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Abstracts of Award Winning and Honorable Mention Essays for 1981

Award Winning Essays

First Award - Black Holes and Everyday Physics by Jacob D. Bekenstein, Physics Department, Ben Gurion University of the Negev, Beer-Sheva 84120, Israel

Abstract - Black holes have piqued much curiosity. But thus far they have been important only in "remote" subjects like astrophysics and quantum gravity. The author shows that the situation can be improved. By a judicious application of black hole physics, one can obtain new results in "everyday physics". For example, black holes yield a quantum universal upper bound on the entropy-to-energy ratio for ordinary thermdynamical systems which was unknown earlier. It can be checked, albeit with much labor, by ordinary statistical methods. Black holes set a limitation on the number of species of elementary particles - quarks, leptons, neutrinos - which may exist. And black holes lead to a fundamental limitation on the rate at which information can be transferred for given message energy by any communication system.

Second Award - Gravitational Radiation Antennas Using the Sagnac Effect by J. Anandan, Department of Mathematics, University of California, Berkeley, California 94720 and R.Y. Chiao, Department of Physics, University of California, Berkeley, California 94720.

Abstract - A new class of gravitational antennas that utilize the general relativistic Sagnac effect is proposed. These antennas are more efficient than the Weber bar by a factor of $(c/v_s)^4 \sim 10^{19}$, where v_s is the velocity of sound in the bar. A specific case of such an antenna consisting of a superfluid helium Josephson interferometer is considered. A general relativistic theory of the interaction of the superfluid with the gravitational field is given. Using this theory, the phase shift due to a gravitational plane wave on one such antenna is obtained. More generally, the proposed interferometer involves the interplay of general relativity and quantum theory and affords the possibility of testing general relativity in the laboratory at the quantum mechanical level. The possibility of detecting gravitons, assuming nearly unit coupling efficiency for the antenna, is explored.

Third Award - General Relativistic Chaos and Non-Linear Dynamics by John D. Barrow, Department of Physics, University of California, Berkeley, CA 94720.

Abstract - The author describes how new ideas in dynamical systems theory find application in the description of general relativistic systems. The concept of dynamical entropy is explained and the associated invariant evaluated for the Mixmaster cosmological model. The description of cosmological models as measure preserving dynamical systems lends to a number of exciting interconnections with new results in non-linear dynamics. This may provide a new avenue of approach to ascertaining the nature of the general solution to Einstein's equations.

Fourth Award - Half-integral Spin from Quantum Gravity by John L. Friedman, Physics Department, University of Wisconsin, Milwaukee, Wisconsin 53201 and Rafael D. Sorkin, Institute for Advanced Study, Princeton, New Jersey 08540.

Abstract - For a certain class of three-manifolds, the angular momentum of an asymptotically flat quantum gravitational field can have half-integral values. In the absence of a full theory of quantum gravity, this result relies on a set of apparently natural assumptions governing the kinematics of such a theory. A key feature is that state vectors are in general invariant only under asymptotically trivial diffeomorphisms that can be continuously deformed to the identity. Angular momentum is associated with diffeomorphisms that look asymptotically like rotations; and the question of whether half-integral values occur depends on whether the diffeomorphism associated with a 2π rotation is itself deformable to the identity.

Fifth Award - Non-Self-Dual Nonlinear Gravitons by Philip B. Yasskin and James A. Isenberg, Department of Mathematics, University of California, Berkeley, California 94720.

Abstract - Penrose has given a twistor description of all self-dual complex Riemannian spacetimes. The authors modify his construction to characterize all complex Riemannian spacetimes and all complex teleparallel spacetimes. This construction may be useful in finding non-self-dual solutions to the gravitational field equations (Einstein's or otherwise) without or with sources. It may also lead to a nonperturbative method of computing path integrals. Whereas Penrose shows that a self-dual spacetime may be specified by a deformation of projective twistor space (the set of α-planes in complex Minkowski space), the authors find that a Riemannian or teleparallel spacetime may be described by a deformation of projective ambitwistor space (the set of null geodesics in complex Minkowski space).

Honorable Mention Essays (Alphabetical Order)

1. Scattering of Scalar Tardyons and Tachyons from a Schwarzschild Black Hole by S. Banerji and D.R. Mandel, Department of Physics, The University of Burdwan, Burdwan 713104, India.

Abstract - The authors have set up the Klein-Gordon equation in the background of the Schwarzschild curved space-time in order to study the behaviour of tardyons and tachyons in a black hole. The authors solve the differential equation for the S-wave exactly and find that black holes of mass $< 5 \times 10^{14}$gm. scatter without absorption all tardyons of pion mass having energy below a certain limit while all black holes do so in the case of tachyons unlike in the classical case. The authors are also able to show that black holes of mass below 7×10^{14} gm. may contain bound

states of tardyons of pion mass within their event horizon contrary to the classical result.

2. Geometrical Formulation of Mach's Principle by J.B. Barbour and B. Bertotti, Istituto di Fisica Teorica Universita Pavia, Pavia, Italy.

Abstract - Mach's Principle is given a rigourous and general formulation, which implements both its aspects: the relational character of the dynamics of the Universe and the relative nature of time. By means of a new mathematical concept, the intrinsic derivative, one arrives at a fundamental postulate underlying Machian dynamics; this postulate is essentially geometrical and is based upon a Riemannian structure on the "intrinsic configuration space". This space is the set of all configurations of the Universe equivalent under the appropriate symmetry transformations. It is shown that if a classical system has vanishing global constants of the motion, it can be set in a Machian form; in particular, Lorentz-invariant field equations and special relativity can be recovered if the total energy of the system vanishes.

3. Can Redshifts Turn Blue? by Jeffrey M. Cohen, Department of Physics, University of Pennsylvania, Philadelphia, PA and Mitchell F. Struble, Department of Astronomy and Astrophysics, University of Pennsylvania, Philadelphia, PA.

Abstract - Redshifts can turn blue and blueshifts can turn red in real astrophysical situations involving magnetic neutron stars. It is even possible for redshifts and blueshifts to be emitted simultaneously from the same object. Although the redshift may be arbitrarily large, the blueshift cannot exceed $\frac{1}{2}$.

4. Classical Analogues of Black Holes by Thibaut Damour, E.R. 176 du C.N.R.S., Groupe d'Astrophysique Relativiste, Observatoire de Paris-Meudon, 92190 Meudon (France).

Abstract - The author describes a precise analogy between the behaviour of purely gravitational, highly relativistic objects (black holes) and of non-gravitational, non-relativistic classical objects. By concentrating on the properties of the surface of a black hole (the horizon), it is shown how a black hole, in its most general dynamic state, is qualitatively and quantitatively similar to a fluid bubble possessing a negative surface tension and endowed with finite values of the shear and bulk viscosities and of the electrical resistivity. This analogy is valid simultaneously at the levels of mechanical, electromagnetical and thermodynamical laws. This includes dissipative phenomena as well as the validity of Prigogine's minimum entropy production principle.

5. A Proposed Laboratory Experiment To Measure $\dot{G}/G$ by Terry Dannehold, Department of Physics, Loyola University of Chicago, 6525 N. Sheridan Road, Chicago, IL 60626

Abstract - An experiment is proposed in which the length of a laser cavity depends on the force of gravity. A change in the gravitational constant will cause a change in the frequency of the laser, which may be measured relative to a reference laser. If an iodine stabilized He-Ne laser is used as the reference $\dot{G}/G$ can be measured to an accuracy of 4×10^{-12} yr^{-1}.

6. On a Possible Connection Between the Spontaneous Breaking of SU(2) x U(1) Symmetry and the Variability of c on a Strong Gravity Background by Venzo De Sabbata and Maurizio Gasperini, Istituto di Fisica di Bologna, Bologna, Italy.

Abstract - Embedding the Yang-Mills Lagrangian of the standard Weinberg-Salam model in a given space-time with constant scalar curvature, and allowing light velocity to be a variable field, spontaneous symmetry breaking is obtained, and a physical interpretation of the Higgs field is given. Strong gravity is used to predict the mass of the charged vector boson and also of the scalar Higgs boson, which is not a free parameter in this model, but it is related to the space-time curvature radius.

7. Exact, Approximate and Numerical Solutions of Einstein's equations and Computers by R. A. d'Inverno, Faculty of Mathematical Studies, Southampton University, England, SO9 5NH.

Abstract - Attempts have been made to solve Einstein's gravitational field equations by a number of routes. Specifically a search has been made for exact solutions, approximate solutions and numerical solutions. The role of the computer in these investigations is shown to be an increasingly central one.

8. The Temperature Function For a Gravitational Oscillator by P. Dolan and P. Choudhury, Imperial College of Science and Technology, London SW7 2BP.

Abstract - The equation of relative motion of two neighbouring test particles in gravitational free fall known as the geodesic deviation equation admits a "constant of the motion" J which is an action. The magnitude of the deviation vector η satisfies the equation of a time-dependent harmonic oscillator which defines an energy E. The authors quantize this one-dimensional system as an approach to the study of gravitational radiation in the microdomain. A temperature function T satisfying the gravitational analogue of Wien's law for classical blackbody radiation is found.

9. Implications of an Alternative Relativistic Transport Theory by John J. Dykla, Department of Physics, Loyola University of Chicago and Anthony E. Hwang, Bell Laboratories, Holmdel, New Jersey.

Abstract - The authors suggest some implications of an alternative to standard general relativistic transport theory based on some recent work in differential geometry which shows a natural way to make the phase space of kinetic theory fully Riemannian. While preserving all the successes of orthodox equilibrium statistical mechanics, this approach produces a new Boltzmann equation for evolving distributions of particles. Physical consequences of the new model include the possibility of a crucial experiment based upon supernovae light curves. Still more speculatively, application to conditions in the very early universe should lead to predictions quite distinct from those of other approaches which have been considered.

10. The Weight, Shape, and Speed of the Universe
by A.J. Fennelly, ES-63, Space Sciences Laboratory, Marshall Space Flight Center, AL 35812.

Abstract - Present astronomical data indicate an unbound universe with density

$\sim 1.6 \times 10^{-31}$ gm cm^{-3} in which galaxies could not have formed gravitationally. The author shows how magnetohydrodynamic (MHD) processes allow galaxy formation in an open anisotropic MHD universe with shear, rotation, and fluid flow. The dipole anisotropy of the microwave background radiation sets their respective first-order values at 3.7×10^{-15} yr^{-1}, 10^{-14} yr^{-1}, and $5 \times 10^{-4}c$. Second-order effects of Maxwell and Reynolds stresses require that the magnetic field, shear, and Hubble expansion be 10^{-8} gauss, 3.7×10^{-15} yr^{-1}, and 10^{-10} yr^{-1} (100 km sec^{-1} Mpc^{-1}). The model is rigidly self-consistent, predicting both the recent value of the Hubble expansion above and of the shear ($\lesssim 9 \times 10^{-15}$ yr^{-1}) given by the microwave background's recently measured quadrupole anisotropy.

11. A Unified Approach to Conservation Laws in General Relativity, Gauge Theories, and Elementary Particle Physics by Arthur E. Fischer, Department of Mathematics, University of California, Santa Cruz, California 95064.

Abstract - A unified treatment of conservation laws in general relativity, gauge theories and elementary particle physics is formulated in the setting of principal fiber bundles. The group AUT(P) is introduced as the general gauge transformation group that covers space-time coordinate transformations. A set of master equations is exhibited for any Lagrangian density generally covariant with respect to AUT(P). The symmetry groups for elementary particle theory is shown to be the structure group of the bundle only in the special case when the gauge potential is flat the spacetime is simply connected. In the general case, the symmetry group is reduced to the symmetry group of the gauge potential. This natural mechanism for a reduction of the symmetry group is speculated on as a model for spontaneous symmetry breaking.

12. Initial Value Problems and Global Space-time Structure by Helmut Friedrich, Hochschule der Bundeswehr, Holstenkofweg 85, 2000 Hamburg 70.

Abstract - The asymptotic characteristic Cauchy problem where data are given on past null infinity and an incoming null-hypersurface can be reduced to an initial value problem for a symmetric hyperbolic system. This result allows one to establish existence theorems for, and to perform numerical calculations of global asymptotically flat solutions from,local initial value problems. The method is applicable to standard Cauchy problems for the vacuum and the conformal vacuum field equations as well. This suggests its application to other global problems. Whence a technique is provided which will help decrease the gap between the work on the global structure of gravitational fields and the results on initial value problems in relativity

13. Thermodynamics of Black Holes In The External Magnetic Field by D.V. Gal'tsov, Moscow State University, Moscow, U.S.S.R.

Abstract - A family of solutions of the Einstein-Maxwell equations describing the Kerr-Newman black hole in the external asymptotically homogeneous magnetic field is obtained within the Ernst approach. It generalises previously known results to the case of arbitary relation between the field strength and the charge of the black hole. It is shown that the magnetic field modifies the surface entropy and the quantum temperature of the black hole, the maximal entropy corresponding to the relation $Q = 2aMB$ between the magnetic field strength B and the hole charge Q. This implies that the initially non-charged black hole acquires an electric charge in the course of its quantum evaporation in presence of the magnetic field. On the

other hand, quantum evaporation of the charged rotating black hole must lead to generation of the magnetic field in the outer region due to the charge and angular momentum asymmetry of the created particles distribution. This effect can be regarded as quantum magnetic dynamo mechanism.

14. Abnormal States of Dense Matter and Astronomical Observations by P. Haensel and M. Proszynski, N. Copernicus Astronomical Center, Polish Academy of Sciences, ul. Bartycka 18, 00-716 Warsaw, Poland.

Abstract - The observational estimates on neutron star masses and moments of inertia are used to rule out some of the possible models of cold dense matter with a pion-condensed phase. In particular, the authors investigate the possibility of an existence of abnormal (superheavy) neutron nuclei, "golf-ball" neutron stars and larger abnormal neutron stars with a superdense liquid surface. These unusual objects, appearing in the literature, are predicted by the models of dense matter which (due to pion condensation) have a superdense abnormal self-bound state, energetically preferred over that of an iron crystal. The authors calculate the models of abnormal neutron stars and confront them with observational constraints on pulsars. In this way, the authors are able to rule out the models of dense matter with an abnormal self-bound state.

15. Energy Conditions and Stability in General Relativity by G.S. Hall, Department of Mathematics, University of Aberdeen, Edward Wright Building, Dunbar Street, Aberdeen AB9 2TY, Scotland.

Abstract - The dominant energy condition in General Relativity Theory, which says that every observer measures a non-negative local energy density and a non-spacelike local energy flow, is examined in connection with the types of energy-momentum tensor it permits. The condition that the energy-momentum tensor be "stable" in obeying the dominant energy condition is then defined in terms of a suitable topology on the set of energy-mementum tensors on space-time and the consequences are evaluated and discussed.

16. Spin Networks: A Discretization of Spacetime Realized by Brosl Hasslacher, Institute for Advanced Study, Princeton, New Jersey 08540 and Malcolm Perry, Department of Physics, Princeton University, New Jersey 08544.

Abstract - Many of the problems of constructing a quantum theory of gravitation can be traced to the idea that spacetime forms a continuum. The authors present a construction of quantum gravity in three dimensions which involves a discretization of spacetime. This method reproduces the correct semiclassical results and has the advantage that all results are automatically finite.

17. Real and Possible Worlds by Craig J. Hogan, Enrico Fermi Institute, The University of Chicago, 5640 South Ellis Avenue, Chicago, Illinois 60637

Abstract - If the universe is infinite and quantum states are well-behaved in a certain sense, then the universe contains an infinite number of worlds identical to ours. The mean separation between them is of order $t^{6t^{3/2}} \sim 10^{10^{93}}$, where t is the horizon size expressed in Planck units. Within this "recurrence length" lies a complete statistical ensemble of worlds compatible with the cosmology, including identical and nearly-identical copies of ourselves. The distinction between "real",

"possible" and "parallel" worlds probably becomes blurred or even erased at a deeper level of description.

18. Grooves, Kinks and Bumps: The Lo-Fi Disk by Vincent Icke, Department of Astronomy, University of Minnesota, Minneapolis, Minnesota 55455

Abstract - Non-Axisymmetric perturbations of a keplerian ('hi-fi') disk lead to the formation of grooves, kinks and bumps. The orbital mechanics of these perturbed ('lo-fi') disks is such that gravitational attraction among disk particles results in an effective repulsion, which is the cause of the grooves and kinks observed in disks around planets. Gaseous disks behave somewhat similarly; an attracting object orbiting in such a disk grows at first by accretion, then stops growing because it acquires angular momentum. Examples of this are galactic molecular clouds and protoplanets.

19. Relative Space-Times by Edwin D. Jones, Department of Astrophysics, University of Oxford, Oxford OX1 3RQ England.

Abstract - The nonlinearity of Einstein's field equations allows, in general, the possibility of a multitude of exact solutions or space-times for any given physical circumstance. Thus, investigations of the "classical field' of General Relativity should extend beyond the study of particular space-times to consider the nature of the manifold of solutions of Einstein's equations.

A heirarchial structure, associated with the Ernst equation, that provides relationships among various stationary, axisymmetric space-times is presented. These relationships, to some extent, explicate the manifold of solutions of the Ernst equation. It is evident that the solution manifold is more than a collection of independent space-times; it is a network of interrelated spacetimes. Each space-time is inextricably connected to others, and, thus, must be judged as a relative space-time.

20. Gamma Ray Bursts from Gravity - the Roundabout Way? by Peter Kafka and Friedrich Meyer, Max-Planck-Institut fur, Physik und Astrophysik, Karl Schwarzschild Strasse 1, 8046 Garching bei Munchen, Germany.

Abstract - It is argued that magnetic neutron stars with aligned rotation axis, accreting matter from the interstellar medium, supply angular momentum to this matter via magnetospheric interaction. Consequently, the accretion flow will only partially be funnelled down to the polar caps, and a thin cool disk in the equatorial plane will form. The greatest part of this disk will be magnetically disconnected from the star. If its inner edge reaches some critical radius, e.g. a pulsar type ignition process will trigger magnetic connection between the star and the disk. A certain inner ring will then fall inwards immediately, while a wider ring and magnetic instabilities may follow on a longer time scale. Even the outstanding event of March 5, 1979 might be understood in a similar way.

21. The Universe That Can Open Up Or Close by Andrzej Krasinski, N. Copernicus Astronomical Center, Polish Academy of Sciences, Bartycka 18, 00716 Warszawa Poland.

Abstract - A generalization of the Friedman Universe models, found in 1967 by Stephani, is discussed. Each spatial section t = const of the Stephani model is identical with a section of one of the Friedman models, but the sign of curvature of the section may be different at different times. A number of physical problems, which emerge if the Stephani solution is taken as the model of the actual Universe, is posed.

22. Gravitation, Phase Transitions and the Big Bang by Lawrence M. Krauss, Laboratory for Nuclear Science and Center for Theoretical Physics, M.I.T., Cambridge, MA 02139.

Abstract - The author proposes to tie the nature of gravitation to the existence of the primeval big bang through the hypothesis that a first order phase transition occurred leaving gravitation as the low energy effective theory and at the same time releasing latent heat. This in turn produced the high temperatures and entropies necessary as initial conditions in the standard big band scenario. It is first shown that recent progress in gravitation theory is suggestedive of such a possibility. Next, possible phase transitions are reviewed, along with their cosmological implications. The author concludes that his hypothesis points toward possible solutions to several outstanding cosmological problems and may provide a physical basis for understanding several parameters which describe our observed universe, most notably the small value of Λ , the cosmological constant. As well, it may serve to distinguish between possible quantum gravity models, by using the early universe as a laboratory.

23. Regge Calculus, Quantum Gravity and Singularities by Steve M. Lewis, Department of Physics, University of Maryland, College Park, Maryland

Abstract - An examination of how Regge calculus can be used to investigate current topics of general relativity is made. Regge calculus is a means of approximating geometry by discrete blocks such that topological information is displayed explicitly. A quick review of Regge theory is made, and some fundamental problems that exist are discussed. A formalism is shown for using this discrete structure as the background for a lattice as in quantum field theory. This would describe the semiclassical problem in relativity. Some comments are made on past work using Regge calculus as a tool for quantum gravity. Finally, the question of the existence of the initial singularity in cosmological models is discussed in the context of Regge calculus.

24. On the Quasi-Normal Modes of a Black Hole by Bahram Mashhoon, Institute for Theoretical Physics, University of Cologne, D-5000 Cologne 41, Federal Republic of Germany.

Abstract - It is shown that for any potential barrier, the quasi-normal modes are uniquely determined by the bound states of the corresponding inverted potential. The quasi-normal modes of a Schwarzschild black hole are discrete and occur in a bounded region of the complex frequency plane. For a given angular momentum parameter $j > 0$, their number is countably infinite. However, for scalar radiation with $j = 0$, the number of such modes is finite. The fundamental (least damped) and the first few modes of a given j may be approximately determined using the exact quasi-normal modes of the inverted harmonic oscillator potential. The scattering of radiation from a black hole is discussed in terms of the quasi-normal modes. A theoretical basis is thus provided for many numerical results in the literature.

24. Classical and Quantum Models of Strong Cosmic Censorship by Vincent E. Moncrief, Department of Physics, Yale University, New Haven, Connecticut 06520.

Abstract - The cosmic censorship conjecture states that naked singularities should not evolve from regular initial conditions in general relativity. In its strong form the conjecture asserts that spacetimes with Cauchy horizons must always be unstable and thus that the generic solution of Einstein's equations must be inextendible beyond its maximal Cauchy development. In this essay the author shows that one can construct an infinite dimensional family of extendible cosmological solutions similar to Taub-NUT spacetime. However he also shows that each of these solutions is unstable in precisely the way demanded by strong cosmic censorship. Finally he shows that quantum fluctuations in the metric always provide (though in an unexpectedly subtle way) the "generic perturbations" which destroy the Cauchy horizons in these models.

25. A Josephson Junction Gravimeter to Measure $\vec{g}(\vec{r})/h$ by Michael Martin Nieto and T. Goldman, Theoretical Division, Los Alamos National Laboratory, University of California, Los Alamos, New Mexico 87545.

Abstract - The authors point out that a battery may be designed so that, in a gravitational field, it will have a gravitationally induced emf in addition to an electrochemical one. The gravitationally induced emf of a battery with a small "effective" electrochemical potential and a long "effective" length can readily be measured to a very high precision by means of a Josephson junction. Such a device may be employed to measure any component of the gravitational acceleration vector. It can be constructed compactly enough to be placed down a bore hole. Thus, in principle it is an extremely precise and adaptable tool for geophysical exploration.

26. Symmetry Breaking in Non-Inertial Frames and Curved Space-Time by T. Padmanabhan, Astrophysics Group, Tata Institute of Fundamental Research, Homi Bhabha Road, Bombay 400 005, India.

Abstract - Spontaneous symmetry breaking of a scalor field is investigated in curved space-time and in non inertial coordinates. It is shown that curvature can induce a symmetry breaking in a very natural way. The structure of the theory is quite different in a curved manifold leading to nontrivial predictions (e.g. the standard high temperature phase transition does not occur.) It is als shown that the formalism is not generally covariant and that the success of the standard model depends crucially on the use of inertial coordinates. Various other aspects of the situation are discussed.

27. Is Quantum Gravity Deterministic and/or Time Symmetric? by Don N. Page, Department of Physics, The Pennsylvania State University, University Park, Pennsylvania 16802 USA.

Abstract - S.W. Hawking suggests that quantum gravity introduces a new level of uncertainty into physics by turning pure states into mixed states. Although the evidence for this information loss is based upon a semiclassical approximation and hence is not conclusive, it is interesting to examine the implications. As originally formulated, Hawking's proposal violates CPT invariance by singling out one direction of time in which pure states turn into mixed states. An alternate hypothesis is

suggested whereby the theory could be time symmetric and yet allow a loss of information. In this model the universe as a whole would be an open system, and event its density matrix would not have a deterministic evolution. The question remains of how much uncertainty there actually is in quantum gravity.

28. A Description of the Gravitational Red-shift Borrowed from the Electrodynamics Continuous Media by F. Pegoraro, Scuolo Normale Superiore, 56100 Pisa, Italy.

Abstract - The description of the effects of a gravitational field on the classical electromagnetic field equations in terms of generalized electric and magnetic permittivities is shown to define an "equivalent" medium with unusual properties. In particular it is remarked that such a medium can be chosen so as to include the behavior, under the effect of gravity, of the bodies that are used to produce and to detect the electromagnetic field. This is illustrated by the example of the gravitational redshift. The introduction of the proper time of the emitting and of the absorbing atoms is shown to define a medium interacting with the electromagnetic field through a drag velocity which increases linearly with time.

29. The Radiative Accelerator by Tsvi Piran, Racah Institute for Physics, The Hebrew University, Jerusalem, Israel, and The Institute for Advanced Study, Princeton, New Jersey 08540 USA

Abstract - The acceleration mechanism of the relativistic jets, observed in extragalactic radio sources is one of the current puzzles of relativistic astrophysics. It is commonly believed that these objects are powered by accretion onto massive black holes, but it is not clear how is the gravitational energy, that is released by the accretion, channeled to accelerate and collimate the jets. The author explores the potential and limitation of Lynden-Bell's radiative acceleration mechanism, which is based on thick accretion disks. He demonstrates that this mechanism can achieve the needed collimation and acceleration if it is based on disks of moderate ($100-200R_g$) sizes.

30. Spiral Galaxies and the Mass of the Universe by Vera C. Rubin, Department of Terrestrial Magnetism, Carnegie Institution of Washington, 5241 Broad Branch Road, N.W., Washington, D.C. 20015.

Abstract - If the distribution of mass in a spiral galaxy follows the distribution of light, then stellar and gas orbital velocities will decrease with increasing nuclear distance. However, recent observations show that velocities remain high across the entire optical image. This implies that a significant fraction of the mass of the galaxy is contained in nonluminous matter located beyond the optical image. Unfortunately, neither the observations nor the analysis specifies the ratio of dark matter to luminous matter. Hence the "total" mass of a spiral galaxy remains unknown. If the ratio of dark matter to luminous matter is about 50, then the universe will be closed.

31. Speculations Concerning a Fermionic Substructure of Spacetime by John H. Schwarz and Peter van Nieuwenhuizen, California Institute of Technology, Pasadena, California 91125.

Abstract - The possibility of obtaining the coordinates of spacetime as "composites" of more fundamental fermionic coordinates is explored. It is suggested that the required algebraic structure may be derived from an action whose equations of motion define suitable constraints. The program is incomplete and very speculative. Some of the problems that remain to be solved are indicated.

32. The Large Scale Primordial Vorticity and Microscopic Asymmetries in Neutrino Physics by I. Damiao Soares, Centro Brasileiro de Pesquisas Fisicas, Rio de Janeiro, Brasil.

Abstract - Motivated by the interpretation of the observed anisotropy of the microwave background radiation as due to a large scale primordial vorticity of the universe, the author examines the gravitational coupling of neutrinos to matter vorticity; for technical simplicity he has considered the Gödel model as the cosmological background, whose matter content has a non-null vorticity. The presence of a vorticity field of matter generates, via gravitation, microscopic asymmetries in neutrino physics. At the microscopic level, currents are asymmetric along the direction determined by the vorticity field: Neutrino (anti.neutrino) currents are larger along the direction antiparallel (parallel) to the vorticity field. In the case of production of pairs *under* CP *violation*, a net number asymmetry is generated between neutrinos and antineutrinos.