

Selected Abstracts from Other Physical Review Journals

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Final results from the Palo Verde neutrino oscillation experiment. F. Boehm,³ J. Busenitz,¹ B. Cook,³ G. Gratta,⁴ H. Henrikson,³ J. Kornis,¹ D. Lawrence,² K. B. Lee,³ K. McKinny,¹ L. Miller,⁴ V. Novikov,³ A. Piepke,^{1,3} B. Ritchie,² D. Tracy,⁴ P. Vogel,³ Y-F. Wang,⁴ and J. Wolf¹ ¹*Department of Physics and Astronomy, University of Alabama, Tuscaloosa, Alabama 35487*, ²*Department of Physics and Astronomy, Arizona State University, Tempe, Arizona 85287*, ³*Division of Physics, Mathematics and Astronomy, Caltech, Pasadena, California 91125*, ⁴*Physics Department, Stanford University, Stanford, California 94305*. (Received 3 July 2001; published 5 November 2001)

The analysis and results are presented from the complete data set recorded at Palo Verde between September 1998 and July 2000. In the experiment, the $\bar{\nu}_e$ interaction rate has been measured at a distance of 750 and 890 m from the reactors of the Palo Verde Nuclear Generating Station for a total of 350 days, including 108 days with one of the three reactors off for refueling. Backgrounds were determined by (a) the *swap* technique based on the difference between signal and background under reversal of the positron and neutron parts of the correlated event, and (b) making use of the conventional reactor-on and reactor-off cycles. There is no evidence for neutrino oscillation and the mode $\bar{\nu}_e \rightarrow \bar{\nu}_x$ was excluded at 90% C.L. for $\Delta m^2 > 1.1 \times 10^{-3} \text{ eV}^2$ at full mixing, and $\sin^2 2\theta > 0.17$ at large Δm^2 . [Phys. Rev. D **64**, 112001 (2001)]

Evidence for neutrino oscillations from the observation of $\bar{\nu}_e$ appearance in a $\bar{\nu}_\mu$ beam. A. Aguilar,⁵ L. B. Auerbach,⁸ R. L. Burman,⁵ D. O. Caldwell,³ E. D. Church,¹ A. K. Cochran,⁷ J. B. Donahue,⁵ A. Fazely,⁷ G. T. Garvey,⁵ R. M. Gunasingha,⁷ R. Imlay,⁶ W. C. Louis,⁵ R. Majkic,⁸ A. Malik,⁶ W. Metcalf,⁶ G. B. Mills,⁵ V. Sandberg,⁵ D. Smith,⁴ I. Stancu,¹ M. Sung,⁶ R. Tayloe,⁵ G. J. VanDalen,¹ W. Vernon,² N. Wadia,⁶ D. H. White,⁵ and S. Yellin³ (LSND Collaboration), ¹*University of California, Riverside, California 92521*, ²*University of California, San Diego, California 92093*, ³*University of California, Santa Barbara, California 93106*, ⁴*Embry Riddle Aeronautical University, Prescott, Arizona 86301*, ⁵*Los Alamos National Laboratory, Los Alamos, New Mexico 87545*, ⁶*Louisiana State University, Baton Rouge, Louisiana 70803*, ⁷*Southern University, Baton Rouge, Louisiana 70813*, ⁸*Temple University, Philadelphia, Pennsylvania 19122*. (Received 27 April 2001; published 13 November 2001)

A search for $\bar{\nu}_\mu \rightarrow \bar{\nu}_e$ oscillations was conducted by the Liquid Scintillator Neutrino Detector at the Los Alamos Neutron Science Center using $\bar{\nu}_\mu$ from μ^+ decay at rest. A total excess of $87.9 \pm 22.4 \pm 6.0$ events consistent with $\bar{\nu}_e p \rightarrow e^+ n$ scattering was observed above the expected background. This excess corresponds to an oscillation probability of $(0.264 \pm 0.067 \pm 0.045)\%$, which is consistent with an earlier analysis. In conjunction with other known

limits on neutrino oscillations, the LSND data suggest that neutrino oscillations occur in the $0.2\text{--}10 \text{ eV}^2/c^4 \Delta m^2$ range, indicating a neutrino mass greater than $0.4 \text{ eV}/c^2$. [Phys. Rev. D **64**, 112007 (2001)]

Global oscillation analysis of solar neutrino data with helioseismically constrained fluxes. Sandhya Choubey,¹ Srubabati Goswami,¹ Kamales Kar,¹ H. M. Antia,² S. M. Chitre,^{2,3} ¹*Saha Institute of Nuclear Physics, 1/AF, Bidhannagar, Kolkata 700 064, India*, ²*Tata Institute of Fundamental Research, Homi Bhabha Road, Mumbai 400005, India*, ³*Queen Mary and Westfield College, Mile End Road, London E1 4NS, United Kingdom*. (Received 18 June 2001; published 31 October 2001)

A seismic model for the Sun calculated using the accurate helioseismic data predicts a lower ^8B neutrino flux as compared to the standard solar model (SSM). However, there persists a discrepancy between the predicted and measured neutrino fluxes and it seems necessary to invoke neutrino oscillations to explain the measurements. In this work, we have performed a global, unified oscillation analysis of the latest solar neutrino data (including the results of SNO charged current rate) using the seismic model fluxes as theoretical predictions. We determine the best-fit values of the neutrino oscillation parameters and the $\chi^2_{\min}$ for both $\nu_e - \nu_{\text{active}}$ and $\nu_e - \nu_{\text{sterile}}$ cases and present the allowed parameter regions in the $\Delta m^2 - \tan^2 \theta$ plane for $\nu_e - \nu_{\text{active}}$ transition. The results are compared with those obtained using the latest SSM by Bahcall and co-workers. [Phys. Rev. D **64**, 113001 (2001)]

Majorana neutrinos, neutrino mass spectrum, CP violation, and neutrinoless double β decay. II. Mixing of four neutrinos. S. M. Bilenky, *Physik Department, Technische Universitat Munchen, D-85748, Garching, Germany*, and *Scuola Internazionale Superiore di Studi Avanzati, I-34014 Trieste, Italy*; S. Pascoli, *Scuola Internazionale Superiore di Studi Avanzati, I-34014 Trieste, Italy*, and *Istituto Nazionale di Fisica Nucleare, Sezione di Trieste, I-34014 Trieste, Italy*; S. T. Petcov, *Scuola Internazionale Superiore di Studi Avanzati, I-34014 Trieste, Italy*, and *Istituto Nazionale di Fisica Nucleare, Sezione di Trieste, I-34014 Trieste, Italy*. (Received 1 May 2001; published 5 November 2001)

Assuming four-neutrino mixing and massive Majorana neutrinos, we study the implications of neutrino oscillation solutions of the solar and atmospheric neutrino problems, of the results of the Liquid Scintillation Neutrino Detector (LSND) experiment and of the constraints on neutrino oscillations, obtained in reactor and accelerator experiments, for the predictions of the effective Majorana mass in neutrinoless double beta $((\beta\beta)_{0\nu})$ decay, $|m|$. All four-

neutrino mass spectra compatible with the existing neutrino mass and oscillation data are considered: $2+2A,B$ and $3+1A,B,C$. The general case of CP nonconservation is investigated. The predicted values of $|\langle m \rangle|$ depend strongly on the value of the lightest neutrino mass m_1 , on the type of the neutrino mass spectrum, on the LSND neutrino mass-squared difference Δm_{SBL}^2 , on the solution of the solar neutrino problem, as well as on the values of the three Majorana CP -violating phases, present in the lepton mixing matrix. If CP invariance holds, $|\langle m \rangle|$ is very sensitive to the values of the relative CP parities of the massive Majorana neutrinos. We also analyze in detail the question of whether a measurement of $|\langle m \rangle| \geq 0.01$ eV in the next generation of $(\beta\beta)_{0\nu}$ -decay experiments (NEMO3, CUORE, EXO, and GENIUS), combined with the data from the solar, atmospheric, reactor and accelerator neutrino oscillation experiments and from the future neutrino mass ^3H β -decay experiment KATRIN would allow us, and under what conditions, (i) to determine the absolute values of the neutrino masses and thus the neutrino mass spectrum, and (ii) to establish the existence of CP violation in the lepton sector. We have pointed out, in particular, that the $2+2A$ and $3+1A$ spectra can be critically tested by the KATRIN experiment. The latter, in particular, can provide information on the value of the lightest neutrino mass m_1 in the cases of the spectra $2+2A$, $3+1A$, $3+1B$, and $3+1C$. For these neutrino mass spectra there exists a direct relation between $|\langle m \rangle|$ or m_1 and the neutrino mass measured in ^3H β decay, m_{ν_e} , and the measurement of $|\langle m \rangle| \geq 0.01$ eV and of $m_{\nu_e} \geq 0.4$ eV will provide the unique possibility to determine the absolute values of all four neutrino masses and to obtain information on CP violation in the lepton sector. [Phys. Rev. D **64**, 113003 (2001)]

Leptogenesis with single right-handed neutrino dominance. M. Hirsch and S. F. King, *Department of Physics and Astronomy, University of Southampton, Southampton, SO17 1BJ, United Kingdom*. (Received 4 July 2001; published 5 November 2001)

We make an analytic and numerical study of leptogenesis in the framework of the (supersymmetric) standard model plus the seesaw mechanism with a $U(1)$ family symmetry and single right-handed neutrino dominance. In presenting our analytic and numerical results we make a clear distinction between the theoretically clean asymmetry parameter ϵ_1 and the baryon asymmetry Y_B . In calculating Y_B we propose and use a fit to the solutions to the Boltzmann equations which gives substantially more reliable results than parametrizations previously used in the literature. Our results show that there is a decoupling between the low energy neutrino observables and the leptogenesis predictions, but that nevertheless leptogenesis is capable of resolving ambiguities within classes of models which would otherwise lead to similar neutrino observables. For example we show that models where the dominant right-handed neutrino is the heaviest are preferred to models where it is the lightest and study an explicit example of a unified model of this type. [Phys. Rev. D **64**, 113005 (2001)]

Neutrino oscillations via the bulk. C. S. Lam, *Department of Physics, McGill University, Montreal, Canada H3A 2T8*; J. N. Ng, *Theory Group, TRIUMF, Vancouver, Canada*. (Received 27 June 2001; published 6 November 2001)

We investigate the possibility that the large mixing of neutrinos is induced by their large coupling to a five-dimensional bulk neutrino. In the strong coupling limit the model is exactly soluble. It gives rise to an oscillation amplitude whose squared-mass difference is independent of the channel, thus making it impossible to explain both the solar and the atmospheric neutrino oscillations simultaneously. [Phys. Rev. D **64**, 113006 (2001)]

High energy neutrino signals of four neutrino mixing. Sharada Iyer Dutta, *Department of Physics, University of Arizona, Tucson, Arizona 85721*; Mary Hall Reno, *Department of Physics and Astronomy, University of Iowa, Iowa City, Iowa 52242*; Ina Sarcevic, *Department of Physics, University of Arizona, Tucson, Arizona 85721*. (Received 27 April 2001; revised manuscript received 7 August 2001; published 12 November 2001)

We evaluate the upward shower and muon event rates for two characteristic four neutrino mixing models for extragalactic neutrinos, as well as for the atmospheric neutrinos, with energy thresholds of 1 TeV, 10 TeV and 100 TeV. We show that by comparing the shower to muon event rates, one can distinguish between oscillation and no-oscillation models. By measuring shower and muon event rates for energy thresholds of 10 TeV and 100 TeV and by considering their ratio, it is possible to use extragalactic neutrino sources to determine the type of four-flavor mixing pattern. We find that over several years of data taking, a kilometer-size detector has a very good chance of providing valuable information about the physics beyond the standard model. [Phys. Rev. D **64**, 113015 (2001)]

Twist-three analysis of photon electroproduction off the pion. A. V. Belitsky,¹ D. Müller,² A. Kirchner,² and A. Schäfer² ¹C. N. Yang Institute for Theoretical Physics, State University of New York at Stony Brook, Stony Brook, New York 11794-3840, ²Institut für Theoretische Physik, Universität Regensburg, D-93040 Regensburg, Germany. (Received 19 April 2001; published 5 November 2001)

We study twist-three effects in spin, charge, and azimuthal asymmetries in deeply virtual Compton scattering on a spin-zero target. Contributions which are power suppressed in $1/Q$ generate a new azimuthal angle dependence of the cross section that is not present in the leading twist results. On the other hand, the leading twist terms are not modified by the twist-three contributions. They may get corrected at the twist-four level, however. In the Wandzura-Wilczek approximation these new terms in the Fourier expansion with respect to the azimuthal angle are entirely determined by the twist-two generalized parton distributions. We also discuss more general issues such as the general form of the angular dependence of the differential cross section, the validity of factorization at the twist-three level, and the relation of generalized parton distributions to spectral functions. [Phys. Rev. D **64**, 116002 (2001)]

Minijet transverse spectrum in high-energy hadron-nucleus collisions. 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*

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Hadron-nucleus collisions at CERN LHC energies are studied by including explicitly semihard parton rescatterings in the collision dynamics. Under rather general conditions, we obtain explicit formulas for the semihard cross section and the inclusive minijet transverse spectrum. As an effect of the rescatterings the spectrum is lowered at small p_t and is enhanced at relatively large transverse momenta, the deformation being more pronounced at increasing rapidity. Its study allows to test the proposed interaction mechanisms and represents an important baseline to examine nucleus-nucleus collisions. [Phys. Rev. D **64**, 116004 (2001)]

New parametrization of the neutrino mixing matrix for neutrino oscillations. Virendra Gupta, *Departamento de Fisica Aplicada, CINVESTAV-Unidad Merida, A.P. 73 Cordemex 97310 Merida, Yucatan, Mexico*; Xiao-Gang He, *Department of Physics, National Taiwan University, Taipei, Taiwan 10764, Republic of China.* (Received 27 June 2001; published 8 November 2001)

In this paper we study three active neutrino oscillations, favored by recent data from SuperK and SNO, using a new parametrization of the lepton mixing matrix V constructed from a linear combination of the unit matrix I , and a Hermitian unitary matrix U , that is, $V = \cos \theta I + i \sin \theta U$. There are only three real parameters in V including the parameter θ . It is interesting to find that experimental data on atmospheric neutrino dictates the angle θ to be $\pi/4$ such that the ν_μ and ν_τ mixing is maximal. The solar neutrino problem is solved via the Mikheyev-Smirnov-Wolfenstein effect with a small mixing angle, with U depending on one small parameter ϵ . The resulting mixing matrix with just two parameters (θ and ϵ) predicts that the oscillating probabilities for $\nu_e \rightarrow \nu_\mu$ and $\nu_e \rightarrow \nu_\tau$ be equal and of the order of $2\epsilon^2 = (0.25-2.5) \times 10^{-3}$. The measurement of CP asymmetries at the proposed neutrino factories would also provide a test of our parametrization. [Phys. Rev. D **64**, 117301 (2001)]

Seesaw mechanism and four light neutrino states. M. Czakon, J. Gluza, and M. Zralek, *Department of Field Theory and Particle Physics, Institute of Physics, University of Silesia, Uniwersytecka 4, PL-40-007 Katowice, Poland.* (Received 8 June 2001; published 13 November 2001)

A formal proof is given that in a seesaw type neutrino mass matrix with only two neutrino mass scales ($m_D \ll m_R$) we cannot get a fourth light sterile neutrino. That is, it is not possible to impose any symmetries on m_D and/or m_R matrices in order to drag a heavy state connected with the m_R matrix to the low mass spectrum. [Phys. Rev. D **64**, 117304 (2001)]

How does the cosmic microwave background plus big bang nucleosynthesis constrain new physics? James P. Kneller, *Department of Physics, The Ohio State University, Columbus, Ohio 43210*;

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Recent cosmic microwave background (CMB) results from BOOMERANG, MAXIMA, and DASI provide cosmological constraints on new physics that can be competitive with those derived from big bang nucleosynthesis (BBN). In particular, both CMB and BBN can be used to place limits on models involving neutrino degeneracy and additional relativistic degrees of freedom. However, for the case of the CMB, these constraints are, in general, sensitive to the assumed priors. We examine the CMB and BBN constraints on such models and study the sensitivity of “new physics” to the assumed priors. If we add a constraint on the age of the universe ($t_0 \gtrsim 11$ Gyr), then for models with a cosmological constant, the range of baryon densities and neutrino degeneracy parameters allowed by the CMB and BBN is fairly robust: $\eta_{10} = 6.0 \pm 0.6$, $\Delta N_\nu \lesssim 6$, $\xi_e \lesssim 0.3$. In the absence of new physics, models without a cosmological constant are only marginally compatible with recent CMB observations (excluded at the 93% confidence level). [Phys. Rev. D **64**, 123506 (2001)]

Spectral function and excited states in lattice QCD with the maximum entropy method. T. Yamazaki,¹ S. Aoki,¹ R. Burkhalter,^{1,2} M. Fukugita,³ S. Hashimoto,⁴ N. Ishizuka,^{1,2} Y. Iwasaki,^{1,2} K. Kanaya,¹ T. Kaneko,⁴ Y. Kuramashi,⁴ M. Okawa,⁴ Y. Taniguchi,¹ A. Ukawa,^{1,2} and T. Yoshié,^{1,2} (CP-PACS Collaboration), ¹*Institute of Physics, University of Tsukuba, Tsukuba, Ibaraki 305-8571, Japan*, ²*Center for Computational Physics, University of Tsukuba, Tsukuba, Ibaraki 305-8577, Japan*, ³*Institute for Cosmic Ray Research, University of Tokyo, Kashiwa, Chiba 277-8582, Japan*, ⁴*High Energy Accelerator Research Organization (KEK), Tsukuba, Ibaraki 305-0801, Japan.* (Received 30 May 2001; published 20 November 2001)

We apply the maximum entropy method to extract the spectral functions for pseudoscalar and vector mesons from hadron correlators previously calculated at four different lattice spacings in quenched QCD with the Wilson quark action. We determine masses and decay constants for the ground and excited states of the pseudoscalar and vector channels from the position and area of peaks in the spectral functions. We obtain the results $m_{\pi_1} = 660(590)$ MeV and $m_{\rho_1} = 1540(570)$ MeV for the first excited state masses, in the continuum limit of quenched QCD. We also find unphysical states that have an infinite mass in the continuum limit, and argue that they are bound states of two doublers of the Wilson quark action. If the interpretation is correct, this is the first time that the state of doublers has been identified in lattice QCD numerical simulations. [Phys. Rev. D **65**, 014501 (2002)]