Selected Abstracts from Other Physical Review Journals

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Correlation-induced collapse of many-body systems with zero-range potentials. D. V. Fedorov and A. S. Jensen, *Institute of Physics and Astronomy, University of Aarhus, DK-8000 Aarhus C, Denmark.* (Received 31 July 2000; published 14 May 2001)

The zero-range potential is customarily employed in various mean-field calculations of many-body systems in atomic and nuclear physics within, correspondingly, Gross-Pitaevskii and Skyrme-Hartree-Fock approaches. We argue, however, that a many-body system with zero-range potentials is unstable against clusterization into collapsed three-body subsystems. We show that neither the density dependence of the potential nor an additional repulsive three-body potential can prevent this unexpected correlational collapse if the potentials are of zero range. Therefore, the zero-range potential can only be used in many-body calculations where all three-body correlations are explicitly excluded. [Phys. Rev. A **63**, 063608 (2001)]

Pion form factor and quark mass evolution in a light-front Bethe-Salpeter model. L. S. Kisslinger and Ho-Meoyng Choi, *Department of Physics, Carnegie-Mellon University, Pittsburgh, Pennsylvania 15213;* Chueng-Ryong Ji, *Department of Physics, North Carolina State University, Raleigh, North Carolina 27695-8202.* (Received 8 January 2001; published 20 April 2001)

We discuss the soft contribution to the elastic pion form factor with the mass evolution from current to constituent quark being taken into account using a light-front Bethe-Salpeter (LFBS) model, which is a light-front quark model (LFQM) with a running mass. It is shown that partial conservation of the axial-vector current (PCAC) is satisfied with a running quark mass. We examine the sensitivity of the pion form factor using two different functional forms of the quark propagator. The Ball-Chiu ansatz is used to maintain local gauge invariance of the quark-photon vertex. The extension of our model to the hard contribution is also discussed. [Phys. Rev. D **63**, 113005 (2001)]

Majorana neutrino masses and neutrino oscillations. Sin Kyu Kang, *School of Physics, Korea Institute for Advanced Study, Seoul 130-012, Korea;* C. S. Kim, *Physics Department and IPAP, Yonsei University, Seoul 120-749, Korea and Department of Physics, University of Wisconsin, Madison, Wisconsin 53706.* (Received 6 September 2000; published 2 May 2001)

We examine some patterns of the Majorana neutrino mass matrix which are compatible with the phenomenological lepton flavor mixing matrix and non-observation of neutrinoless double beta decay. Imposing $(M_\nu)_{ee}=0$ for the Majorana neutrino mass matrix in the leading order, we obtain a relationship between the solar mixing angle and the neutrino masses m_1 and m_2. Additional possible texture zeros are assigned to the mass matrix so as for the nonvanishing θ_{13} to be predictable in terms of neutrino masses. We also show how three neutrino masses can be predicted from the solar mixing angle and the experimental results of $\Delta m^2_{\rm sol}$ and $\Delta m^2_{\rm atm}$ in this framework, and we discuss the naturality of the forms of the mass matrix found in our work. [Phys. Rev. D **63**, 113010 (2001)]

Exploring neutrino oscillations with superbeams. V. Barger, *Department of Physics, University of Wisconsin, Madison, Wisconsin 53706;* S. Geer and R. Raja, *Fermi National Accelerator Laboratory, P.O. Box 500, Batavia, Illinois 60510;* K. Whisnant, *Department of Physics and Astronomy, Iowa State University, Ames, Iowa 50011.* (Received 4 December 2000; published 2 May 2001)

We consider the medium- and long-baseline oscillation physics capabilities of intense muon-neutrino and muon-antineutrino beams produced using future upgraded megawatt-scale high-energy proton beams. In particular we consider the potential of these conventional neutrino ''superbeams'' for observing $\nu_\mu \to \nu_e$ oscillations, determining the hierarchy of neutrino mass eigenstates, and measuring CP violation in the lepton sector. The physics capabilities of superbeams are explored as a function of the beam energy, baseline, and the detector parameters (fiducial mass, background rates, and systematic uncertainties on the backgrounds). The trade-offs between very large detectors with poor background rejection and smaller detectors with excellent background rejection are illustrated. We find that, with an aggressive set of detector parameters, it may be possible to observe $\nu_\mu \to \nu_e$ oscillations with a superbeam provided that the amplitude parameter $\sin^2 2\theta_{13}$ is larger than a few $\times 10^{-3}$. If $\sin^2 2\theta_{13}$ is of order 10^{-2} or larger, then the neutrino mass hierarchy can be determined in long-baseline experiments, and if in addition the large mixing angle MSW solution describes the solar neutrino deficit, then there is a small region of parameter space within which maximal CP violation in the lepton sector would be observable (with a significance of a few standard deviations) in a low-energy medium-baseline experiment. We illustrate our results by explicitly considering massive water Cherenkov and liquid argon detectors at superbeams with neutrino energies ranging from 1 GeV to 15 GeV, and baselines ranging from 295 km to 9300 km. Finally, we compare the oscillation physics prospects at superbeams with the corresponding prospects at neutrino factories. The sensitivity at a neutrino factory to CP violation and the neutrino mass hierarchy extends to values of the amplitude parameter $\sin^2 2\theta_{13}$ that are one to two orders of magnitude lower than at a superbeam. [Phys. Rev. D **63**, 113011 (2001)]

Absolute neutrino mass determination. H. Päs and T. J. Weiler, *Department of Physics and Astronomy, Vanderbilt University, Nashville, Tennessee 37235.* (Received 11 January 2001; published 8 May 2001)

We discuss four approaches to the determination of absolute neutrino mass. These are the measurement of the zero-neutrino double beta decay rate, of the tritium decay end-point spectrum, of the cosmic ray spectrum above the GZK cutoff (in the *Z*-burst model), and the cosmological measurement of the power spectrum governing the CMB and large scale structure. The first two approaches are sensitive to the mass eigenstates coupling to the electron neutrino, whereas the latter two are sensitive to the heavy component of the cosmic neutrino background. All mass eigenstates are related by the δm^2's inferred from neutrino oscillation data. Consequently, the potential for the absolute mass determination of each of the four approaches is correlated with the other three, in ways that we point out. [Phys. Rev. D **63**, 113015 (2001)]

Neutrino suppression and extra dimensions: A minimal model. N. Cosme, J.-M. Frère, Y. Gouverneur, F.-S. Ling, D. Monderen, and V. Van Elewyck, *Service de Physique Théorique, CP225, Université Libre de Bruxelles, Bvd du Triomphe, B-1050 Brussels, Belgium.* (Received 15 November 2000; published 9 May 2001)

We study flavor neutrinos confined to our four-dimensional world coupled to one ''bulk'' state, i.e., a Kaluza-Klein tower. We discuss the spatial development of the neutrino disappearance, the possibility of resurgence, and the effective flavor transitions induced in this mechanism. We show that even a simple model can produce an energy independent suppression at large distances, and relate this to experimental data. [Phys. Rev. D **63**, 113018 (2001)]

MSW mediated neutrino decay and the solar neutrino problem. Abhijit Bandyopadhyay, Sandhya Choubey, and Srubabati Goswami, *Saha Institute of Nuclear Physics, 1/AF, Bidhannagar, Calcutta 700 064, India.* (Received 25 January 2001; published 10 May 2001)

We investigate the solar neutrino problem assuming the simultaneous presence of MSW transitions in the Sun and neutrino decay on the way from the Sun to Earth. We do a global χ^2 analysis of the data on the total rates in Cl, Ga, and SuperKamiokande (SK) experiments and the SK day-night spectrum data and determine the changes in the allowed region in the Δm^2 -tan$^2\,\theta$ plane in the presence of decay. We also discuss the implications for unstable neutrinos in the SNO experiment. [Phys. Rev. D **63**, 113019 (2001)]

Transverse energy from minijets in ultrarelativistic nuclear collisions: A next-to-leading order analysis. K. J. Eskola, *Department of Physics, University of Jyväskylä, P.O. Box 35, FIN-40351, Jyväskylä, Finland and Helsinki Institute of Physics, P.O. Box 9, FIN-00014, University of Helsinki, Finland;* K. Tuominen, *Department of Physics, University of Jyväskylä, P.O. Box 35, FIN-40351, Jyväskylä, Finland.* (Received 30 October 2000; published 18 April 2001)

We compute in next-to-leading order (NLO) perturbative QCD the amount of transverse energy produced into a rapidity region ΔY of a nuclear collision from partons created in the few-GeV subcollisions. The NLO formulation assumes collinear factorization and is based on the subtraction method. We first study the results as a function of the minimum transverse momentum scale and define and determine the associated *K* factors. The dependence of the NLO results on the scale choice and on the size of ΔY is also studied. The calculations are performed for GRV94 and CTEQ5 sets of parton distributions. Also the effect of nuclear shadowing to the NLO results is investigated. The main results are that the NLO results are stable relative to the leading-order (LO) ones even in the few-GeV domain and that there exists a new kinematical region not present in the LO, which is responsible for the magnitude of the *K* factors. The dependence on the size of ΔY is found to be practically linear within two central units of rapidity, and the scale dependence present at BNL RHIC energies is seen to vanish at the CERN LHC energies. Finally, the effect of NLO corrections to the determination of transverse energies and multiplicities in nuclear collisions is discussed within the framework of parton saturation. [Phys. Rev. D **63**, 114006 (2001)]

Calculation of the continuum contribution to hadronic current correlation functions in a chiral quark model with confinement. C. M. Shakin and Huangsheng Wang, *Department of Physics and Center for Nuclear Theory, Brooklyn College of the City University of New York, Brooklyn, New York 11210.* (Received 6 December 2000; published 18 April 2001)

A powerful technique for the calculation of hadronic properties is the application of QCD sum rules in a study of correlation functions. The calculation of hadronic current correlation functions may be carried out using the operator-product expansion. The correlator may also be represented by hadronic states, which include one or more discrete levels and a continuum contribution. Comparison of the two methods of calculation of the same correlator allows for the determination of hadronic parameters after one estimates the continuum contribution and specifies the values of the vacuum condensates. In this work we consider two types of contribution to the continuum. The first involves the radially excited states of a meson. These states appear as resonances which ultimately decay into the continuum of multimeson states. In a second process, the multimeson continuum is reached in a direct process, without the excitation of a resonance. For the resonances, we calculate the contribution to the hadronic correlator by calculating the meson decay constants in the region $0<P^2<6$ GeV^2, making use of our generalized Nambu–Jona-Lasinio model, which includes a covariant model of confinement. [Our model provides a good fit to the decay constants of the $a_0(1450)$ and K_0^* (1430) mesons. Our value for the $a_0(980)$ is about 60% larger than the value obtained by Maltman using QCD sum rules. Also, our values for the pion and kaon decay constants are about 35 and 10% too large, respectively. We have not performed any parameter variations to improve upon these values.] The second contribution to the correlator arises from the direct excitation of multimeson continuum states. For the $a_0(980)$ and its radial excitations, we calculate both the resonant and direct contributions. In the case of the isovector pseudoscalar states we calculate the resonance contribution and parametrize the direct multimeson contribution so as to reproduce a phenomenological expression of the quark-hadron duality model. In this case the calculated resonance contribution is about 15% of the phenomenological result after a Borel transformation is made. The resonance contribution

plus a quark-hadron duality model contribution with $s_0 = 1.65\,\mathrm{GeV}^2$ yields a good fit to the phenomenological form. In this phenomenological form only the quark-hadron duality model is used with $s_0 = 1.53\,\mathrm{GeV}^2$. We also provide values of the resonance contribution to the continuum strength in the case of the strange pseudoscalar states. In the case of the isovector scalar mesons we find significant disagreement between our microscopic calculations and the result of the quark-duality model for the continuum of the hadronic current correlator. Indeed, the contribution of the resonances to the continuum is a least an order of magnitude larger than the values obtained from the quark-hadron duality model. That result may suggest an explanation for the problems encountered by some authors who have studied the isovector scalar mesons using QCD sum rules. [Phys. Rev. D **63**, 114007 (2001)]

Dileptons from a quark-gluon plasma with finite baryon density. A. Majumder and C. Gale, *Physics Department, McGill University, 3600 University Street, Montréal, QC, Canada H3A 2T8.* (Received 5 December 2000; published 19 April 2001)

We investigate the effects of a baryon-antibaryon asymmetry on the spectrum of dileptons radiating from a quark-gluon plasma. We demonstrate the existence of a new set of processes in this regime. The dilepton production rate from the corresponding diagrams is shown to be as important as that obtained from the usual quark-antiquark annihilation. [Phys. Rev. D **63**, 114008 (2001)]

Pion-pion phase shifts and the value of the quark-antiquark condensate in the chiral limit. Isabela P. Cavalcante and J. Sá Borges, *Universidade do Estado do Rio de Janeiro, Rua São Francisco Xavier, 524, Maracanã, Rio de Janeiro, Brazil.* (Received 10 November 2000; published 7 May 2001)

We use low energy pion-pion phase shifts in order to make a distinction between the alternatives for the value of the quark-antiquark condensate B_0 in the chiral limit. We consider the amplitude up to and including $\mathcal{O}(p^4)$ contributions within the standard and generalized chiral perturbation theory frameworks. They are unitarized by means of Padé approximants in order to fit experimental phase shifts in the resonance region. As the best fits correspond to $\alpha = \beta = 1$, we conclude that a pion-pion phase-shift analysis favors the standard chiral perturbation theory scenario, which assumes just one large leading order parameter $\langle \bar{q}q \rangle_0$. [Phys. Rev. D **63**, 114022 (2001)]

Specific heat of normal, degenerate quark matter: Non-Fermi liquid corrections. D. Boyanovsky, *Department of Physics and Astronomy, University of Pittsburgh, Pittsburgh, Pennsylvania 15260 and LPTHE, Université Pierre et Marie Curie (Paris VI) et Denis Diderot (Paris VII), Tour 16, 1er. étage, 4, Place Jussieu, 75252 Paris, Cedex 05, France;* H. J. de Vega, *LPTHE, Université Pierre et Marie Curie (Paris VI) et Denis Diderot (Paris VII), Tour 16, 1er. étage, 4, Place Jussieu, 75252 Paris, Cedex 05, France and Department of Physics and Astronomy, University of Pittsburgh, Pittsburgh, Pennsylvania 15260.* (Received 28 November 2000; published 10 May 2001)

In normal degenerate quark matter, the exchange of dynamically screened transverse gluons introduces infrared divergences in the quark self-energies that lead to the breakdown of the Fermi liquid description. If the cores of neutron stars are composed of quark matter with a normal component, cooling by direct quark URCA processes may be modified by non-Fermi liquid corrections. We find that while the quasiparticle density of states is finite and nonzero at the Fermi surface, its frequency derivative diverges and results in non-Fermi liquid corrections to the specific heat of the normal, degenerate component of quark matter. We study these non-perturbative non-Fermi liquid corrections to the specific heat and the temperature dependence of the chemical potential and show that these lead to a reduction of the specific heat. [Phys. Rev. D **63**, 114028 (2001)]

Hard parton rescatterings and minijets in nuclear collisions at the CERN LHC. Alberto Accardi and Daniele Treleani, *Dipartimento di Fisica Teorica, Università di Trieste, Strada Costiera 11, I-34014 Trieste, Italy and INFN, Sezione di Trieste via Valerio 2, I-34127 Trieste, Italy.* (Received 20 September 2000; published 17 April 2001)

The average number of minijets and the corresponding transverse energy produced in heavy ion collisions are evaluated by including explicitly semi-hard parton rescatterings in the dynamics of the interaction. At the CERN LHC semi-hard rescatterings have a sizable effect on the global characteristics of the typical inelastic event. An interesting feature is that the dependence on the cutoff which separates soft and hard parton interactions becomes less critical after taking rescatterings into account. [Phys. Rev. D **63**, 116002 (2001)]

Neutrino masses and lepton-flavor violation in supersymmetric modelswith lopsided Froggatt-Nielsen charges. Joe Sato, *Research Center for Higher Education, Kyushu University, Roppon-matsu, Chuo-ku, Fukuoka, 810-8560, Japan;* Kazuhiro Tobe, *CERN, Theory Division, CH-1211 Geneva 23, Switzerland.* (Received 26 December 2000; published 9 May 2001)

We analyze in detail lepton-flavor violation (LFV) in the charged-lepton sector such as $\mu \to e\gamma$, $\tau \to \mu\gamma$, $\mu \to eee$, and $\mu \to e$ conversion in nuclei, within the framework of supersymmetric models with lopsided Froggatt-Nielsen charges, in which the large mixing in the neutrino sector as well as small mixing in the quark sector can be naturally accommodated. We show that the present experimental limits on the LFV processes already exclude some of the models. The future proposed search for LFV, especially in muon processes, can provide a significant probe to this framework. We also stress the importance of the measurement of U_{e3}^{MNS} in neutrino experiments, and the fact that the KamLAND experiment could play a significant role to test a certain class of models. [Phys. Rev. D **63**, 116010 (2001)]

Maki-Nakagawa-Sakata parameters from neutrino oscillations, single beta decay, and double beta decay. K. Matsuda, N. Takeda, and T. Fukuyama, *Department of Physics, Ritsumeikan University, Kusatsu, Shiga 525-8577, Japan;* H. Nishiura, *Department of General Education, Junior College of Osaka Institute of Technology, Asahi-ku, Osaka 535-8585, Japan.* (Received 21 December 2000; published 15 May 2001)

We examine the constraints on the Maki-Nakagawa-Sakata lepton mixing matrix from the present and future experimental data of neutrino oscillation, tritium beta decay, and neutrinoless double beta decay for the Majorana neutrinos. We show that the small mixing angle solutions for solar neutrino problem are disfavored for small averaged mass ($\langle m_\nu \rangle$) of neutrinoless double beta decay ($\leqslant 0.01$ eV) in the inverse neutrino mass hierarchy scenario. This is the case even in the normal mass hierarchy scenario except for a very restrictive value of the averaged neutrino mass ($\overline{m_\nu}$) of single beta decay. The lower mass bound for $\overline{m_\nu}$ is given from the present neutrino oscillation data. We obtain some relations between $\langle m_\nu \rangle$ and $\overline{m_\nu}$. The constraints on the Majorana CP violating phases are also given. [Phys. Rev. D **64**, 013001 (2001)]

Glueball as a bound state in the self-dual homogeneous vacuum gluon field. Ja. V. Burdanov, *Laboratory of Nuclear Problems, Joint Institute for Nuclear Research, Dubna, Russia;* G. V. Efimov, *Bogoliubov Laboratory of Theoretical Physics, Joint Institute for Nuclear Research, Dubna, Russia.* (Received 5 September 2000; published 14 May 2001)

Using a simple relativistic QFT model of scalar fields we demonstrate that the analytic confinement (propagator is an entire function in the complex p^2 plane) and the weak coupling constant lead to the Regge behavior of the two-particle bound states. In QCD we assume that the gluon vacuum is realized by the self-dual homogeneous classical field which is the solution of the Yang-Mills equations. This assumption leads to analytical confinement of quarks and gluons. We extract the colorless 0^{++} two-gluon state from the QCD generating functional in the one-gluon exchange approximation. The mass of this bound state is defined by the Bethe-Salpeter equation. The glueball mass is 1765 MeV for $\alpha_s = 0.33$ if the gluon condensate is $\langle (\alpha_s/\pi) GG \rangle = 0.012$ GeV^4. [Phys. Rev. D **64**, 014001 (2001)]

Production processes as a tool to study parametrizations of quark confinement. S. Ahlig, R. Alkofer, C. Fischer, M. Oettel, H. Reinhardt, and H. Weigel, *Institute for Theoretical Physics, University of Tübingen, Auf der Morgenstelle 14, D-72076 Tübingen, Germany.* (Received 21 December 2000; published 18 May 2001)

We introduce diquarks as separable correlations in the two-quark Green's function to facilitate the description of baryons as relativistic three-quark bound states. These states then emerge as solutions of Bethe-Salpeter equations for quarks and diquarks that interact via quark exchange. When solving these equations we consider various dressing functions for the free quark and diquark propagators that prohibit the existence of corresponding asymptotic states and thus effectively parametrize confinement. We study the implications of qualitatively different dressing functions on the model predictions for the masses of the octet baryons as well as the electromagnetic and strong form factors of the nucleon. For different dressing functions we in particular compare the predictions for kaon photoproduction, $\gamma p \rightarrow K\Lambda$, and associated strangeness production, $pp \rightarrow pK\Lambda$, with experimental data. This leads to conclusions on the permissibility of different dressing functions. [Phys. Rev. D **64**, 014004 (2001)]

Quark description of nuclear matter. Jürgen Berges, *Institut für Theoretische Physik, Philosophenweg 16, D-69120 Heidelberg, Germany.* (Received 3 January 2001; published 23 May 2001)

We discuss the role of an adjoint chiral condensate for color superconducting quark matter. Its presence leads to color-flavor locking in two-flavor quark matter. Color is broken completely as well as chiral symmetry in the two-flavor theory with coexisting adjoint quark-antiquark and antitriplet quark-quark condensates. The qualitative properties of this phase match the properties of ordinary nuclear matter without strange baryons. This complements earlier proposals by Schäfer and Wilczek for a quark description of hadronic phases. We show for a class of models with effective four-fermion interactions that adjoint chiral and diquark condensates do not compete, in the sense that simultaneous condensation occurs for sufficiently strong interactions in the adjoint chiral channel. [Phys. Rev. D **64**, 014010 (2001)]

Finite temperature QCD phase transition with domain wall fermions. P. Chen, N. Christ, G. Fleming, A. Kaehler, C. Malureanu, R. Mawhinney, G. Siegert, C. Sui, L. Wu, and Y. Zhestkov, *Physics Department, Columbia University, New York, New York 10027;* P. Vranas, *Physics Department, University of Illinois, Urbana, Illinois 61801.* (Received 12 June 2000; published 21 May 2001)

The domain wall formulation of lattice fermions is expected to support accurate chiral symmetry, even at finite lattice spacing. Here we attempt to use this new fermion formulation to simulate two-flavor, finite temperature QCD near the chiral phase transition. In this initial study, a variety of quark masses, domain wall heights and domain wall separations are explored using an $8^3 \times 4$ lattice. Both the expectation value of the Wilson line and the chiral condensate show the temperature dependence expected for the QCD phase transition. Further, the desired chiral properties are seen for the chiral condensate, suggesting that the domain wall fermion formulation may be an effective approach for the numerical study of QCD at finite temperature. [Phys. Rev. D **64**, 014503 (2001)]