Selected Abstracts from Other Physical Review Journals

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Excited nucleons with chirally improved fermions. Dirk Brömmel,[1] Peter Crompton,[2,1] Christof Gattringer,[1] Leonid Ya. Glozman,[3] C. B. Lang,[3] Stefan Schaefer,[1] and Andreas Schäfer[1] (Bern-Graz-Regensburg Collaboration), [1]*Institut für Theoretische Physik, Universität Regensburg, D-93040 Regensburg, Germany,* [2]*Departament de Fisica Teorica, Universitat de Valencia, E-46100, Burjassot, Valencia, Spain,* [3]*Institut für Theoretische Physik, Universität Graz, A-8010 Graz, Austria.* (Received 16 January 2004; published 28 May 2004)

We study positive and negative parity nucleons on the lattice using the chirally improved lattice Dirac operator. Our analysis is based on a set of three operators χ_i with the nucleon quantum numbers but in different representations of the chiral group and with different diquark content. We use a variational method to separate the ground state and excited states and determine the mixing coefficients for the optimal nucleon operators in terms of the χ_i. We clearly identify the negative parity resonances $N(1535)$ and $N(1650)$ and their masses agree well with experimental data. The mass of the observed excited positive parity state is too high to be interpreted as the Roper state. Our results for the mixing coefficients indicate that chiral symmetry is important for $N(1535)$ and $N(1650)$ states. We confront our data for the mixing coefficients with quark models and provide insights into the physics of the nucleon system and the nature of strong decays. [Phys. Rev. D **69**, 094513 (2004)]

Homestake result, sterile neutrinos, and low energy solar neutrino experiments. P. C. de Holanda, *Instituto de Física Gleb Wataghin - UNICAMP, 13083-970 Campinas SP, Brazil;* A. Yu. Smirnov, *The Abdus Salam International Centre for Theoretical Physics, I-34100 Trieste, Italy, and Institute for Nuclear Research of Russian Academy of Sciences, Moscow 117312, Russia.* (Received 11 August 2003; published 2 June 2004)

The Homestake result is about $\sim 2\sigma$ lower than the Ar-production rate, Q_{Ar}, predicted by the large mixing angle (LMA) Mikheyev-Smirnov-Wolfenstein solution of the solar neutrino problem. Also there is no apparent upturn of the energy spectrum ($R \equiv N_{obs}/N_{SSM}$) at low energies in SNO and Super-Kamiokande. Both these facts can be explained if a light, $\Delta m^2_{01} \sim (0.2\text{–}2) \times 10^{-5}$ eV^2, sterile neutrino exists which mixes very weakly with active neutrinos: $\sin^2 2\alpha \sim (10^{-5}\text{–}10^{-3})$. We perform both the analytical and numerical study of the conversion effects in the system of two active neutrinos with the LMA parameters and one weakly mixed sterile neutrino. The presence of sterile neutrino leads to a dip in the survival probability in the intermediate energy range $E = (0.5\text{–}5)$ MeV thus suppressing the Be, or/and pep, CNO, as well as B electron neutrino fluxes. Apart from diminishing Q_{Ar} it leads to decrease of the Ge-production rate and may lead to the decrease of the BOREXINO signal as well as the CC/NC ratio at SNO. Future studies of the solar neutrinos by SNO, SK, BOREXINO, and KamLAND as well as by the new low energy experiments will allow us to check this possibility. [Phys. Rev. D **69**, 113002 (2004)]

Isospin dependence of power corrections in deep inelastic scattering. S. I. Alekhin,[1] S. A. Kulagin,[2] and S. Liuti[3] [1]*Institute of High Energy Physics, Protvino, Russia,* [2]*Institute for Nuclear Research, 117312 Moscow, Russia,* [3]*University of Virginia, Charlottesville, Virginia 22901, USA.* (Received 20 June 2003; published 2 June 2004)

We present results of a perturbative QCD analysis of deep inelastic measurements of both the deuteron and proton structure functions. We evaluate the theoretical uncertainty associated with nuclear effects in the deuteron, and we extract simultaneously the isospin dependence of (i) the higher twists terms, (ii) the ratio of the longitudinal to transverse cross sections, $R = \sigma_L/\sigma_T$, and (iii) the ratio of the neutron to proton structure functions, F_2^n/F_2^p. The extraction of the latter, in particular, has been at the center of an intense debate. Its accurate determination is crucial both theoretically and for the interpretation of the more precise neutrino experiments including the newly planned high intensity 50 GeV proton synchrotron. [Phys. Rev. D **69**, 114009 (2004)]

Analytic estimates of the QCD corrections to neutrino-nucleus scattering. Bogdan A. Dobrescu and R. Keith Ellis, *Theoretical Physics Department, Fermilab, Batavia, Illinois 60510, USA.* (Received 28 October 2003; published 15 June 2004)

We study the QCD corrections to neutrino deep-inelastic scattering on a nucleus, and analytically estimate their size. For an isoscalar target, we show that the dominant QCD corrections to the ratio of the neutral- to charged-current events are suppressed by $\sin^4\theta_W$, where θ_W is the weak mixing angle. We then discuss the implications for the NuTeV determination of $\sin^2\theta_W$. [Phys. Rev. D **69**, 114014 (2004)]

Systematics of exotic cascade decays. Robert Jaffe and Frank Wilczek, *Center for Theoretical Physics, Laboratory for Nuclear Science and Department of Physics, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139, USA.* (Received 19 January 2004; published 22 June 2004)

Theoretical considerations prompted by the discovery of the exotic $\Theta^+(uudd\bar{s})$ led us to propose a dynamical picture emphasizing the role of diquark correlations, which are also useful in eluci-

dating other aspects of low-energy QCD. A notable prediction of this picture is the existence of new exotic and nonexotic $S=-2$ ''cascade'' baryons with specific, characteristic properties. We argue here that recent observations by the NA49 Collaboration are broadly consistent with our predictions, and propose further tests. [Phys. Rev. D **69**, 114017 (2004)]

***N* to Δ electromagnetic transition form factors from lattice QCD.** C. Alexandrou,[1] Ph. de Forcrand,[2] Th. Lippert,[3] H. Neff,[4] J.W. Negele,[5] K. Schilling,[3] W. Schroers,[5] and A. Tsapalis[1] [1]*Department of Physics, University of Cyprus, CY-1678 Nicosia, Cyprus,* [2]*ETH-Zürich, CH-8093 Zürich, and CERN Theory Division, CH-1211 Geneva 23, Switzerland,* [3]*Department of Physics, University of Wuppertal, D-42097 Wuppertal, Germany,* [4]*Institute of Accelerating Systems and Applications, University of Athens, Athens, Greece, and Physics Department, Boston University, Boston, Massachusetts 02215, USA,* [5]*Center for Theoretical Physics, Laboratory for Nuclear Science and Department of Physics, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139, USA.* (Received 21 July 2003; revised manuscript received 2 March 2004; published 29 June 2004)

The magnetic dipole, the electric quadrupole, and the Coulomb quadrupole amplitudes for the transition $\gamma N\rightarrow\Delta$ are evaluated both in quenched lattice QCD at $\beta=6.0$ and using two dynamical Wilson fermions simulated at $\beta=5.6$. The dipole transition form factor is accurately determined at several values of momentum transfer. On the lattices studied in this work, the electric quadrupole amplitude is found to be nonzero, yielding a negative value for the ratio R_{EM} of electric quadrupole to magnetic dipole amplitudes at three values of momentum transfer. [Phys. Rev. D **69**, 114506 (2004)]

Limits on variations of the quark masses, QCD scale, and fine structure constant. V. V. Flambaum, *Institute for Advanced Study, Einstein Drive, Princeton, New Jersey 08540, USA, and School of Physics, The University of New South Wales, Sydney NSW 2052, Australia;* D. B. Leinweber, A. W. Thomas, and R. D. Young, *Special Research Centre for the Subatomic Structure of Matter and Department of Physics, University of Adelaide, Adelaide SA 5005, Australia.* (Received 10 February 2004; published 2 June 2004)

We perform calculations of the dependence of nuclear magnetic moments on quark masses and obtain limits on the variation of the fine structure constant α and (m_q/Λ_{QCD}) from recent measurements of hydrogen hyperfine (21 cm) and molecular rotational transitions in quasar absorption systems, atomic clock experiments with hyperfine transitions in H, Rb, Cs, Yb^+, Hg^+, and optical transition in Hg^+. Experiments with Cd^+, deuterium/hydrogen, molecular SF_6, and Zeeman transitions in ^{3}He/Xe are also discussed. [Phys. Rev. D **69**, 115006 (2004)]

Remarks on the Θ(1540) pentaquark. Shmuel Nussinov, *School of Physics and Astronomy, Tel Aviv University, Ramat-Aviv, Tel Aviv 69978, Israel, and Department of Physics, University of Maryland, College Park, Maryland 20742-4111, USA.* (Received 3 March 2004; published 15 June 2004)

Additional broader $I=0$ states in the *KN* channel near $\Theta^+(1540)$ are expected in many models, making the absence of any signature in the K^+-deuteron scattering data even more puzzling. In an ideal ''three-body'' picture the Θ is viewed as two compact $ud(1)ud(2)\overline{3}$ color diquarks and an $\overline{s}$ quark. A ''QCD-type'' inequality involving $m(\Theta^+)$, $m(\Lambda)$, the mass of the $\Lambda(1/2^-)$ $L=1$ excitation, and that of a new $I=0$ tetraquark vector meson then follows. The inequality suggests a very light new vector meson, and is violated. We note that ''associated production'' of the pentaquark with another quadriquark or antipentaquark may be favored. This along with some estimates of the actual production cross sections suggest that the Θ can be found in BaBar or Belle e^+-e^- colliders. [Phys. Rev. D **69**, 116001 (2004)]

Thermal heat kernel expansion and the one-loop effective action of QCD at finite temperature. E. Megías, E. Ruiz Arriola, and L. L. Salcedo, *Departamento de Física Moderna, Universidad de Granada, E-18071 Granada, Spain.* (Received 11 December 2003; published 28 June 2004)

The heat kernel expansion for field theory at finite temperature is constructed. It is based on the imaginary time formalism and applies to generic Klein-Gordon operators in flat space-time. Full gauge invariance is manifest at each order of the expansion and the Polyakov loop plays an important role at any temperature. The expansion is explicitly worked out up to operators of dimension 6 included. The method is then applied to compute the one-loop effective action of QCD at finite temperature with massless quarks. The calculation is carried out within the background field method in the $\overline{\text{MS}}$ scheme up to dimension-6 operators. Further, the action of the dimensionally reduced effective theory at high temperature is also computed to the same order. Existing calculations are reproduced and new results are obtained in the quark sector for which only partial results existed up to dimension 6. [Phys. Rev. D **69**, 116003 (2004)]

Viscosity of meson matter. Antonio Dobado and Felipe J. Llanes-Estrada, *Departamento de Física Teórica I, Universidad Complutense, 28040 Madrid, Spain.* (Received 29 September 2003; published 29 June 2004)

We report a calculation of the shear viscosity in a relativistic multicomponent meson gas as a function of temperature and chemical potentials. We approximately solve the Uehling-Uhlenbeck transport equation of kinetic theory, appropriate for a boson gas, with relativistic kinematics. Since at low temperatures the gas can be taken as mostly composed of pions, with a fraction of kaons and etas, we explore the region where binary elastic collisions with at least one pion are the dominant scattering processes. Our input meson scattering phase shifts are fits to the experimental data obtained from chiral perturbation theory and the inverse amplitude method. Our results take the correct nonrelativistic limit (viscosity proportional to the square root of the temperature), show a viscosity of the order of the cube of the pion mass up to temperatures some-

what below that mass, and then a large increase due to kaons and etas. Our approximation may break down at even higher temperatures, where the viscosity follows a temperature power law with an exponent near 3.
[Phys. Rev. D **69**, 116004 (2004)]

Unified graphical summary of neutrino mixing parameters. Olga Mena and Stephen Parke, *Theoretical Physics Department, Fermi National Accelerator Laboratory, P.O. Box 500, Batavia, Illinois 60510, USA.* (Received 10 December 2003; published 2 June 2004)

The neutrino mixing parameters are presented in a number of different ways by the various experiments, e.g., SuperKamiokande, K2K, SNO, KamLAND, and CHOOZ, and also by the Particle Data Group. In this paper, we argue that presenting the data in terms of $\sin^2\theta$, where θ is the mixing angle appropriate for a given experiment, has a direct physical interpretation. For current atmospheric, solar, and reactor neutrino experiments, the $\sin^2\theta$'s are effectively the probabilities of finding a given flavor in a particular neutrino mass eigenstate. The given flavor and particular mass eigenstate vary from experiment to experiment; however, the use of $\sin^2\theta$ provides a unified picture of all the data. Using this unified picture we present a graphical way to represent these neutrino mixing parameters which includes the uncertainties. All of this is performed in the context of the present experimental status of three neutrino oscillations. [Phys. Rev. D **69**, 117301 (2004)]

Pentaquark as a kaon-nucleon resonance. D. E. Kahana, *31 Pembrook Drive, Stony Brook, New York 11790, USA;* S. H. Kahana, *Physics Department, Brookhaven National Laboratory Upton, New York 11973, USA.* (Received 10 October 2003; revised manuscript received 9 March 2004; published 18 June 2004)

Several recent experiments have reported evidence for a narrow feature in the K^+-neutron system, an apparent resonant state ~ 100 MeV above threshold and with a width $\leqslant 25$ MeV. This state has been labeled as Θ^+ (previously as Z^*), and because of the implied inclusion of a strange antiquark is referred to as a pentaquark, that is, five quarks within a single bag. We present an alternative explanation for such a structure, as a higher angular momentum resonance in the isospin zero K^+N system. One might call this an exit channel or molecular resonance. In a nonrelativistic potential model we find a possible candidate for the kaon-nucleon system with a relative angular momentum $L=3$, while $L=1$ states possess centripetal barriers much too low to confine the kaon and nucleon at an energy so high above threshold. Under some circumstances, however, an $L=2$ state can exist. [Phys. Rev. D **69**, 117502 (2004)]

Neutron moderation in the Oklo natural reactor and the time variation of α. S. K. Lamoreaux and J. R. Torgerson, *University of California, Los Alamos National Laboratory, Physics Division P-23, M.S. H803, Los Alamos, New Mexico 87545, USA.* (Received 24 March 2004; published 2 June 2004)

In previous analyses of the Oklo (Gabon) natural reactor to test for a possible time variation of the fine-structure constant α, a Maxwell-Boltzmann low energy neutron spectrum was assumed. We present here an analysis where a more realistic spectrum is employed and show that the most recent isotopic analysis of samples implies a decrease in α, over the last 2×10^9 years since the reactor was operating, of $(\alpha_{past}-\alpha_{now})/\alpha \geqslant 4.5\times10^{-8}$ (6σ confidence). Issues regarding the interpretation of the shifts of the low energy neutron absorption resonances are discussed. [Phys. Rev. D **69**, 121701 (2004)]