in nonforward matrix elements $\langle p'|\mathcal{O}(0,z)|p\rangle$ of quark and gluon light-cone operators. We describe two types of nonperturbative functions parametrizing such matrix elements: double distributions $F(x,y;t)$ and nonforward distribution functions $\mathcal{F}_\xi(X;t)$, discuss their spectral properties, evolution equations which they satisfy, basic uses and general aspects of factorization for hard exclusive processes. [S0556-2821(97)00521-3] [Phys. Rev. D **56**, 5524 (1997)]

Finite density QCD with chiral-invariant four-fermion interactions. Michael Chavel, *Department of Physics, University of Illinois at Urbana, 1110 West Green Street, Urbana, Illinois 61801-3080.* (Received 28 April 1997)

A mean field analysis of finite density QCD is presented including the effects of additional chiral-invariant four-fermion interactions. A lattice regularization is used with $N_f=4$ flavors of staggered fermions. The use of the four-fermion coupling as an improved extrapolation parameter over the bare quark mass in Monte Carlo simulations is discussed. Particular attention is given to the structure of the phase diagram and the order of the chiral phase transition. At zero gauge coupling, the model reduces to a Nambu–Jona-Lasinio model. In this limit the chiral phase transition is found to be second-order near the zero-density critical point and otherwise first order. In the strong gauge coupling limit a first-order chiral phase transition is found. In this limit the additional four-fermion interactions do not qualitatively change the physics. The results agree with previous studies of QCD as the four-fermion coupling vanishes. [S0556-2821(97)07219-6] [Phys. Rev. D **56**, 5596 (1997)]

New QCD sum rules for the nucleon tensor charge. Xuemin Jin and Jian Tang, *Center for Theoretical Physics, Laboratory for Nuclear Science and Department of Physics, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139.* (Received 9 May 1997)

Two new QCD sum rules for the nucleon tensor charge are derived from a mixed correlator of spin-1/2 and spin-3/2 nucleon interpolating fields. These sum rules are analyzed along with a sum rule obtained from the usual correlator of a general spin-1/2 nucleon interpolating field. The validity and reliability of the sum rules are examined by monitoring the contaminations arising from the transitions and continuum and the convergence of the operator product expansion. Valid sum rules are identified and their predictions are presented. It is found that the vacuum tensor susceptibility induced by the external field plays an important role in determining both the validity and predictions of the sum rules. The uncertainties associated with the sum-rule predictions are also discussed. [S0556-2821(97)05821-9] [Phys. Rev. D **56**, 5618 (1997)]

Neutrinoless double β decay with composite neutrinos. O. Panella,[1,2] C. Carimalo,[2] Y. N. Srivastava,[1,3] and A. Widom,[3] [1]*Istituto Nazionale di Fisica Nucleare, Sezione di Perugia, Via A. Pascoli, I-06123 Perugia, Italy* [2]*Laboratoire de Physique Corpusculaire, Collège de France, 11 Place Marcelin Berthelot, F-75231, Paris Cedex 05, France* [3]*Physics Department, Northeastern University, Boston, Massachusetts 02115.* (Received 18 December 1996)

We study in detail the contribution of heavy composite Majorana neutrinos to neutrinoless double beta decay ($0\nu\beta\beta$). Our analysis confirms the result of a previous estimate by two of the authors. Excited neutrinos couple to the electroweak gauge bosons through a magnetic-type effective Lagrangian. The relevant nuclear matrix element is related to matrix elements available in the literature and current bounds on the half-life of $0\nu\beta\beta$ are converted into bounds on the compositeness scale and/or the heavy neutrino mass. Our bounds are of the same order of magnitude as those available from accelerator experiments. [S0556-2821(97)03919-2] [Phys. Rev. D **56**, 5766 (1997)]

Coherent neutrino interactions in a dense medium. Ken Kiers, *Department of Physics, Brookhaven National Laboratory, Upton, New York 11973-5000;* Nathan Weiss, *School of Physics and Astronomy, Tel Aviv University, Tel Aviv, Israel; Department of Particle Physics, Weizmann Institute, Rehovot, Israel; and Department of Physics and Astronomy, University of British Columbia, Vancouver, British Columbia, Canada V6T 1Z1.* (Received 2 May 1997)

Motivated by the effect of matter on neutrino oscillations (the MSW effect) we study in more detail the propagation of neutrinos in a dense medium. The dispersion relation for massive neutrinos in a medium is known to have a minimum at nonzero momentum $p \sim G_F \rho/\sqrt{2}$. We study in detail the origin and consequences of this dispersion relation for both Dirac and Majorana neutrinos both in a toy model with only neutral currents and a single neutrino flavor and in a realistic ''standard model'' with two neutrino flavors. We find that for a range of neutrino momenta near the minimum of the dispersion relation, Dirac neutrinos are trapped by their coherent interactions with the medium. This effect does not lead to the trapping of Majorana neutrinos. [S0556-2821(97)01021-7] [Phys. Rev. D **56**, 5776 (1997)]

Proton spin structure in the rest frame. Petr Závada, *Institute of Physics, Academy of Sciences of Czech Republic, Na Slovance 2, CZ-180 40 Prague 8, Czech Republic.* (Received 15 April 1997)

It is shown that the quark-parton model in the standard infinite momentum approach overestimates the proton spin structure function $g_1(x)$ in comparison with the approach taking consistently into account the internal motion of quarks described by a spherical phase space in the proton rest frame. Particularly, it is shown the first moment of the spin structure function in the latter approach, assuming only the valence quarks contribution to the proton spin, does not contradict the experimental data. [S0556-2821(97)02821-X] [Phys. Rev. D **56**, 5834 (1997)]

Multifractal analysis of extreme fluctuations in hadron multiplicities. F. Takagi, *Department of Physics, Tohoku University, Sendai 980-77, Japan;* D. Kiang, *Department of Physics, Dalhousie University, Halifax, Nova Scotia, Canada B3H3J5.* (Received 29 August 1996; revised manuscript received 21 May 1997)

If a limited region of the final state phase space of multiparticle production in high-energy particle collisions is divided into many bins (cells) of equal size, it may happen occasionally that a single bin contains q particles and all the other bins are empty. It is pointed out that the probability $S(q)$ to find such extremely fluctuating events carries useful information which is independent of that carried by the scaled factorial moments F_q. The generalized dimension D_q can be estimated if $S(q)$ obeys a power law. Several models and experimental feasibility are examined in detail. [S0556-2821(97)03721-1] [Phys. Rev. D **56**, 5862 (1997)]

Nucleon contribution to the neutrino electromagnetic vertex in matter. Juan Carlos D'Olivo, *Instituto de Ciencias Nucleares, Universidad Nacional Autónoma de México, Apartado Postal 70-543, 04510 México, D.F., Mexico;* José F. Nieves, *Laboratory of Theoretical Physics, Department of Physics, P.O. Box 23343, University of Puerto Rico, Río Piedras, Puerto Rico 00931-3343.* (Received 25 June 1997)

We calculate the nucleon contribution to the electromagnetic vertex of a neutrino in a background of particles, including the effect of the anomalous magnetic moment of the nucleons. Explicit formulas for the form factors are given in various physical limits of practical interest. Several applications of the results are mentioned, including the effect of an external magnetic field on the dispersion relation of a neutrino in matter. [S0556-2821(97)04721-8] [Phys. Rev. D **56**, 5898 (1997)]

Study of the day-night effect for the Super-Kamiokande detector. I. Time-averaged solar neutrino survival probability. Q. Y. Liu, *Scuola Internazionale Superiore di Studi Avanzati, Trieste, Italy;* M. Maris, *Scuola Internazionale Superiore di Studi Avanzati, Trieste, Italy and INFN, Sezione di Pavia, Pavia, Italy;* S. T. Petcov, *Scuola Internazionale Superiore di Studi Avanzati, Trieste, Italy and INFN, Sezione di Trieste, Trieste, Italy.* (Received 24 February 1997)

This is the first of two articles aimed at providing comprehensive predictions for the day-night (D-N) effect for the Super-Kamiokande detector in the case of the Mikheyev-Smirnov-Wolfenstein (MSW) $\nu_e \rightarrow \nu_{\mu(\tau)}$ transition solution of the solar neutrino problem. The one-year-averaged probability of survival of the solar ν_e crossing the Earth's mantle, the core, the inner 2/3 of the core, and the (core+mantle) is calculated with high precision (better than 1%) using the elliptical orbit approximation to describe the Earth's motion around the Sun. Results for the survival probability in the indicated cases are obtained for a large set of values of the MSW transition parameters Δm^2 and $\sin^2 2\theta_V$ from the ''conservative'' regions of the MSW solution, derived by taking into account possible relatively large uncertainties in the values of the ^{8}B and ^{7}Be neutrino fluxes. Our results show that the one-year-averaged D-N asymmetry in the ν_e survival probability for neutrinos crossing the Earth's core can be, in the case of $\sin^2 2\theta_V \leqslant 0.013$, larger than the asymmetry in the probability for (only mantle crossing +core crossing) neutrinos by a factor of up to 6. The enhancement is larger in the case of neutrinos crossing the inner 2/3 of the core. This indicates that the Super-Kamiokande experiment might be able to test the $\sin^2 2\theta_V \leqslant 0.01$ region of the MSW solution of the solar neutrino problem by performing selective D-N asymmetry mea-

surements. [S0556-2821(97)04419-6] [Phys. Rev. D **56**, 5991 (1997)]

Atomic mass dependence of Ξ^- and $\overline{\Xi}^+$ production in central 250 GeV π^--nucleon interactions. G. A. Alves,[1] S. Amato,[1] J. C. Anjos,[1] J. A. Appel,[2] J. Astorga,[5] T. Bernard,[5] S. B. Bracker,[4] L. M. Cremaldi,[3] W. D. Dagenhart,[5] C. L. Darling,[8] R. L. Dixon,[2] D. Errede,[7] H. C. Fenker,[2] C. Gay,[4] D. R. Green,[2] R. Jedicke,[4] P. E. Karchin,[6] C. Kennedy,[8] S. Kwan,[2] L. H. Lueking,[2] J. R. T. de Mello Neto,[1] J. Metheny,[5] R. H. Milburn,[5] J. M. de Miranda,[1] H. da Motta Filho,[1] A. Napier,[5] D. Passmore,[5] A. Rafatian,[3] A. C. dos Reis,[1] W. R. Ross,[8] A. F. S. Santoro,[1] M. Sheaff,[7] M. H. G. Souza,[1] C. Stoughton,[2] M. E. Streetman,[2] D. J. Summers,[3] S. F. Takach,[6] A. Wallace,[8] and Z. Wu,[8] [1]*Centro Brasileiro de Pesquisas Físicas, Rio de Janeiro, Brazil* [2]*Fermi National Accelerator Laboratory, Batavia, Illinois 60510* [3]*University of Mississippi, University, Mississippi 38677* [4]*University of Toronto, Toronto, Ontario, Canada M5S 1A7* [5]*Tufts University, Medford, Massachusetts 02155* [6]*Wayne State University, Detroit, Michigan 48202* [7]*University of Wisconsin, Madison, Wisconsin 53706* [8]*Yale University, New Haven, Connecticut 06511 (Fermilab E769 Collaboration).* (Received 26 March 1997)

We present a measurement of the atomic mass dependence of central Ξ^- and $\overline{\Xi}^+$ production. It is measured using a sample of 22 459 Ξ^-'s and $\overline{\Xi}^+$'s produced in collisions between a 250 GeV π^- beam and targets of beryllium, aluminum, copper, and tungsten. The relative cross sections are fit to the two parameter function $\sigma_0 A^\alpha$, where A is the atomic mass. We measure $\alpha = 0.924 \pm 0.020 \pm 0.025$, for Feynman x in the range $-0.09 < x_F < 0.15$. [S0556-2821(97)05621-X] [Phys. Rev. D **56**, 6003 (1997)]