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.*

Effects of electron band structure on neutrino pair bremsstrahlung in neutron star crusts. C. J. Pethick, *NORDITA, Blegdamsvej 17, DK-2100 Copenhagen Ø, Denmark; Department of Physics, University of Illinois at Urbana-Champaign, 1110 West Green St., Urbana, Illinois 61801-3080; and Institute for Nuclear Theory, University of Washington, Box 351550; Seattle, Washington 98195-1550;* Vesteinn Thorsson, *NORDITA, Blegdamsvej 17, DK-2100 Copenhagen Ø, Denmark and Department of Physics, University of Washington, Box 351560, Seattle, Washington 98195-1560.* (Received 11 July 1996)

We calculate the rate of energy emission by bremsstrahlung of neutrino pairs by electrons moving in the crystalline lattice of ions in dense matter in the crust of a neutron star. Since the periodic potential in the solid gives rise to electronic band gaps which can be as large as about 1 MeV, it is necessary in estimating the bremsstrahlung rate at low temperatures to take into account band structure in detail. We find that, in the densest parts of the inner crust of a neutron star, neutrino emission at temperatures of about 2×10^9 K or less is much suppressed compared with earlier estimates that treated the electron-lattice interaction perturbatively, and conclude that neutrino pair bremsstrahlung by electrons in the crusts of neutron stars is much less important for neutron star thermal evolution than was previously thought. [S0556-2821(97)01322-2] [Phys. Rev. D **56**, 7548 (1997)]

Mikheyev-Smirnov-Wolfenstein effect as a probe of the solar interior. L. H. Li,[1] Q. L. Cheng,[1] Q. H. Peng,[2] and H. Q. Zhang,[1] [1]*Purple Mountain Observatory, Academia Sinica, Nanjing 210008, Peoples' Republic of China* [2]*Department of Astronomy, Nanjing University, Nanjing 210008, Peoples' Republic of China.* (Received 2 June 1997)

We relate the Mikheyev-Smirnov-Wolfenstein (MSW) effect to the efective absorption of the electronic collective motion energy by retaining the imaginary part of the index of refraction associated with the charged-current scattering and show that the small angle MSW solution to the solar neutrino anomaly can be used as a probe of the physical conditions of the solar interior if it is correct. We find that the constraint on the absorption imposed by the small angle MSW solution and the theoretical estimate of the absorption by the Boltzmann kinetic theory are consistent, which shows that a consistent theoretical picture can be developed when plasma absorption processes are taken into account.
[S0556-2821(97)04522-0] [Phys. Rev. D **56**, 8082 (1997)]

Padé improvement of the free energy in high temperature QCD. T. Hatsuda, *Institute of Physics, University of Tsukuba, Tsukuba, Ibaraki 305, Japan.* (Received 6 August 1997)

Padé approximants (PA's) are constructed from the perturbative coefficients of free energy through $O(g^5)$ in hot QCD. Padé summation is shown to reduce the renormalization-scale dependence substantially even at a temperature (T) as low as 250 MeV. Also, PA's predict that the free energy does not deviate more than 10% from the Stefan-Boltzmann limit for $T>250$ MeV. [S0556-2821(98)04201-5] [Phys. Rev. D **56**, 8111 (1998)]

Soft modes associated with chiral transition at finite temperature. S. Chiku and T. Hatsuda, *Institute of Physics, University of Tsukuba, Tsukuba, Ibaraki 305, Japan.* (Received 23 June 1997; published 26 November 1997)

Using a novel resummation procedure of thermal loops, real-time correlations in the scalar and pseudoscalar channels are studied in the O(4) linear σ model at finite temperature. A threshold enhancement of the spectral function in the scalar channel is shown to be a noticeable precritical phenomenon of the chiral phase transition. [S0556-2821(98)50101-4] [Phys. Rev. D **57**, 6 (1998)]

Effective field theory and matching in nonrelativistic gauge theories. Benjamin Grinstein and Ira Z. Rothstein, *Department of Physics, University of California at San Diego, La Jolla, California 92122.* (Received 12 March 1997; published 10 November 1997)

The effective Lagrangian and power counting rules for nonrelativistic gauge theories are derived via a systematic expansion in the large c limit. It is shown that the $1/c$ expansion leads to an effective field theory which incorporates a multipole expansion. Within this theory there is no need for heuristic arguments to determine the scalings of operators. After eliminating c from the lowest order Lagrangian the states of the theory become independent of c and the scaling of an operator is given simply by its overall coefficient. We show how this power counting works in the calculation of the Lamb shift within the effective field theory formalism. [S0556-2821(98)00501-3] [Phys. Rev. D **57**, 78 (1998)]

Effective equation of state for a spherically expanding pion plasma. Melissa A. Lampert, *Department of Physics, University of New Hampshire, Durham, New Hampshire 03824;* Carmen Molina-París, *Theoretical Division, Los Alamos National Laboratory, Los Alamos, New Mexico 87545.* (Received 8 August 1997; published 9 December 1997)

Following a relativistic heavy ion collision, the quark-gluon plasma produced eventually undergoes a chiral phase transition. We assume that during this phase transition one can describe the dynamics of the system by the linear σ model and that the expansion can be thought of as mostly radial. Because the σ model is an

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effective field theory there is an actual momentum cutoff (Landau pole) in the theory at around 1 GeV. Thus it is necessary to find ways of obtaining a covariantly conserved, renormalized energy-momentum tensor when there is a cutoff present (which breaks covariance), in order to identify the effective equation of state of this time evolving system. We show how to solve this technical problem and then determine the energy density and pressure of the system as a function of the proper time. We consider different initial conditions and search for instabilities which can lead to the formation of disoriented chiral condensates. We find that the energy density and pressure both decrease quickly, as is appropriate for a rapidly cooling system, and that the energy is numerically conserved. [S0556-2821(98)04501-9] [Phys. Rev. D **57**, 83 (1998)]

Three-pion interferometry in high energy collisions. Q. H. Zhang, *Institut für Theoretische Physik, Universität Regensburg D-93040 Regensburg, Germany.* (Received 3 April 1997; published 4 December 1997)

The data of the three-pion correlation function are analyzed. It is shown that three-pion interferometry not only can act as an independent tool to extract the source information but also can be used to test if we have assumed the right correlation function. [S0556-2821(98)03701-1] [Phys. Rev. D **57**, 287 (1998)]

Disoriented chiral condensate formation from tubes of hot quark plasma. Abdellatif Abada and Michael C. Birse, *Theoretical Physics Group, Department of Physics and Astronomy, University of Manchester, Manchester M13 9PL, England.* (Received 7 July 1997; published 10 November 1997)

We investigate the time evolution of a system of quarks interacting with σ and pion fields starting from an initial configuration consisting of a tube of hot quark plasma undergoing a boost-invariant longitudinal expansion. We work within the framework of the linear sigma model using classical transport equations for the quarks coupled to the mean-field equations for the meson fields. In certain cases we find strong amplifications of any initial pion fields. For large-radius tubes, starting from quark densities that are very close to critical, we find that a disoriented chiral condensate can form in the center of the tube. Eventually the collapse of the tube drives this state back to the true vacuum. This process converts the disoriented condensate, dominated by long-wavelength pion modes, into a coherent excitation of the pion field that includes significant components with transverse momenta of around 400 MeV. In contrast, for narrow tubes or larger initial temperatures, amplification occurs only via the pion-laser-like mechanism found previously for spherical systems. In addition, we find that explicit chiral symmetry breaking significantly suppresses the formation of disoriented condensates. [S0556-2821(98)03101-4] [Phys. Rev. D **57**, 292 (1998)]

Chiral quark model of nucleon spin-flavor structure with SU(3) and axial-U(1) breakings. T. P. Cheng, *Department of Physics and Astronomy, University of Missouri, St. Louis, Missouri 63121;* Ling-Fong Li, *Department of Physics, Carnegie Mellon University, Pittsburgh, Pennsylvania 15213.* (Received 9 January 1997; published 26 November 1997)

The chiral quark model with a nonet of Goldstone bosons can yield an adequate description of the observed proton flavor and spin structure. In a previous publication we have compared the results of an SU(3) symmetric calculation with the phenomenological findings based on experimental measurements and SU(3) symmetry relations. In this paper we discuss their SU(3) and axial U(1) breaking corrections. Our result demonstrates the broad consistency of the chiral quark model with the experimental observations of the proton spin-flavor structure. With two parameters, we obtain a very satisfactory fit to the F/D ratios for the octet baryon masses and for their axial vector couplings, as well as the different quark flavor contributions to the proton spin. The result also can account for not only the light quark asymmetry $\overline{u}-\overline{d}$ but also the strange quark content $\overline{s}$ of the proton sea. SU(3) breaking is the key in reconciling the $\overline{s}$ value as measured in the neutrino charm production and that as deduced from the pion nucleon σ term. [S0556-2821(98)02301-7] [Phys. Rev. D **57**, 344 (1998)]

Diffractive heavy quarkonium photoproduction and electroproduction in QCD. Leonid Frankfurt, *School of Physics and Astronomy, Raymond and Beverly Sackler Faculty of Exact Sciences, Tel Aviv University, Tel Aviv, Israel;* Werner Koepf, *Department of Physics, The Ohio State University, Columbus, Ohio 43210;* Mark Strikman, *Department of Physics, Pennsylvania State University, University Park, Pennsylvania 16802.* (Received 5 February 1997; published 5 December 1997)

Hard diffractive photoproduction and electroproduction of heavy vector mesons (J/ψ and Υ) is evaluated within the leading $\alpha_s \ln(Q^2/\Lambda^2_{\rm QCD})$ approximation of QCD. Different from our earlier work on that subject, also the production of transversely polarized vector mesons is calculated. Special emphasis is placed on the role of the vector meson's $q\overline{q}$ light-cone wave function. In that context, conventional nonrelativistic quarkonium models and a light-front QCD bound state calculation are critically examined and confronted with QCD expectations. Our numerical analysis finds a significant high momentum tail in the latter wave functions and a deviation from the expected asymptotic behavior of $\phi_V(z,b=0)\propto z(1-z)$. We then design an interpolation to match the quarkonium models at large interquark separations with QCD expectations at small distances. We use these results to compare our predictions for the forward differential cross section of J/ψ photoproduction and electroproduction with recent experimental results from DESY HERA. In addition, our earlier discussion of ρ° electroproduction is updated in light of recent experimental and theoretical enhancements. [S0556-2821(98)05601-X] [Phys. Rev. D **57**, 512 (1998)]

Self-similarity of the negative binomial multiplicity distributions. G. Calucci and D. Treleani, *Dipartimento di Fisica Teorica dell'Universitàand INFN, Trieste, I 34014 Italy.* (Received 7 August 1997; published 2 December 1997)

The negative binomial distribution is self-similar: If the spectrum over the whole rapidity range gives rise to a negative binomial, in the absence of correlation and if the source is unique, also a partial range in rapidity gives rise to the same distribution. The property is not seen in experimental data, which are rather consistent with the presence of a number of independent sources. When multiplicities are very large, self-similarity might be used to isolate individual sources in a complex production process. [S0556-2821(98)00401-9] [Phys. Rev. D **57**, 602 (1998)]