

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.

Cold dark matter in SUSY theories: The role of nuclear form factors and the folding with the LSP velocity. T. S. Kosmas, *Theoretical Physics Section, University of Ioannina, GR 451 10, Ioannina, Greece*; J. D. Vergados, *Theoretical Physics Section, University of Ioannina, GR 451 10, Ioannina, Greece and Department of Natural Sciences, University of Cyprus, 1678 Nicosia, Cyprus*. (Received 29 May 1996; revised manuscript received 22 August 1996)

The momentum transfer dependence of the total cross section for elastic scattering of cold dark matter candidates, i.e., lightest supersymmetric particles (LSP's), with nuclei is examined. The presented calculations of the event rates refer to a number of representative nuclear targets throughout the periodic table and have been obtained in a relatively wide phenomenologically allowed SUSY parameter space. For the coherent cross sections it is shown that, since the momentum transfer can be quite big for a large mass of the LSP and heavy nuclei even though the energy transfer is small (≤ 100 keV), the total cross section can in such instances be reduced by a factor of about 5. For the spin-induced cross section of odd- A nuclear targets, as is the case of ^{207}Pb studied in this work, we found that the reduction is less pronounced, since the high multipoles tend to enhance the cross section as the momentum transfer increases (for a LSP mass < 200 GeV) and partially cancel the momentum retardation. The effect of the Earth's revolution around the Sun on these event rates is also studied by folding with a Maxwellian LSP-velocity distribution which is consistent with its density in the halos. We thus find that the convoluted event rates do not appreciably change compared to those obtained with an average velocity. The event rates increase with A and, in the SUSY parameter space considered, they can reach values up to $140 \text{ yr}^{-1} \text{ kg}^{-1}$ for Pb. The modulation effect, however, was found to be small (less than $\pm 5\%$). [S0556-2821(97)00904-1] [Phys. Rev. D **55**, 1752 (1997)]

Pontecorvo reactions in antiproton annihilation at rest in deuterium to $\pi^0 n$, $\pi^0 \Delta^0$, ηn , and $\eta \Delta^0$. M. Chiba,⁵ T. Fujitani,⁴ J. Iwahori,¹ M. Kawaguti,¹ M. Kobayashi,² S. Kurokawa,² Y. Nagashima,⁴ T. Omori,⁴ S. Sugimoto,⁴ M. Takasaki,² F. Takeuchi,³ Y. Yamaguchi,⁴ and H. Yoshida¹ (Fukui-KEK-Kyoto Sangyo-Osaka-Tokyo Metropolitan Collaboration) ¹*Faculty of Engineering, Fukui University, Fukui, Fukui, 910 Japan* ²*KEK, National Laboratory for High Energy Physics, Tsukuba, 305 Japan* ³*Faculty of Science, Kyoto Sangyo University, Kita, Kyoto, 603 Japan* ⁴*Department of Physics, Osaka University, Toyonaka, Osaka, 560 Japan* ⁵*Department of Physics, Tokyo Metropolitan University, Hachioji, 192-03, Japan*. (Received 30 September 1996)

Using modularized NaI(Tl) detectors, we carried out a high statistics measurement of inclusive γ -ray, π^0 , and η spectra, and determined the branching ratios or upper limits of Pontecorvo reactions $\bar{p}d \rightarrow \pi^0 n$, $\pi^0 \Delta^0$, ηn , and $\eta \Delta^0$ from the corresponding monochromatic peaks in them. The obtained branching ratios are

$$B(\bar{p}d \rightarrow \pi^0 n) = (1.03 \pm 0.41) \times 10^{-5}, \quad B(\bar{p}d \rightarrow \pi^0 \Delta^0) = (4.67 \pm 1.66) \times 10^{-5}, \quad B(\bar{p}d \rightarrow \eta n) < 8.94 \times 10^{-6} \quad (95\% \text{ C.L.}), \quad \text{and} \\ B(\bar{p}d \rightarrow \eta \Delta^0) < 6.49 \times 10^{-5} \quad (95\% \text{ C.L.}). \quad [\text{S0556-2821(97)04305-1}] \\ [\text{Phys. Rev. D } \mathbf{55}, 2577 \text{ (1997)}]$$

Vector meson leptoproduction and nonperturbative gluon fluctuations in QCD. H. G. Dosch, T. Gousset, G. Kulzinger, and H. J. Pirner, *Institut für Theoretische Physik der Universität Heidelberg, Philosophenweg 16 & 19, D69120 Heidelberg, Germany*. (Received 25 July 1996)

We present a nonperturbative QCD calculation of diffractive vector meson production in virtual photon nucleon scattering at high energy. We use the nonperturbative model of the stochastic QCD vacuum which yields linear confinement and makes specific predictions for the dependence of high-energy scattering cross sections on the hadron size. Using light cone wave functions of the photon and vector mesons, we calculate electroproduction cross sections for ρ , ω , ϕ , and J/ψ . We emphasize the behavior of specific observables such as the ratio of longitudinal to transverse production cross section and the t dependence of the differential cross section. [S0556-2821(97)05405-2] [Phys. Rev. D **55**, 2602 (1997)]

Passage of charmed particles through the mixed phase in high-energy heavy-ion collisions. Benjamin Svetitsky and Asher Uziel, *School of Physics and Astronomy, Raymond and Beverly Sackler Faculty of Exact Sciences, Tel Aviv University, 69978 Tel Aviv, Israel*. (Received 10 June 1996)

We employ a modified cascade hydrodynamics code to simulate the phase transition of an expanding quark-gluon plasma and the passage of a charmed particle through it. When inside the plasma droplets, the charmed quark experiences drag and diffusion forces. When outside the plasma, the quark travels as a D meson and experiences collisions with pions. Additional energy transfer takes place when the quark enters or leaves a droplet. We find that the transverse momentum of D mesons provides a rough thermometer of the phase transition. [S0556-2821(97)03905-2] [Phys. Rev. D **55**, 2616 (1997)]

Nucleon spin-flavor structure in the SU(3)-breaking chiral quark model. X. Song, J. S. McCarthy, and H. J. Weber, *Institute of Nuclear and Particle Physics, Department of Physics, University of Virginia, Charlottesville, Virginia 22901*. (Received 21 June 1996; revised manuscript received 19 November 1996)

The SU(3) symmetric chiral quark model, which describes interactions between quarks, gluons, and the Goldstone bosons, explains

reasonably well many aspects of the flavor and spin structure of the proton, except for the values of f_3/f_8 and Δ_3/Δ_8 . Introducing the SU(3)-breaking effect suggested by the mass difference between the strange and nonstrange quarks, we find that this discrepancy can be removed and better overall agreement obtained. [S0556-2821(97)07205-6] [Phys. Rev. D **55**, 2624 (1997)]

Virtual Compton scattering off the nucleon in chiral perturbation theory. Thomas R. Hemmert and Barry R. Holstein, *Department of Physics and Astronomy, University of Massachusetts, Amherst, Massachusetts 01003*; Germar Knöchlein and Stefan Scherer, *Institut für Kernphysik, Johannes Gutenberg-Universität, D-55099 Mainz, Germany*. (Received 10 July 1996)

We investigate the spin-independent part of the virtual Compton scattering (VCS) amplitude off the nucleon within the framework of chiral perturbation theory. We perform a consistent calculation to third order in external momenta according to Weinberg's power counting. With this calculation we can determine the second- and fourth-order structure-dependent coefficients of the general low-energy expansion of the spin-averaged VCS amplitude based on gauge invariance, crossing symmetry, and the discrete symmetries. We discuss the kinematical regime to which our calculation can be applied and compare our expansion with the multipole expansion by Guichon, Liu, and Thomas. We establish the connection of our calculation with the generalized polarizabilities of the nucleon where it is possible. [S0556-2821(97)00405-0] [Phys. Rev. D **55**, 2630 (1997)]

Baryon magnetic moments and proton spin: A model with collective quark rotation. Massimo Casu and L. M. Sehgal, *Institute for Theoretical Physics (E), RWTH Aachen, D-52074 Aachen, Germany*. (Received 10 June 1996)

We analyze the baryon magnetic moments in a model that relates them to the parton spins Δu , Δd , Δs , and includes a contribution from orbital angular momentum. The specific assumption is the existence of a three-quark correlation (such as a flux string) that rotates with angular momentum $\langle L_z \rangle$ around the proton spin axis. A fit to the baryon magnetic moments, constrained by the measured values of the axial vector coupling constants $a^{(3)} = F + D$, $a^{(8)} = 3F - D$, yields $\langle S_z \rangle = 0.08 \pm 0.13$, $\langle L_z \rangle = 0.39 \pm 0.09$, where the error is a theoretical estimate. A second fit, under slightly different assumptions, gives $\langle L_z \rangle = 0.37 \pm 0.09$, with no constraint on $\langle S_z \rangle$. The model provides a consistent description of axial vector couplings, magnetic moments, and the quark polarization $\langle S_z \rangle$ measured in deep inelastic scattering. The fits suggest that a significant part of the angular momentum of the proton may reside in a collective rotation of the constituent quarks. [S0556-2821(97)03503-0] [Phys. Rev. D **55**, 2644 (1997)]

Nucleon strangeness and unitarity. M. J. Musolf, *Institute for Nuclear Theory, University of Washington, Seattle, Washington 98195*; H.-W. Hammer, *Institute for Nuclear Theory, University of Washington, Seattle, Washington 98195 and Universität Mainz, Institut für Kernphysik, J.-J.-Becher Weg 45, D-55099 Mainz, Ger-*

many; D. Drechsel, *Universität Mainz, Institut für Kernphysik, J.-J.-Becher Weg 45, D-55099 Mainz, Germany*. (Received 18 October 1996)

The strange-quark vector current form factors of the nucleon are analyzed within the framework of dispersion relations. Particular attention is paid to contributions made by KK intermediate states to the form factor spectral functions. It is shown that, when the $KK \rightarrow NN$ amplitude is evaluated in the Born approximation, the KK contributions are identical to those arising from a one-loop calculation and entail a serious violation of unitarity. The mean square strangeness radius and magnetic moment are evaluated by imposing unitarity bounds on the kaon-nucleon partial wave amplitudes. The impact of including the kaon's strangeness vector current form factor in the dispersion integrals is also evaluated. [S0556-2821(97)05605-1] [Phys. Rev. D **55**, 2741 (1997)]

Strong decays of nonstrange q^3 baryons. R. Bijker, *Instituto de Ciencias Nucleares, Universidad Nacional Autónoma de México, Apartado Postal 70-543, 04510 México, D.F., México*; F. Iachello, *Center for Theoretical Physics, Sloane Laboratory, Yale University, New Haven, Connecticut 06520-8120*; A. Leviatan, *Racah Institute of Physics, The Hebrew University, Jerusalem 91904, Israel*. (Received 26 August 1996)

We study strong decays of nonstrange baryons by making use of the algebraic approach to hadron structure. Within this framework we derive closed expressions for decay widths in an elementary-meson emission model and use these to analyze the experimental data for $N^* \rightarrow N + \pi$, $N^* \rightarrow \Delta + \pi$, $N^* \rightarrow N + \eta$, $\Delta^* \rightarrow N + \pi$, $\Delta^* \rightarrow \Delta + \pi$, and $\Delta^* \rightarrow \Delta + \eta$ decays. [S0556-2821(97)04503-7] [Phys. Rev. D **55**, 2862 (1997)]

Microscopic foundations of the vector meson dominance model and the analysis of ρ - ω mixing. C. M. Shakin and Wei-Dong Sun, *Department of Physics and Center for Nuclear Theory, Brooklyn College of the City University of New York, Brooklyn, New York 11210*. (Received 8 March 1996; revised manuscript received 22 August 1996)

We use a momentum-space analysis of a generalized Nambu–Jona-Lasinio (NJL) model to provide a microscopic foundation for the vector-meson-dominance model. (In our model the photon interacts with the constituent quarks rather than with the hadrons.) A novel feature of our model is the introduction of q^2 -dependent meson decay constants, $g^\rho(q^2)$ and $g^\omega(q^2)$, as well as q^2 -dependent meson-meson coupling constants, such as $g_{\rho\pi\pi}(q^2)$. We discuss the values of $g^\rho(q^2)$, $g^\omega(q^2)$, and $g_{\rho\pi\pi}(q^2)$ obtained using our generalized NJL model, considering different choices for the parameters of the model. We also provide a quark-based description of ρ - ω mixing including the effects of direct $\omega \rightarrow \pi^+ + \pi^-$ decay. The definition of momentum-dependent meson decay constants allows us to introduce current correlation functions for the ρ and ω mesons into the analysis in an unambiguous manner, when we start with an analysis of hadronic current correlators that are expressed in terms of quark fields. A good fit is obtained for the pion form factor in the

region where ρ - ω mixing is important. [S0556-2821(97)05805-0] [Phys. Rev. D **55**, 2874 (1997)]

Accelerator, reactor, solar, and atmospheric neutrino oscillations: Beyond three generations. Srubabati Goswami, *Department of Pure Physics, University of Calcutta, 92 Acharya Prafulla Chandra Road, Calcutta 700 009, India.* (Received 20 August 1996)

We perform a phenomenological analysis of neutrino oscillations introducing an additional sterile neutrino. In such a scenario, more than one spectrum is possible that can accommodate three hierarchically different mass-squared differences as required by the present experiments. We considered two different spectra. Choosing the Δm^2 's in the ranges suitable for the LSND, atmospheric, and solar neutrino oscillations, limits on the mixing angles are derived, consistent with the most restrictive accelerator and reactor data as well as the atmospheric and solar neutrino results. We show that the present data disfavor one of these mass spectra leaving us with a very stringent choice of mass and mixing angle. The potential of the future heavy water solar neutrino experiment SNO to distinguish between the four-neutrino mixing and two-neutrino mixing cases is explored. [S0556-2821(97)01603-2] [Phys. Rev. D **55**, 2931 (1997)]

Strange and charmed quarks in the nucleon. Ariel R. Zhitnitsky, *Physics Department, University of British Columbia, 6224 Agricultural Road, Vancouver, British Columbia, Canada V6T 1Z1.* (Received 17 April 1996; revised manuscript received 14 November 1996)

We discuss the general method of the calculation of the nucleon matrix elements of an operator associated with nonvalence quarks. The method is based on the QCD sum rules and low energy theorems. As an application of these considerations, we calculate the strange quark matrix element as well as the momentum distribution of the strangeness in the nucleon. We also calculate the singlet axial constant associated with η' meson as well as an axial constant associated with heavy quarks. [S0556-2821(97)06205-X] [Phys. Rev. D **55**, 3006 (1997)]

Quenched chiral perturbation theory for vector mesons. Michael Booth, George Chiladze, and Adam F. Falk, *Department of Physics and Astronomy, The Johns Hopkins University, 3400 North Charles Street, Baltimore, Maryland 21218.* (Received 1 November 1996)

We develop quenched chiral perturbation theory for vector mesons made of light quarks, in the limit where the vector meson masses are much larger than the pion mass. We use this theory to extract the leading nonanalytic dependence of the vector meson masses on the masses of the light quarks. By comparing with analogous quantities computed in ordinary chiral perturbation theory, we estimate the size of quenching effects, observing that in general they can be quite large. This estimate is relevant to lattice simulations, where the ρ mass is often used to set the lattice spacing. [S0556-2821(97)06405-9] [Phys. Rev. D **55**, 3092 (1997)]

Damping rate of quasiparticles in degenerate ultrarelativistic plasmas. Michel Le Bellac, *Institut Non Linéaire de Nice, UMR 129 1361 Route des Lucioles, 06560 Valbonne, France;* Cristina Manuel, *Department Estructura i Constituents de la Matèria, Facultat de Física, Universitat de Barcelona, Diagonal 647, 08028 Barcelona, Spain.* (Received 16 September 1996)

We compute the damping rate of a fermion in a dense relativistic plasma at zero temperature. Just above the Fermi sea, the damping rate is dominated by the exchange of soft magnetic photons (or gluons in QCD) and is proportional to $(E - \mu)$, where E is the fermion energy and μ the chemical potential. We also compute the contribution of soft electric photons and of hard photons. As in the nonrelativistic case, the contribution of longitudinal photons is proportional to $(E - \mu)^2$, and is thus nonleading in the relativistic case. [S0556-2821(97)01505-1] [Phys. Rev. D **55**, 3215 (1997)]

Applicability of Martin's equations in high-energy elastic hadron scattering. Vojtěch Kandrát and Miloš Lokajíček, *Institute of Physics, AS CR, 180 40 Praha 8, Czech Republic.* (Received 2 March 1995; revised manuscript received 28 May 1996)

The validity region of Martin's equations enabling one to determine the t dependence of the real part of the elastic hadron amplitude from its imaginary part is critically reexamined. It can be concluded on the basis of a more precise analysis that quite unjustified and in principle incorrect physical results are obtained if the equations are used outside this region, i.e., for $|t| \gtrsim 0.15 \text{ GeV}^2$. [S0556-2821(97)04905-9] [Phys. Rev. D **55**, 3221 (1997)]