Selected Abstracts from Other Physical Review Journals

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Supernova neutrinos and the LSND evidence for neutrino oscillations. Michel Sorel and Janet Conrad, *Department of Physics, Columbia University, New York, New York 10027.* (Received 15 December 2001; published 23 August 2002)

The observation of the $\overline{\nu}_e$ energy spectrum from a supernova burst can provide constraints on neutrino oscillations. We derive formulas for adiabatic oscillations of supernova antineutrinos for a variety of 3- and 4-neutrino mixing schemes and mass hierarchies which are consistent with the Liquid Scintillation Neutrino Detector (LSND) evidence for $\overline{\nu}_\mu \to \overline{\nu}_e$ oscillations. Finally, we explore the constraints on these models and LSND given by the supernova SN 1987A $\overline{\nu}_e$'s observed by the Kamiokande-2 and IMB-3 detectors. [Phys. Rev. D **66**, 033009 (2002)]

Perturbative saturation and the soft Pomeron. A. Kovner, *Department of Mathematics and Statistics, University of Plymouth, 2 Kirkby Place, Plymouth, PL4 8AA, United Kingdom and, Department of Physics, University of Connecticut, Storrs, Connecticut 06269;* U. A. Wiedemann, *CERN, Theory Division, CH-1211 Geneva 23, Switzerland.* (Received 24 April 2002; published 28 August 2002)

We show that perturbation theory provides two distinct mechanisms for the powerlike growth of hadronic cross sections at high energy. One, the leading Balitskiĭ-Fadin-Kuraev-Lipatov (BFKL) effect, is due to the growth of the parton density, and is characterized by the leading BFKL exponent ω. The other mechanism is due to the infrared diffusion, or the long range nature of the Coulomb field of perturbatively massless gluons. When perturbative saturation effects are taken into account, the first mechanism is rendered ineffective but the second one persists. We suggest that these two distinct mechanisms are responsible for the appearance of two Pomerons. The density growth effects are responsible for the hard Pomeron and manifest themselves in small systems (e.g. γ^* or small size fluctuations in the proton wave function) where saturation effects are not important. The soft Pomeron is the manifestation of the exponential growth of the black saturated regions which appear in typical hadronic systems. We point out that the nonlinear generalization of the BFKL equation which takes into account wave function saturation effects (''Pomeron loops'') provides a well defined perturbative framework for the calculation of the soft Pomeron intercept. The conjecture of a perturbative soft Pomeron is consistent with picturing the proton as a loosely bound system of several small black regions corresponding e.g. to constituent quarks of size about 0.3 fm. Phenomenological implications of this picture are compatible with the main qualitative features of data on p-p scattering. [Phys. Rev. D **66**, 034031 (2002)]

Inhomogeneous bigbang nucleosynthesis and mutual ion diffusion. Elina Keihänen, *Department of Physical Sciences, University of Helsinki, P.O. Box 64, FIN-00014 University of Helsinki, Finland.* (Received 26 April 2002; published 16 August 2002)

We present a study of inhomogeneous big bang nucleosynthesis with emphasis on transport phenomena. We combine a hydrodynamic treatment to a nuclear reaction network and compute the light element abundances for a range of inhomogeneity parameters. We find that shortly after annihilation of electron-positron pairs, Thomson scattering on background photons prevents the diffusion of the remaining electrons. Protons and multiply charged ions then tend to diffuse into opposite directions so that no net charge is carried. Ions with $Z>1$ get enriched in the overdense regions, while protons diffuse out into regions of lower density. This leads to a second burst of nucleosynthesis in the overdense regions at $T<20$ keV, leading to enhanced destruction of deuterium and lithium. We find a region in the parameter space at $2.1\times10^{-10}<\eta<5.2\times10^{-10}$ where constraints $^7\mathrm{Li/H}<10^{-9.7}$ and $\mathrm{D/H}<10^{-4.4}$ are satisfied simultaneously. [Phys. Rev. D **66**, 043512 (2002)]

Nonlinear QCD evolution: Saturation without unitarization. Alexander Kovner, *Department of Mathematics and Statistics, University of Plymouth, 2 Kirkby Place, Plymouth, PL4 8AA, United Kingdom;* Urs Achim Wiedemann, *Theory Division, CERN, CH-1211 Geneva 23, Switzerland.* (Received 17 December 2001; published 30 September 2002)

We consider the perturbative description of saturation based on the nonlinear QCD evolution equation of Balitsky and Kovchegov. Although the nonlinear corrections lead to saturation of the scattering amplitude locally in impact parameter space, we show that they do not unitarize the total cross section. The total cross section for the scattering of a strongly interacting probe on a hadronic target is found to grow exponentially with rapidity $t=\ln(s/s_0)$, $\sigma \propto \exp\{(\alpha_s N_c/2\pi)\epsilon t\}$ where ϵ is a number of order unity. The origin of this violation of unitarity is the presence of long range Coulomb fields away from the saturation region. The growth of these fields with rapidity is not tempered by the nonlinearity of the Balitsky-Kovchegov equation. [Phys. Rev. D **66**, 051502 (2002)]

Atmospheric gamma-ray observation with the BETS detector for calibrating atmospheric neutrino flux calculations. K. Kasahara,[1] E. Mochizuki,[1] S. Torii,[2] T. Tamura,[2] N. Tateyama,[2] K. Yoshida,[2] T. Yamagami,[3] Y. Saito,[3] J. Nishimura,[3] H. Murakami,[4] T. Kobayashi,[5] Y. Komori,[6] M. Honda,[7] T. Ohuchi,[7] S. Midorikawa,[8] and T. Yuda[9] [1]*Shibaura Institute of Technology, Saitama, Japan,* [2]*Faculty of Engineering, Kanagawa University, Yokohama, Japan,* [3]*Institute of Space and Astronautical Science, Sagamihara, Japan,* [4]*Department of Physics, Rikkyo University, Toshima-ku, Japan,* [5]*Department of Physics, Aoyama Gakuin University, Setagaya-ku, Japan,* [6]*Kanagawa Prefectural College, Kanagawa, Japan,* [7]*Institute for Cosmic Ray Research, University of Tokyo, Kashiwa, Japan,* [8]*Information Department, Aomori University, Aomori, Japan,* [9]*Solar-Terrestrial Environment Laboratory, Nagoya Univer-*

sity, Aichi, Japan. (Received 24 June 2002; published 30 September 2002)

We observed atmospheric gamma rays around 10 GeV at balloon altitudes (15–25 km) and at a mountain (2770 m a.s.l). The observed results were compared with Monte Carlo calculations to find that an interaction model (Lund FRITIOF1.6) used in an old neutrino flux calculation was not good enough for describing the observed values. Instead, we found that two other nuclear interaction models, Lund FRITIOF7.02 and DPMJET3.03, gave much better agreement with the observations. Our data will serve for examining nuclear interaction models and for deriving a reliable absolute atmospheric neutrino flux in the GeV region. [Phys. Rev. D **66**, 052004 (2002)]

Texture of neutrino mass matrix in view of recent neutrino experimental results. Ambar Ghosal and Debasish Majumdar, *Saha Institute of Nuclear Physics, 1/AF Bidhannagar, Kolkata 700 064, India.* (Received 10 July 2002; published 20 September 2002)

In view of recent neutrino experimental results such as SNO, Super-Kamiokande (SK), CHOOZ and neutrinoless double beta decay ($\beta\beta_{0\nu}$), we consider a texture of neutrino mass matrix which contains three parameters in order to explain those neutrino experimental results. We first fitted the parameters in a model independent way with solar and atmospheric neutrino mass squared differences and a solar neutrino mixing angle which satisfies the LMA solution. The maximal value of the atmospheric neutrino mixing angle comes out naturally in the present texture. Most interestingly, the fitted parameters of the neutrino mass matrix considered here also marginally satisfy the recent limit on the effective Majorana neutrino mass obtained from the neutrinoless double beta decay experiment. We further demonstrate an explicit model which gives rise to the texture investigated by considering an $SU(2)_L \times U(1)_Y$ gauge group with two extra real scalar singlets and a discrete $Z_2 \times Z_3$ symmetry. Majorana neutrino masses are generated through higher dimensional operators at the scale M. We have estimated the scales at which singlets get VEV's and M by comparing with the best fitted results obtained in the present work. [Phys. Rev. D **66**, 053004 (2002)]

Resonance spin flavor precession of solar neutrinos after SNO neutral current data. Bhag C. Chauhan and João Pulido, *Centro de Física das Interacções Fundamentais (CFIF), Departamento de Física, Instituto Superior Técnico, Av. Rovisco Pais, P-1049-001 Lisboa, Portugal.* (Received 20 June 2002; published 23 September 2002)

We present an analysis of the solar neutrino data assuming the deficit of solar neutrinos to originate from the interaction of their transition magnetic moments with the solar magnetic field. We perform fits to the rates only and global fits and consider separately the existing data prior to the announcement of the SNO neutral current results, and the present data. Predictions for the Borexino experiment are also derived. The solar field profiles are taken both in the radiation zone and core of the Sun, and in the convective zone. The latter are chosen so as to exhibit a rapid increase across the bottom of the convective zone and a moderate decrease toward the surface. Regarding the field profiles in the radiative zone and core, it is found that the data show a preference for those cases in which a strong field rests at the solar center with a steep decrease thereafter. For these, the quality of the global fits is as good as the one from the best oscillation solutions and the same as for the convective zone profiles examined. It is also found that the χ^2 of the fits increases when the most recent data are considered, owing to the smaller errors involved. This in turn provides more precise predictions for Borexino than previous ones, thus resulting in a clearer possible distinction between magnetic moment and the currently favored oscillation solutions. [Phys. Rev. D **66**, 053006 (2002)]

Off-axis beams and detector clusters: Resolving neutrino parameter degeneracies. V. Barger, *Department of Physics, University of Wisconsin, Madison, Wisconsin 53706;* D. Marfatia, *Department of Physics, Boston University, Boston, Massachusetts 02215;* K. Whisnant, *Department of Physics and Astronomy, Iowa State University, Ames, Iowa 50011.* (Received 18 June 2002; published 23 September 2002)

There are three parameter degeneracies inherent in the three-neutrino analysis of long-baseline neutrino experiments. We develop a systematic method for determining whether or not a set of measurements in neutrino oscillation appearance experiments with approximately monoenergetic beams can completely resolve these ambiguities. We then use this method to identify experimental scenarios in which the parameter degeneracies may be efficiently resolved. Generally speaking, with two appearance measurements degeneracies can occur over wide areas of the (δ, θ_{13}) parameter space; with three measurements they occur along lines in the parameter space and with four measurements they occur only at isolated points. If two detectors are placed at the same distance from the source but at different locations with respect to the main axis of the beam (a detector cluster), each detector will measure neutrinos at different energies. Then one run with neutrinos and one run with antineutrinos will give the four independent measurements that in principle can resolve all of the parameter degeneracies if $\sin^2 2\theta_{13} \geqslant 0.002$. We also examine scenarios with detector clusters using only neutrino beams. Without detector clusters, the measurement of neutrinos and antineutrinos at a short distance and only neutrinos at a longer distance may also work. [Phys. Rev. D **66**, 053007 (2002)]

Getting the most from the statistical analysis of solar neutrino oscillations. G. L. Fogli,[1] E. Lisi,[1] A. Marrone,[1] D. Montanino,[2] and A. Palazzo[1] [1]*Dipartimento di Fisica and Sezione INFN di Bari, Via Amendola 173, 70126 Bari, Italy,* [2]*Dipartimento di Scienza dei Materiali and Sezione INFN di Lecce, Via Arnesano, 73100 Lecce, Italy.* (Received 25 June 2002; published 30 September 2002)

We present a thorough analysis of the current solar neutrino data, in the context of two-flavor active neutrino oscillations. We aim at performing an accurate and exhaustive statistical treatment of both the input and the output information. Concerning the input information, we analyze 81 observables, including the total event rate from the chlorine experiment, the total gallium event rate and its winter-summer difference, the 44 bins of the Super-Kamiokande (SK) energy-nadir electron spectrum, and the 34 day-night energy spectrum bins from the Sudbury Neutrino Observatory (SNO) experiment. We carefully evaluate and propagate the effects of 31 sources of correlated systematic uncertainties, including 12 standard solar model (SSM) input errors, the ^{8}B neutrino energy spectrum uncertainty, as well as 11 and 7 systematics in SK and SNO, respectively. Concerning the output information, we express the χ^2 analysis re-

sults in terms of ''pulls,'' embedding the single contributions to the total χ^2 coming from both the observables and the systematics. It is shown that the pull method, as compared to the (numerically equivalent) covariance matrix approach, is not only simpler and more advantageous, but also includes useful indications about the preferred variations of the neutrino fluxes with respect to their SSM predictions. Our final results confirm the current best-fit solution at large mixing angle (LMA), but also allow, with acceptable statistical significance, other solutions in the low-mass (LOW) or in the quasivacuum oscillation (QVO) regime. Concerning the LMA solution, our analysis provides conservative bounds on the oscillation parameters, and shows that the contribution of correlated systematics to the total χ^2 is rather modest. In addition, within the LMA solution, the allowed variations from SSM neutrino fluxes are presented in detail. Concerning the LOW and QVO solutions, the analysis of the pull distributions clearly shows that they are still statistically acceptable, while the small mixing angle (SMA) solution could be recovered only by *ad hoc* ''recalibrations'' of several SSM and experimental systematics. A series of Appendixes elucidate various topics related to the χ^2 statistics, the winter-summer difference in GALLEX-GNO, the treatment of the SK and SNO spectra, and a quasi-model-independent comparison of the SK and SNO total rates. [Phys. Rev. D **66**, 053010 (2002)]

***CP* violating neutrino oscillation and uncertainties in Earth matter density.** Lian-You Shan, *Institute of High Energy Physics, Chinese Academy of Sciences, P. O. Box 918, Beijing 100039, China, and CCAST (World Laboratory), P. O. Box 8730, Beijing 100080, China;* Bing-Lin Young, *Department of Physics and Astronomy, Iowa State University, Ames, Iowa 50011;* Xinmin Zhang, *Institute of High Energy Physics, Chinese Academy of Sciences, P. O. Box 918, Beijing 100039, China.* (Received 5 November 2001; published 30 September 2002)

We propose a statistical formulation to estimate possible errors in long baseline neutrino oscillation experiments caused by uncertainties in the Earth matter density. A quantitative investigation of the effect is made using the CP asymmetry in future experiments at the neutrino factory and superbeam. [Phys. Rev. D **66**, 053012 (2002)]

Pedagogic model for deeply virtual Compton scattering with quark-hadron duality. Frank E. Close, *Department of Theoretical Physics, University of Oxford, Keble Rd., Oxford, OX1 3NP, United Kingdom;* Qiang Zhao, *Department of Physics, University of Surrey, Guildford, GU2 7XH, United Kingdom.* (Received 8 March 2002; published 3 September 2002)

We show how quark-hadron duality can emerge for valence spin-averaged structure functions, and for the non-forward distributions of deeply virtual Compton scattering. Novel factorizations of the non-forward amplitudes are proposed. Some implications for large angle scattering and deviations from the quark counting rules are illustrated. [Phys. Rev. D **66**, 054001 (2002)]

Splitting of the π-ρ spectrum in a renormalized light-cone QCD-inspired model. T. Frederico, *Dep.de Física, Instituto Tecnológico de Aeronáutica, Centro Técnico Aeroespacial, 12.228-900 São José dos Campos, São Paulo, Brazil;* Hans-Christian Pauli, *Max-Planck Institut für Kernphysik, D-69029 Heidelberg, Germany;* Shan-Gui Zhou, *Max-Planck Institut für Kernphysik, D-69029 Heidelberg, Germany, and School of Physics, Peking University, Beijing 100871, China.* (Received 25 June 2002; published 19 September 2002)

We show that the splitting between the light pseudoscalar and vector meson states is due to the strong short-range attraction in the $^1S_0$ sector which makes the pion and the kaon light particles. We use a light-cone QCD-inspired model of the mass squared operator with harmonic confinement and a Dirac-delta interaction. We apply a renormalization method to define the model, in which the pseudoscalar ground state mass fixes the renormalized strength of the Dirac-delta interaction. [Phys. Rev. D **66**, 054007 (2002)]

Quark and nucleon self-energy in dense matter. L. S. Celenza, Hu Li, C. M. Shakin, and Qing Sun, *Department of Physics and Center for Nuclear Theory, Brooklyn College of the City University of New York, Brooklyn, New York 11210.* (Received 19 April 2002; published 23 September 2002)

In a recent work we introduced a nonlocal version of the Nambu–Jona-Lasinio (NJL) model that was designed to generate a quark self-energy in Euclidean space that was similar to that obtained in lattice simulations of QCD. In the present work we carry out related calculations in Minkowski space, so that we can study the effects of the significant vector and axial-vector interactions that appear in extended NJL models and which play an important role in the study of the ρ, ω and a_1 mesons. We study the modification of the quark self-energy in the presence of matter and find that our model reproduces the behavior of the quark condensate predicted by the model-independent relation $\langle\overline{q}q\rangle_\rho = \langle\overline{q}q\rangle_0(1-\sigma_N\rho_N/f_\pi^2 m_\pi^2+\cdots)$, where σ_N is the pion-nucleon sigma term and ρ_N is the density of nuclear matter. (Since we do not include a model of confinement, our study is restricted to the analysis of quark matter. We provide some discussion of the modification of the above formula for quark matter.) We find a restoration of chiral symmetry of about 80% at twice the nuclear matter density for the model considered in this work. We also find that the part of the quark self-energy that is explicitly dependent upon the density has a strong negative scalar term and a strong positive vector term, which is analogous to the self-energy found for the nucleon in nuclear matter when one makes use of the Dirac equation for the nucleon. In this work we calculate the nucleon self-energy in nuclear matter using our model of the quark self-energy and obtain satisfactory results in agreement with the values of the scalar and vector nucleon potentials in matter found in either theoretical or phenomenological studies. [Phys. Rev. D **66**, 054010 (2002)]

Longitudinal gluons and Nambu-Goldstone bosons in a two-flavor color superconductor. Dirk H. Rischke, *Institut für Theoretische Physik, Johann Wolfgang Goethe-Universität, Robert-Mayer-Strasse 8–10, D-60054 Frankfurt/Main, Germany;* Igor A. Shovkovy, *School of Physics and Astronomy, University of Minnesota, 116 Church Street S.E., Minneapolis, Minnesota 55455.* (Received 12 June 2002; published 30 September 2002)

In a two-flavor color superconductor, the $SU(3)_c$ gauge symmetry is spontaneously broken by diquark condensation. The Nambu-

Goldstone excitations of the diquark condensate mix with the gluons associated with the broken generators of the original gauge group. It is shown how one can decouple these modes with a particular choice of 't Hooft gauge. We then explicitly compute the spectral density for transverse and longitudinal gluons of adjoint color 8. The Nambu-Goldstone excitations give rise to a singularity in the real part of the longitudinal gluon self-energy. This leads to a vanishing gluon spectral density for energies and momenta located on the dispersion branch of the Nambu-Goldstone excitations. [Phys. Rev. D **66**, 054019 (2002)]

Dissipation at the two-loop level: Undressing the chiral condensate. Ágnes Mócsy, *The Niels Bohr Institute, Blegdamsvej 17, DK-2100 Copenhagen Ø, Denmark, and School of Physics and Astronomy, University of Minnesota, Minneapolis, Minnesota 55455.* (Received 3 July 2002; published 26 September 2002)

A simple and consistent real time analysis of the long-wavelength chiral condensate fields in the background of hard thermal modes is presented in the framework of the linear sigma model. Effective evolution equations are derived for the inhomogeneous condensate fields coupled to a heat bath. The multiple effects of the thermal background on the disoriented chiral condensate are studied using linear response theory. I determine the temperature dependence of the equilibrium condensate, and examine the modification of the sigma and pion dispersion relations as these mesons traverse a hot medium. I calculate the widths by determining the dissipative coefficients at nonzero temperature at one- and two-loop order with resummed meson masses. My results show that not only decay processes, but elastic scattering processes are significant at high temperatures, yielding to short relaxation times in the phase transition region. The relaxation times obtained are shorter than in previous estimates, making the observation of disoriented chiral condensate signals questionable. Throughout this work Goldstone's theorem is satisfied when chiral symmetry is spontaneously broken. [Phys. Rev. D **66**, 056010 (2002)]

Neutrinoless double beta decay in the supersymmetric seesaw model. Tai-Fu Feng, *CCAST (World Laboratory), P.O. Box 8730, Beijing 100080, China, and Institute of High Energy Physics, Academy of Science of China, P.O. Box 918, Beijing, 100039, China;* Xue-Qian Li and Yan-An Luo, *CCAST (World Laboratory), P.O. Box 8730, Beijing 100080, China, and Department of Physics, Nankai University, Tianjin 300070, China.* (Received 11 May 2002; published 30 September 2002)

Inspired by the recent Heidelberg-Moscow double beta decay experiment, we discuss the neutrinoless double beta decay in the supersymmetric seesaw model. Our numerical analysis indicates that we can naturally explain the data of the observed neutrinoless double beta decay, as well as that of the solar and atmospheric neutrino experiments with at least one Majorana-like sneutrino of middle energy scale in the model. [Phys. Rev. D **66**, 056011 (2002)]

Comment on "Protonium annihilation into $\pi^0\pi^0$ at rest in a liquid hydrogen target". C. Amsler,[1] C. A. Baker,[2] B. M. Barnett,[3] C. J. Batty,[2] M. Benayoun,[4] P. Blüm,[5] K. Braune,[6] D. V. Bugg,[7] T. Case,[8] V. Credé,[3] K. M. Crowe,[8] M. Doser,[9] W. Dünnweber,[6] D. Engelhardt,[5] M. A. Faessler,[6] R. P. Haddock,[10] F. H. Heinsius,[8] M. Heinzelmann,[1] N. P. Hessey,[6] P. Hidas,[11] D. Jamnik,[6] H. Kalinowsky,[3] P. Kammel,[8] J. Kisiel,[9] E. Klempt,[3] H. Koch,[12] M. Kunze,[12] U. Kurilla,[12] R. Landua,[9] H. Matthäy,[12] C. A. Meyer,[13] F. Meyer-Wildhagen,[6] R. Ouared,[3] K. Peters,[12] B. Pick,[3] M. Ratajczak,[12] C. Regenfus,[1] J. Reinnarth,[3] W. Roethel,[6] A. Sarantsev,[3] S. Spanier,[1] U. Strohbusch,[14] M. Suffert,[15] J. S. Suh,[3] U. Thoma,[3] I. Uman,[6] S. Wallis-Plachner,[6] D. Walther,[6] U. Wiedner,[6] K. Wittmack,[3] and B. S. Zou[7] (Crystal Barrel Collaboration), [1]*Universität Zürich, CH-8057 Zürich, Switzerland,* [2]*Rutherford Appleton Laboratory, Chilton, Didcot OX11 0QX, United Kingdom,* [3]*Universität Bonn, D-53115 Bonn, Federal Republic of Germany,* [4]*LPNHE Paris VI, VII, F-75252 Paris, France,* [5]*Universität Karlsruhe, D-76021 Karlsruhe, Federal Republic of Germany,* [6]*Universität München, D-80333 München, Federal Republic of Germany,* [7]*Queen Mary and Westfield College, London E1 4NS, United Kingdom,* [8]*University of California, LBNL, Berkeley, California 94720,* [9]*CERN, CH-1211 Geneva 4, Switzerland,* [10]*University of California, Los Angeles, California 90024,* [11]*Academy of Science, H-1525 Budapest, Hungary,* [12]*Universität Bochum, D-44780 Bochum, Federal Republic of Germany,* [13]*Carnegie Mellon University, Pittsburgh, Pennsylvania 15213,* [14]*Universität Hamburg, D-22761 Hamburg, Federal Republic of Germany,* [15]*Centre de Recherches Nucléaires, F-67037 Strasbourg, France.* (Received 4 April 2002; published 26 September 2002)

We comment on the recent paper published by the Obelix Collaboration on protonium annihilation into $\pi^0\pi^0$ at rest in a liquid hydrogen target [Phys. Rev. D **65**, 012001 (2002)], with particular reference to the discrepancy with the results obtained by the Crystal Barrel Collaboration. [Phys. Rev. D **66**, 058101 (2002)]

Crystallography of color superconductivity. Jeffrey A. Bowers and Krishna Rajagopal, *Center for Theoretical Physics, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139.* (Received 3 May 2002; published 10 September 2002)

We develop the Ginzburg-Landau approach to comparing different possible crystal structures for the crystalline color superconducting phase of QCD, the QCD incarnation of the Larkin-Ovchinnikov-Fulde-Ferrell phase. In this phase, quarks of different flavor with differing Fermi momenta form Cooper pairs with nonzero total momentum, yielding a condensate that varies in space like a sum of plane waves. We work at zero temperature, as is relevant for compact star physics. The Ginzburg-Landau approach predicts a strong first-order phase transition (as a function of the chemical potential difference between quarks) and for this reason is not under quantitative control. Nevertheless, by organizing the comparison between different possible arrangements of plane waves (i.e., different crystal structures) it provides considerable qualitative insight into what makes a crystal structure favorable. Together, the qualitative insights and the quantitative, but not controlled, calculations make a compelling case that the favored pairing pattern yields a condensate which is a sum of eight plane waves forming a

face-centered cubic structure. They also predict that the phase is quite robust, with gaps comparable in magnitude to the BCS gap that would form if the Fermi momenta were degenerate. These predictions may be tested in ultracold gases made of fermionic atoms. In a QCD context, our results lay the foundation for a calculation of vortex pinning in a crystalline color superconductor, and thus for the analysis of pulsar glitches that may originate within the core of a compact star. [Phys. Rev. D **66**, 065002 (2002)]