

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.

Measurement of the $\bar{p}p \rightarrow K_S K_S$ reaction from 0.6 to 1.9 GeV/c.

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The $\bar{p}p \rightarrow K_S K_S \rightarrow 4\pi^\pm$ cross section was measured at incident antiproton momenta between 0.6 and 1.9 GeV/c using the CERN Low Energy Antiproton Ring. This investigation was part of a systematic study of in-flight antiproton-proton annihilations into two-neutral-meson final states in a search for hadronic resonances. A coarse scan of the $\bar{p}p \rightarrow K_S K_S$ cross section as a function of center-of-mass energy between 1.964 and 2.395 GeV/c² and a fine scan of the region surrounding the $\xi(2220)$ are presented. Upper limits on the product branching ratio $B(\xi \rightarrow \bar{p}p) \times B(\xi \rightarrow K_S K_S)$ are determined for a wide range of mass and width assumptions based on the nonobservation of the $\xi(2220)$. A rise in the $\bar{p}p \rightarrow K_S K_S$ cross section is observed near 2.15 GeV/c², which is consistent with the $f_2(2150)$ resonance. [S0556-2821(97)06919-1] [Phys. Rev. D **56**, 3803 (1997)]

Characteristics of muonic and electromagnetic components far from the core of giant air showers above 10¹⁸ eV. K. Honda,¹ K. Hashimoto,¹ N. Kawasumi,¹ T. Kutter,² M. Nagano,³ and I. Tsushima,¹ ¹*Faculty of Education, Yamanashi University, Kofu 400, Japan* ²*Department of Physics, University of Heidelberg, Heidelberg, Germany* ³*Institute for Cosmic Ray Research, University of Tokyo, Tokyo 188, Japan*. (Received 4 December 1996)

In order to know the relative proportion of electrons, photons, and muons far from the cores of giant air showers, a detector with two scintillators sandwiching a lead plate of 1 cm thickness (leadburger) has been built and placed at one corner of the Akeno Giant Air Shower Array (AGASA). Results obtained from data collected over an 18-month run are reported here. Lateral distributions and arrival time distributions of electrons, photons, and muons at around 1000 m–2500 m from the core for showers of energies larger than 10^{18.0} eV have been determined. Our observations show that muons

may be separated from electromagnetic components far from the shower core with a lead layer of 1 cm thickness, as suggested from Monte Carlo simulations using the MOCCA program. These studies show the MOCCA program to be a powerful simulation tool for further development of the detector design for the Pierre Auger project. [S0556-2821(97)03219-0] [Phys. Rev. D **56**, 3833 (1997)]

Hot nucleons in chiral soliton models. H. Walliser, *Fachbereich Physik, Universität-GH-Siegen, D-57068 Siegen, Germany*. (Received 28 April 1997)

Nucleons in a hot pion gas are studied within the framework of chiral soliton models which contain pions and also baryons as solitons of the same chiral action. The semiclassical treatment of the soliton solutions must be augmented by pionic fluctuations which requires renormalization to one loop, and finite temperatures do not introduce new ultraviolet divergencies and may easily be considered. Alternatively, a renormalization scheme based on the renormalization group equation at finite temperature comprises and extends the rigorous results of chiral perturbation theory and renders the low-energy constants temperature dependent, which allows the construction of temperature-dependent solitons below the critical temperature. The temperature dependence of the baryon energy and the pion-nucleon coupling is studied. There is no simple scaling law for the temperature dependence of these quantities. [S0556-2821(97)05519-7] [Phys. Rev. D **56**, 3866 (1997)]

Analysis of diagonal and nondiagonal QCD sum rules for heavy baryons at next-to-leading order in α_s . S. Groote and J. G. Körner, *Institut für Physik, Johannes-Gutenberg-Universität, Staudinger Weg 7, D-55099 Mainz, Germany*; O. I. Yakovlev, *Institut für theoretische Physik II, Bayrische Julius-Maximilians-Universität, Am Hubland, D-97074 Würzburg, Germany*. (Received 28 May 1997)

We consider diagonal and nondiagonal QCD sum rules for the ground state heavy baryons to leading order in $1/m_Q$ and at next-to-leading order in α_s . In the nondiagonal case we evaluate the eight different two-loop diagrams which determine the perturbative α_s corrections to the Wilson coefficient of the quark condensate in the operator product expansion. The QCD corrections to the nondiagonal sum rules are moderate compared to the QCD corrections in the diagonal case. We also consider constituent-type sum rules using constituent-type interpolating currents. The obtained results are in reasonable agreement with the corresponding results obtained in the diagonal case. As central values for the bound state energies we find $m(\Lambda_Q) - m_Q \approx 760$ MeV and $m(\Sigma_Q) - m_Q \approx 940$ MeV. The

central values for the residues are given by $F(\Lambda_Q) \approx 0.030 \text{ GeV}^3$ and $F(\Sigma_Q) \approx 0.038 \text{ GeV}^3$. [S0556-2821(97)00119-7] [Phys. Rev. D **56**, 3943 (1997)]

Reggeon and pion contributions in semiexclusive diffractive processes at DESY HERA. K. Golec-Biernat, J. Kwieciński, and A. Szczurek, *H. Niewodniczański Institute of Nuclear Physics, ul. Radzikowskiego 152, PL-31-342 Kraków, Poland.* (Received 14 April 1997; revised manuscript received 6 June 1997)

A detailed analysis of semiexclusive diffractive processes in ep deep-inelastic scattering at DESY HERA, with the diffractive final states in the forward direction, is presented. The contributions of the subleading f_2 , ω , a_2 , ρ Reggeons and the pion exchanges to the diffractive structure function with the forward proton or neutron are estimated. It is found that the (a_2, ρ) Reggeons are entirely responsible for the forward neutron production at $x_p < 10^{-3}$. The πN production in the forward region is estimated using the Deck mechanism. The significance of this reaction for the processes measured at HERA, especially with the leading neutron, is discussed. [S0556-2821(97)03419-X] [Phys. Rev. D **56**, 3955 (1997)]

Wavelet analysis in multiplicity fluctuations. Ding-wei Huang, *Department of Physics, Chung Yuan Christian University, Chung-li, Taiwan.* (Received 15 January 1997)

A wavelet analysis is applied to the study of correlations in multiplicity fluctuations. Both the usual correlation functions as well as the wavelet transformed functions are calculated and compared with three different models: the FRITIOF, random cascade, and Ising models. The large off-diagonal bin correlations are effectively suppressed by the wavelets. The correlations from different scales nearly decouple. The wavelet analysis provides a useful tool for studying the self-similarity of multiparticle production in high-energy collisions. [S0556-2821(97)03217-7] [Phys. Rev. D **56**, 3961 (1997)]

Neutrino physics from a U(2) flavor symmetry. Christopher D. Carone, *Theoretical Physics Group, Ernest Orlando Lawrence Berkeley National Laboratory, University of California, Berkeley, California 94720*; Lawrence J. Hall, *Theoretical Physics Group, Ernest Orlando Lawrence Berkeley National Laboratory, University of California, Berkeley, California 94720 and Department of Physics, University of California, Berkeley, California 94720.* (Received 28 February 1997)

We consider the neutrino physics of models with a sequentially broken U(2) flavor symmetry. Such theories yield the observed pattern of quark and lepton masses, while maintaining sufficient degeneracies between superparticles of the first two generations to solve the supersymmetric flavor problem. Neutrino mass ratios and mixing angles in these models may differ significantly from those of the charged leptons, even though the neutrinos and charged leptons transform identically under the flavor group. A wide class of well-motivated U(2) theories yield order one ν_μ - ν_τ mixing, without a fine-tuning of parameters. These models provide a natural solution

to the atmospheric neutrino deficit, and also have distinctive signatures at long-baseline neutrino oscillation experiments. [S0556-2821(97)06019-0] [Phys. Rev. D **56**, 4198 (1997)]

Constrained MSSM and the electric dipole moment of the neutron. C. Hamzaoui, *Département de Physique, Université du Québec à Montréal, C.P. 8888, Succ. Centre-Ville, Montréal, Québec, Canada H3C 3P8*; M. Pospelov, *Département de Physique, Université du Québec à Montréal, C.P. 8888, Succ. Centre-Ville, Montréal, Québec, Canada H3C 3P8 and Budker Institute of Nuclear Physics, Novosibirsk, 630090, Russia*; R. Roiban, *Département de Physique, Université du Québec à Montréal, C.P. 8888, Succ. Centre-Ville, Montréal, Québec, Canada H3C 3P8.* (Received 26 February 1997)

Solving the renormalization group equations analytically by iterations, we calculate the electric dipole moment (EDM) of the neutron in the MSSM with CP -conserving soft-breaking parameters for the case of three and four generations. For the three-generation case we resolve the apparent discrepancies between order-of-magnitude estimates and numerical calculations existing in the literature. The nonvanishing result arises in first order in the renormalization group coefficient $t = (4\pi)^{-2} \ln(\Lambda^2/M_W^2)$. The EDM of the neutron does not exceed $10^{-32}e \text{ cm}$ in this case. For the four-generation case we show that there is a significant enhancement which renders the EDM of the neutron at a measurable level of $10^{-26}e \text{ cm}$. [S0556-2821(97)00619-X] [Phys. Rev. D **56**, 4295 (1997)]

Pion-nucleon phase shifts in heavy baryon chiral perturbation theory. Alakabha Datta, *Department of Physics and Astronomy, Iowa State University, Ames, Iowa 50011*; Sandip Pakvasa, *Department of Physics and Astronomy, University of Hawaii at Manoa, Honolulu, Hawaii 96822.* (Received 10 June 1996; revised manuscript received 12 June 1997)

We calculate the phase shifts in pion-nucleon scattering using the heavy baryon formalism. We consider phase shifts for the pion energy range of 140 to 200 MeV. We employ two different methods for calculating the phase shifts—the first using the full third order calculation of the pion-nucleon scattering amplitude and the second by including the resonances Δ and N^* as explicit degrees of freedom in the Lagrangian. We compare the results of the two methods with phase shifts extracted from fits to the pion-nucleon scattering data. We find good to fair agreement between the calculations and the phase shifts from scattering data. [S0556-2821(97)07919-8] [Phys. Rev. D **56**, 4322 (1997)]

Chiral two-loop pion-pion scattering parameters from crossing-symmetric constraints. G. Wanders, *Institut de Physique Théorique, Université de Lausanne, CH-1015 Lausanne, Switzerland.* (Received 7 May 1997)

Constraints on the parameters in the one- and two-loop pion-pion scattering amplitudes of standard chiral perturbation theory are obtained from explicitly crossing-symmetric sum rules. These constraints are based on a matching of the chiral amplitudes and the

physical amplitudes at the symmetry point of the Mandelstam plane. The integrals over absorptive parts appearing in the sum rules are decomposed into crossing-symmetric low- and high-energy components and the chiral parameters are finally related to high-energy absorptive parts. One application uses a simple model of these absorptive parts. The sensitivity of the results to the choice of the energy separating high and low energies is examined with care. A weak dependence on this energy is obtained as long as it stays below ~ 560 MeV. Reliable predictions are obtained for three two-loop parameters. [S0556-2821(97)02819-1] [Phys. Rev. D **56**, 4328 (1997)]

Multiple diffraction model for proton-proton elastic scattering and total cross section extrapolations to cosmic-ray energies. A. F. Martini and M. J. Menon, *Instituto de Fisica "Gleb Wataghin," Universidade Estadual de Campinas, Unicamp, 13083-970 Campinas, São Paulo, Brazil.* (Received 4 February 1997)

We analyze pp elastic scattering data at the highest accelerator energy region ($10 < \sqrt{s} \leq 62.5$ GeV) through a multiple diffraction approach. The use of Martin's formula in a model developed earlier is substituted by the introduction of a complex elementary (parton-parton) amplitude. With this the total cross section and the ρ parameter may be simultaneously investigated and, with the exception of the diffraction minimum at some CERN ISR energies, a satisfactory description of all experimental data is obtained. Total cross section extrapolations to cosmic-ray energies ($\sqrt{s} > 6$ TeV) show agreement with the reanalysis of the Akeno data performed by Nikolaev and also with Gaisser, Sukhatme, and Yodh results, leading to the prediction $\sigma_{\text{tot}}^{pp}(\sqrt{s} = 16 \text{ TeV}) = 147$ mb. Physical interpretations and critical remarks concerning our parametrizations and results are also presented and discussed. [S0556-2821(97)04917-5] [Phys. Rev. D **56**, 4338 (1997)]

Amplitude analysis of reactions $\pi^- p \rightarrow \eta \pi^- p$ and $\pi^- p \rightarrow \eta \pi^0 n$ measured on a polarized target and the exotic 1^{-+} meson. M. Svec, *Physics Department, Dawson College, Montreal, Quebec, Canada H3Z 1A4 and McGill University, Montreal, Quebec, Canada H3A 2T8.* (Received 29 August 1996; revised manuscript received 28 January 1997)

Recently several experimental groups analyzed data on $\pi^- p \rightarrow \eta \pi^- p$ and $\pi^- p \rightarrow \eta \pi^0 n$ reactions with an exotic 1^{-+} P wave and found conflicting evidence for an exotic meson $I = 1^{-+}(1405)$. High statistics data on these reactions are presently being analyzed by the BNL E852 Collaboration. All these analyses are based on the crucial assumption that the production amplitudes do not depend on nucleon spin. This assumption is in sharp conflict with the results of measurements of $\pi^- p \rightarrow \pi^- \pi^+ n$, $\pi^+ n \rightarrow \pi^+ \pi^- p$, and $K^+ n \rightarrow K^+ \pi^- p$ on polarized targets at CERN, which find a strong dependence of production amplitudes on the nucleon spin. To ascertain the existence of an exotic meson $1^{-+}(1405)$, it is necessary to perform a model-independent amplitude analysis of reactions $\pi^- p \rightarrow \eta \pi^- p$ and $\pi^- p \rightarrow \eta \pi^0 n$. We demonstrate that measurements of these reactions on transversely polarized targets enable the required model-independent amplitude analysis without the assumption that production amplitudes are independent of nucleon spin. Two variants of the Monte Carlo method are proposed for finding the amplitudes and their errors. We

suggest that high statistics measurements of the reactions $\pi^- p \rightarrow \eta \pi^- p$ and $\pi^- p \rightarrow \eta \pi^0 n$ be made on polarized targets at BNL and at Protvino IHEP and that model-independent amplitude analyses of these polarized data be performed to advance hadron spectroscopy on the level of spin-dependent production amplitudes. [S0556-2821(97)04219-7] [Phys. Rev. D **56**, 4355 (1997)]

Reconciling solar and terrestrial neutrino oscillation evidence with minimum sacrifice. G. L. Fogli, E. Lisi, D. Montanino, and G. Scioscia, *Dipartimento di Fisica and Sezione INFN di Bari, Via Amendola 173, I-70126 Bari, Italy.* (Received 5 June 1997)

The present possible evidence in favor of neutrino masses and mixings from solar, atmospheric, and accelerator experiments cannot all be reconciled in a three-family framework, unless some data are excluded. We grade all possible three-family scenarios according to their compatibility with the available data. A recently proposed scenario appears to emerge naturally as the most likely solution to all oscillation evidence, with the only exception being the angular dependence of multi-GeV atmospheric data in the Kamio-kande experiment. We describe in detail the status and the phenomenological implications of this "minimum sacrifice" solution. [S0556-2821(97)06719-2] [Phys. Rev. D **56**, 4365 (1997)]

Fourier analysis of real-time, high-statistics solar neutrino observations. G. L. Fogli, E. Lisi, and D. Montanino, *Dipartimento di Fisica and Sezione INFN di Bari, Via Amendola 173, I-70126 Bari, Italy.* (Received 5 June 1997)

Solar neutrino oscillations with wavelengths comparable to the Earth-Sun distance provide a viable explanation of the long-standing solar neutrino deficit. They imply a time-dependent modulation of the solar neutrino flux due to the eccentricity of the Earth orbit. Motivated by this testable prediction, we propose a Fourier analysis of the signal observable in real-time, solar neutrino experiments. We give the general expressions of the Fourier coefficients and of their correlated uncertainties in the presence of background. The expressions assume a particularly compact form in the case of two-flavor neutrino oscillations in vacuum. We discuss the sensitivity to the lowest harmonics of the new-generation, high-statistics experiments SuperKamiokande, Sudbury Neutrino Observatory, and Borexino. [S0556-2821(97)07719-9] [Phys. Rev. D **56**, 4374 (1997)]

Analysis of DCC domain structure. Jørgen Randrup, *Nuclear Science Division, Lawrence Berkeley National Laboratory, University of California, Berkeley, California 94720;* Robert L. Thews, *Department of Physics, University of Arizona, Tucson, Arizona 85721.* (Received 9 May 1997)

Wavelet-type methods are employed for the analysis of pion field configurations that have been obtained by dynamical simulations in idealized scenarios relevant to the formation of disoriented chiral condensates. It is illustrated how the measurement of the isospin domain structure depends on the ability to zoom in on limited parts of the phase space, due to the interplay between the pion correlation

length and the effective source geometry. The need for advanced analysis methods is underscored by the fact that the extracted neutral-fraction distribution would differ significantly from the ideal form, even under perfect experimental conditions, and, moreover, by the circumstance that thermal sources with suitably adjusted temperatures can lead to distributions that may be practically indistinguishable from those arising from DCC-type nonequilibrium evolutions. [S0556-2821(97)01019-9] [Phys. Rev. D **56**, 4392 (1997)]

Isospin mixing and model dependence. Euy Soo Na and Barry R. Holstein, *Department of Physics and Astronomy, University of Massachusetts, Amherst, Massachusetts 01003*. (Received 30 April 1997)

We show that recent calculations of $\Delta I = \frac{3}{2}$ effects in nonleptonic hyperon decay induced by $m_d - m_u \neq 0$ are subject to significant model dependence. [S0556-2821(97)04819-4] [Phys. Rev. D **56**, 4404 (1997)]