Abstracts of Award Winning and Honorable Mention Essays for 1997

Award Essays

First Award - Pure States Don't Wear Black - by Robert Myers, Department of Physics, McGill University, Montréal, Québec H3A-2T8 Canada.

Abstract - Recently string theory has provided some remarkable new insights into the microphysics of black holes. The author argues that a simple and important lesson is also provided with regards to the information loss paradox, namely, pure quantum states do not form black holes! Thus it seems black hole formation, as well as evaporation, must be understood within the framework of quantum decoherence.

Second Award - A Strategy for a Vanishing Cosmological Constant in the Presence of Scale Invariance Breaking -by Stephen L. Adler, Institute for Advanced Study, Princeton, NJ 08540.

Abstract - Recent work has shown that complex quantum field theory emerges as a statistical mechanical approximation to an underlying noncommutative operator dynamics based on a total trace action. In this dynamics, scale invariance of the trace action becomes the statement $0 = \mathrm{Re} Tr T_\mu^\mu$ with $T_{\mu\nu}$ the operator stress energy tensor, and with Tr the trace over the underlying Hilbert space. The author shows that this condition implies the vanishing of the cosmological constant and vacuum energy in the emergent quantum field theory. However, since the scale invariance condition does not require the operator T_μ^μ to vanish, the spontaneous breakdown of scale invariance is still permitted.

Third Award - On Gravitational Repulsion - by Tsvi Piran, Racah Institute for Physics, The Hebrew University, Jerusalem 91904, Israel.

Abstract - The concepts of negative gravitational mass and gravitational repulsion are alien to general relativity. Still, the author shows here that small negative fluctuations - small dimples in the primordial density field - that act as if they have an effective negative gravitational mass, play a dominant role in shaping our Universe. These initially tiny perturbations repel matter surrounding them, expand and grow to become voids in the galaxy distribution. These voids - regions with a diameter of $40h^{-1}$ Mpc which are almost devoid of galaxies - are the largest objects in the Universe.

Fourth Award - On a New Non-Geometric Element in Gravity - by D. V. Ahluwalia, P-25 Subatomic Physics Group, Mail Stop H-846, Los Alamos National Laboratory, Los Alamos, NM 87545.

Abstract - In this essay a generalized notion of flavor-oscillation clocks is introduced. The generalization contains the element that various superimposed mass eigenstates may have different relative orientation of the component of their spin with respect to the rotational axis of the gravitational source. It is found that these quantum mechanical clocks do not always redshift identically when moved from the gravitational environment of a non-rotating source to the field of a rotating source. The non-geometric contributions to the redshifts may be interpreted as quantum mechanically induced fluctuations over a geometric structure of space-time.

Fifth Award - Can Inflation be Falsified? - by John D. Barrow and Andrew R. Liddle, Astronomy Centre, University of Sussex, Falmer, Brighton BN1 9QH, U.K.

Abstract - Despite its central role in modern cosmology, doubts are often expressed as to whether cosmological inflation is really a falsifiable theory. The authors distinguish two facets of inflation, one as a theory of initial conditions for the hot big bang and the other as a model for the origin of structure in the Universe. They argue that the latter can readily be excluded by observations, and that there are also a number of ways in which the former can find itself in conflict with observational data. Both aspects of the theory are indeed falsifiable.

Honorable Mention Awards (Alphabetical Order)

1. Classicality, Matter-Antimatter Asymmetry, and Quantum-Gravity Deformed Uncertainty Relations - by Giovanni Amelino-Camelia, Theoretical Physics, University of Oxford, 1 Keble Road, Oxford OX1 3NP, U.K.

Abstract - Some of the recent work on quantum gravity has involved modified uncertainty relations such that the products of the uncertainties of certain pairs of observables increase with time. It is here observed that this type of modified uncertainty relations would lead to quantum decoherence, which could explain the classical behavior of macroscopic systems, and CPT violation, which could provide the seed for the emergence of a matter-antimatter asymmetry.

2. A Proposal of New Gravitational Experiments - by John Argyris and Corneliu Ciubotariu, Institute for Computer Applications, University of Stuttgart, Pfaffenwaldring 27, D-70569 Stuttgart, Germany.

Abstract - The authors propose in this note some new experiments on the physics of gravitation. These experiments refer to: simulation of accelerations produced by a gravity wave, a direct current gravitational machine, materials with high gravitomagnetic permeability, and finally the possibility of an attenuation of the gravitational attraction. The new ideas involve essentially first the conception of a detector or a source of gravitational radiation in the form of a body in which the motions of particles are precisely the same as those induced by a real gravitational wave in that body, and second, to design a detector having two principal components placed at a distance of $\lambda/2$ along the direction of propagation of a gravity wave. They define also a new concept: the gravitational superconductor.

3. Are Naked Singularities Forbidden by the Second Law of Thermodynamics? - by Sukratu Barve and T. P. Singh, Theoretical Astrophysics Group, Tata Institute of Fundamental Research, Homi Bhabha Road, Bombay 400 005, India.

Abstract - By now, many examples of naked singularities in classical general relativity are known. It may however be that a physical principle over and above the general theory prevents the occurrence of such singularities in nature. Assuming the validity of the Weyl curvature hypothesis, the authors propose that naked singularities are forbidden by the second law of thermodynamics.

4. Lorentz Invariance and the Cosmological Constant - by O. Bertolami, Instituto Superior Técnico, Departamento de Física, Av. Rovisco Pais 1, 1096 Lisboa Codex, Portugal.

Abstract - Non-trivial solutions in string field theory may lead to the spontaneous breaking of Lorentz invariance and to new tensor-matter interactions. It is argued that requiring the contribution of the vacuum expectation values of Lorentz tensors account for the vacuum energy up to the level that $\Omega_0^{\Lambda} = 0.5$ implies the new interaction=s range is $\lambda \sim 10^{-4}\, m$. These conjectured violations of the Lorentz symmetry are consistent with the most stringent experimental limits.

5. Doppler Effect in a Moving Medium - by Bruno Bertotti, Dipartimento di Fisica Nucleare e Teorica, Università di Pavia, Italy.

Abstract - The great increase in the accuracy of Doppler measurements in space requires a rigorous definition of the observed quantity in a moving medium like the solar wind. This is usually done in two divergent ways: in the phase point of view it is the time derivative of the correction to the optical path; in the ray point of view the signal is obtained from the deflection produced in the ray. They can be reconciled by using the time derivative of the optical path in the Lagrangean sense, i.e., differentiating from ray to ray. To rigorously derive this result an understanding, through relativistic Hamiltonian theory, of the delicate interplay between rays and phase is required; a general perturbation theorem which generalizes the concept of the Doppler effect as a Lagrangean derivative is proved. Relativistic retardation corrections O(v) are obtained, well within the expected sensitivity of Doppler experiments near solar conjunction.

6. A Closed Contour of Integration in Regge Calculus - by Danny Birmingham, University College Dublin, Department of Mathematical Physics, Belfield, Dublin 4, Ireland.

Abstract - The analytic structure of the Regge action on a cone in *d* dimensions over a boundary of arbitrary topology is determined in simplicial minisuperspace. The Regge action depends on a single complex edge length variable, and it is shown that there are three finite branch points in this complex plane. A closed contour of integration encircling the branch points is shown to yield a convergent wave function. This closed contour can be deformed to a steepest descent contour for all sizes of the bounding universe. In general, the contour yields an oscillating wave function for bounding universes of size greater than a critical value which depends on the topology of the bounding universe.

7. String Theory Does not Like Curvature Singularities - by A. Buonanno, M. Gasperini and C. Ungarelli, Theory Division, CERN, CH-1211, Geneva 23, Switzerland.

Abstract - The authors show that string theory admits, already to first order in αN and in the critical vacuum, a class of static and spherically symmetric solutions with no curvature singularities. In the string frame the solutions approach asymptotically (at *r* 6 0 and *r* 6 4) two different anti-de Sitter configurations, thus interpolating between two maximally symmetric states of different constant curvature. The radial-dependent dilaton defines a string coupling which is everywhere finite and arbitrarily small, so that quantum-loop corrections remain negligible. This example stresses the importance of finite-size αN corrections, typical of string theory, in regularizing space-time singularities.

8. Sub-millisecond Absolute Timing: Toward an Actual Gravitational Observatory - by M. Cerdonio[*], V. Crivelli Visconti[*], A. Ortolan[+], G. Prodi[#], L. Taffarello[*], G. Vedovato[+], and S. Vitale[#], [*]Dipartimento di Fisica, Università di Padova and INFN, Sezione di Padova, via Marzolo, 8 35100 Padova, Italy; [+]INFN, Laboratori Nazionali di Legnaro, via Romea 4, I-35020, Legnaro, Padova, Italy; [#]Dipartimento di Fisica Università di Trento and INFN, Gruppo Collegato di Trento, Sezione di Padova, I-38050, Povo, Trento, Italy.

Abstract - In this paper the authors report on the results they obtained in experimentally demonstrating the feasibility of absolute timing of impulsive gravitational wave signals by means of a resonant bar detector. They reached a resolution of less than 20 μs for SNR ∃ 10. They also discuss the important prospects this result opens for the present and for the future, as a necessary condition for the implementation of a global network of gravitational wave detectors.

9. Dilatonic Dark Matter - A New Paradigm - by Y. M. Cho, Asia Pacific Center for Theoretical Physics, and Department of Physics, College of Natural Sciences, Seoul National University, Seoul 151-742, Korea.

Abstract - The author finds that the condition for the dilaton to be the dark matter of the universe strongly restricts its mass to be around 0.5 keV or 171 MeV. For the other mass ranges, the dilaton either undercloses or else overcloses the universe. The 0.5 keV dilaton has the free-streaming distance of about 1.4 Mpc and becomes an excellent candidate for warm dark matter, while the 171 MeV one has the free-streaming distance of about 12 pc and becomes a candidate for cold dark matter. The author discusses the possible ways to detect the dilaton experimentally.

10. Is the Expansion of the Universe Universal? - by F. I. Cooperstock and V. Faraoni, Department of Physics and Astronomy, University of Victoria, P.O. Box 3055, Victoria, B.C. Canada V8W 3P6.

Abstract - Through the years, various authors have debated whether or not the expansion of the universe proceeds on all scales. The objection on the basis that universal cosmological expansion would imply an unobservable universal rescaling is incorrect. The apparent lack of a logical cutoff leads the authors to view the expansion as universal. Analyses to this point have not been referred to the astronomically employed locally inertial frame (LIF). Assuming universal expansion and employing the LIF, the authors determine, as expected, that the effect is very small. However, cumulative effects are potentially significant: for example the present size of the solar system would have a 1-2% contribution from the global expansion.

11. Regge Calculus of Fundamental Particles - by John Bruce Davies, Department of Physics, University of Colorado, Boulder, CO 80309.

Abstract - In a discrete space-time, governed by Regge calculus, curvature is distributed over the 2-simplex defect with energy-momentum concentrated on the legs of the 2-simplex. The author proposes that massive particles can be identified with these discrete defects. A baryon, composed of 3 quarks, is modeled by the triangular 2-simplex, where the quarks carry energy-momentum on the legs. Mesons and leptons correspond to collapsed line and point 2-simplexes, respectively, where curvature and Action remain well-behaved through the collapse. There are 6 invariants of the 2-simplex defect corresponding to the 6 quark flavors. The 3 on-diagonal invariants have inner products of 2/3 while the 3 off-diagonal invariants have -1/3 inner products. The closure condition on these invariants is used to explain the confinement of the quarks. An unexpected consequence of this model is the explanation of Heisenberg's Uncertainty Principle and the structure of particle families.

12. Can Exotic Matter Have Anti-gravity? - by Feng Zhao[*] and Liao Liu[+], [*]Department of Biomedical Engineering, Capital University of Medical Sciences, Beijing 100054, China; [+]Department of Physics, Beijing Normal University, Beijing 100875, China.

Abstract - The exotic matter is a troublesome and interesting problem in traversable Lorentzian wormhole physics for its negative energy density or violation of the weak energy conditions. In this paper, the authors present a hypothesis: exotic matter has negative gravitational mass but positive inertial mass, so it has anti-gravity. This hypothesis, together with the Einstein field equations, makes it more convenient for the authors to study the geometry of the wormhole's interior space. For a special example, they investigate the traversability of the wormholes constructed by Visser's scenario.

13. Fisher's Arrow of Time in Quantum Cosmology - by B. Roy Frieden[*] and H. C. Rosu[+], [*]Optical Sciences Center, University of Arizona, Tucson, AZ 85721; [+]Instituto de Física de la Universidad de Guanajuato, Apdo Postal E-143, León, Gto, México and Institute of Gravitation and Space Sciences, Magurele-Bucharest, Romania.

Abstract - Fisher's arrow of time is introduced in quantum cosmology. Assuming that the evolution of the universe in phase space starts from an initial squeezed cosmological state towards a final thermal one, a Fokker-Planck equation for the time-dependent, cosmological *Q* phase space probability distribution can be written down. Next, using some recent results in the literature, the authors derive an information arrow of time for the Fisher phase space cosmological entropy. They also mention the application of Fisher's arrow of time to stochastic inflation models.

14. Plenty of Nothing: Black Hole Entropy in Induced Gravity - by V. P. Frolov and D. V. Fursaev, Department of Physics, University of Alberta, Edmonton, Canada T6G 2J1.

Abstract - The authors demonstrate how Sakharov's idea of induced gravity allows one to explain the statistical-mechanical origin of the entropy of a black hole. According to this idea, gravity becomes dynamical as the result of quantum effects in the system of heavy constituents of the underlying theory. The black hole entropy is related to the properties of the vacuum in the induced gravity in the presence of the horizon. The authors obtain the Bekenstein-Hawking entropy by direct counting of the states of the constituents.

15. Can One Observe Large Quantum Gravity Effects? - by Rodolfo Gambini[*] and Jorge Pullin[+], [*]Instituto de Física, Facultad de Ciencias, Tristan Narvaja 1674, Montevideo, Uruguay; [+]Center for Gravitational Physics and Geometry, Department of Physics, 104 Davey Lab, The Pennsylvania State University, University Park, PA 16802.

Abstract - The authors reexamine the large quantum gravity effects discovered by Ashtekar in the context of 2 + 1 dimensional gravity coupled to matter. They study an alternative one-parameter family of coherent states of the theory in which the large quantum gravity effects on the metric can be diminished, at the expense of losing coherence in the matter sector. Which set of states is the one that occurs in nature will determine if the large quantum gravity effects are actually observable as wild fluctuations of the metric or rapid loss of coherence of matter fields.

16. Gravitational Theory without the Cosmological Constant Problem - by E. I. Guendelman and A. B. Kaganovich, Physics Department, Ben Gurion University, Beer Sheva, Israel.

Abstract - The authors develop a gravitational theory where the measure of integration in the action principle is not necessarily $(-G)^2$ but it is determined dynamically through additional degrees of freedom. This theory is based on the demand that such measure respects the principle of "non gravitating vacuum energy" which states that the Lagrangian density L can be changed to $L + constant$ without affecting the dynamics. Formulating the theory in the first order formalism, the authors get as a consequence of the variational principle a constraint that enforces the vanishing of the cosmological constant. The most realistic model that implements these ideas is realized in a six or higher dimensional space-time. The compactification of extra dimensions into a sphere gives the possibility of generating scalar masses and potentials, gauge fields and fermionic masses. It turns out that the remaining four dimensional space-time must have effective zero cosmological constant.

17. Geometric Foundation of the Magnetic Dipole Moment - by Richard T. Hammond, North Dakota State University, Physics Department, Fargo, ND 58105.

Abstract - The existence of the measured value of the magnetic dipole moment of an elementary particle is forbidden - that is, it is forbidden according to Maxwell's equations, the known upper bound on the size of the particle and the speed of light. In gravitation with an asymmetric connection, the intrinsic spin of an elementary particle gives rise to torsion. It is shown here that this source, spin, can also give rise to the observed magnetic dipole moment of the electron, and do so with no moving parts.

18. Getting Around Cosmic Variance - by Marc Kamionkowski[*] and Abraham Loeb[+], [*]Department of Physics, Columbia University, 538 West 120th Street, New York, NY 10027; [+]Astronomy Department, Harvard University, Cambridge, MA 02138.

Abstract - Cosmic microwave background (CMB) anisotropies probe the primordial density field at the edge of the observable Universe. There is a limiting precision ("cosmic variance") with which anisotropies can determine the amplitude of primordial mass fluctuations. This arises because the surface of last scatter (SLS) probes only a finite two-dimensional slice of the Universe. Probing other SLSs observed from different locations in the Universe would reduce the cosmic variance. In particular, the polarization of CMB photons scattered by the electron gas in a cluster of galaxies provides a measurement of the CMB quadrapole moment seen by the cluster. Therefore, CMB polarization measurements toward many clusters would probe the anisotropy on a variety of SLSs within the observable Universe, and hence reduce the cosmic-variance uncertainty.

19. Black Holes Really Are Black - by Andrew King, Astronomy Group, University of Leicester, Leicester, LE1 7RH, U.K.

Abstract - There is strong evidence that the compact stars in certain X-ray-emitting binary systems are black holes. Yet all of this evidence is necessarily circumstantial: our knowledge of stellar evolution does not offer us any alternative object with the mass and small size observed in these systems. The author describes recent work showing directly that the compact stars have the fundamental black hole property of lacking a stellar surface. For the mass inflow towards the compact star is known to be unstable, leading to very bright outbursts. If the central star had a surface, this would be hot, and the radiation from it would stabilize the inflow. The presence of outbursts thus tells us that the black holes in these systems really are black.

20. Gravity Generation of Electromagnetic Radiation and the Luminosity of Quasars - by David W. Kraft[*] and Lloyd Motz[+], [*]Division of Natural Sciences & Mathematics, University of Bridgeport, Bridgeport, CT 06601; [+]Department of Astronomy, Columbia University, New York, NY 10027.

Abstract - A mechanism is proposed for the emission of radiation by charged particles in a gravitational field whereby the gravitational field is coupled directly to the radiation field of the charge via the principle of equivalence. This leads to a Larmor formula for the electromagnetic power emitted by a charge at rest in a gravitational field, which can account for the total radiant energy and spectral distribution emitted by quasars. This gravitational mechanism for the emission of electromagnetic radiation becomes more important than any other mechanism when the radius of the quasar is near its Schwarzschild radius.

21. Gravity from Dirac Eigenvalues - by Giovanni Landi[*] and Carlo Rovelli[+], [*]Dipartimento Scienze Matematiche, Trieste University, Italia, and INFN, Napoli, Italia; [+]Physics Department, University of Pittsburgh, Pittsburgh, PA, and Center for Gravity and Geometry, The Pennsylvania State University, University Park, PA 16802.

Abstract - The eigenvalues of the Dirac operator on a curved spacetime are diffeomorphism invariant functions of the geometry. They form an infinite set of "observables" for general relativity and can be taken as variables for an invariant description of the gravitational field dynamics. The Poisson brackets of these eigenvalues are computed and expressed in terms of the energy-momentum of the eigenspinors and the propagator of the linearized Einstein equations. The eigenspinors' energy-momentum forms the Jacobian matrix of the change of coordinates from metric to eigenvalues. In order to eliminate a disturbingly huge cosmological term, a modification of the spectral action is considered. The corresponding equations of motion require that the energy momenta scale linearly: this scaling law yields the Einstein equations.

22. Campbell's Embedding Theorem - by James E. Lidsey[*], Carlos Romero[+] and Reza Tavako[*], [*]School of Mathematical Sciences, Queen Mary & Westfield College, Mile End Road, London E1 4NS, U.K.; [+]Departmento de Física, Universidade Federal da Paraíba, C. Postal 5008 - J. Pessoa - Pb, 58059-970, Brazil.

Abstract - A little known embedding theorem due to Campbell is discussed and employed to establish the local embedding of 4-dimensional gravitational and electromagnetic plane waves in 5-dimensional Ricci-flat spaces. In general, this theorem can be employed as a way of relating n-dimensional gravity to $(n + 1)$-dimensional vacuum theories.

23. An Application of the Topological Degree to Gravitational Lenses - by Marco Lombardi, Scuola Normale Speriore, I-56126 Pisa, Italy.

Abstract - In this paper the author provides a new proof of a general theorem on gravitational lenses, first proven by Burke (1981) for the special case of thin lenses. The theorem states that a transparent gravitational lens with non-singular mass distribution produces an odd number of images of a point source. The general proof shows that the topological degree finds natural and interesting applications in the theory of gravitational lenses. Since the first discovery of a gravitational lens with multiple images, the theory of gravitational lenses has developed at an impressive rate, while observations have shown a variety of cases where lensing occurs, from microlensing in the halo of our Galaxy to weak lensing of galaxies at very high redshifts. Gravitational lenses have now become a powerful tool in astronomy, especially in the cosmological context.

24. Infall of a Particle into a Black Hole as a Model for Gravitational Radiation from the Galactic Center - by Carlos O. Lousto, Department of Physics, University of Utah, Salt Lake City, UT 84112.

Abstract - The author presents here the results of the study of the gravitational radiation generated by the infall (from rest at radius r_0) of a point particle of mass m_0 into a Schwarzschild black hole of mass M. He uses Laplace's transform methods and finds that the spectra of radiation for $\sim 5M < r_0 < 4$ presents a series of evenly spaced bumps. The total radiated energy is not monotonically decreasing with r_0, but presents a *joroba* (hunch-back) at around $r_0 - 4.5M$. The author finally discusses the detectability of the gravitational radiation coming from the black hole in the center of our galaxy.

25. Origin of Structure in a Supersymmetric Quantum Universe - by P. Vargas Moniz, DAMTP, University of Cambridge, Silver Street, Cambridge, CB3 9EW, UK.

Abstract - This essay extends the current repertoire of quantum cosmological models to incorporate inhomogeneous field modes in a supersymmetric manner. In particular, the author introduces perturbations about a supersymmetric FRW model, by expanding scalar and fermionic fields in adequate harmonics on the spatial sections, taken to be three spheres. He treats the homogeneous and isotropic degrees of freedom exactly, and the others up to quartic order. Subsequently, the supersymmetry and Lorentz constraints are derived. These are sufficient and distinguish this method from others where supersymmetry is absent. Solutions for the perturbed model are then obtained. Among them one is identified which has properties typical of the no-boundary (Hartle-Hawking) proposal. This solution may lead to a scale-free spectrum of density perturbations. Other solutions are also found and discussed. The author believes that this essay may constitute a promising step in a valuable direction. Namely, where cosmological models are retrieved from supergravity theories. Hence, they may constitute improved methods of studying the cosmological features of a very early universe, improvements over using plain gravitational theories with matter fields but no supersymmetry.

26. Quantum Black Hole Physics from Quantum Kantowski-Sachs Solutions - by Octavio Obregón[*] and Michael P. Ryan, Jr.[+], [*]Instituto de Física, Universidad de Guanajuato, A. Postal E-143, León 37150 Guanajuato, México, México, and Universidad Autónoma Metropolitana-Iztapalapa, Departamento de Física, A. Postal 55-534, México, D.F., México; [+]Instituto de Ciencias Nucleares-UNAM, A. Postal 70-543, México 05249 D.F., México.

Abstract - The authors present a "dangerous" coordinate transformation that exchanges *t* and *r* (thus changing the light cone structure) in Kantowski-Sachs-type cosmological metrics. This allows the construction of "Schwarzschild-like" quantum solutions from known Kantowski-Sachs eigensolutions. Two static, spherically symmetric minisuperspace coherent states are constructed, one that represents a "vacuum" state, and another that represents a Planck-size quantum object that might possibly be considered a "black hole remnant"

27. Gravitation at the Mesoscopic Scale - by R. Onofrio[*] and L. Viola[+], [*]Dipartimento di Fisica "G. Galilei", Università di Padova, and INFN, Sezione di Padova, Via Marzolo 8, Padova, Italy 35131; [+]Department of Physics, Massachusetts Institute of Technology, 12-127, 77 Massachusetts Avenue, Cambridge, MA 02139.

Abstract - Free fall experiments are discussed by using test masses associated to quantum states not necessarily possessing a classical counterpart. The times of flight of the Galilean experiments using classical test masses are replaced in the quantum case by probability distributions which, although still not defined in an uncontroversial manner, become manifestly dependent upon the mass and the initial state. Such a dependence is also expected in non inertial frames of reference if the weak equivalence principle still holds. This last could be tested, merging recent achievements in mesoscopic physics, by using cooled atoms in free fall and accelerated frames initially prepared in nonclassical quantum states.

28. Testing Cosmic Censorship in Kerr-like Collapse Situations - by Wieslaw Rudnicki, Institute of Physics, University of Rzeszów, ul. Rejtana 16A, PL-35-310 Rzeszów, Poland.

Abstract - According to the cosmic censorship hypothesis put forward by Penrose, naked singularities should never occur in realistic collapse situations. One of the major open problems in this context is the existence of a naked singularity in the Kerr solution with $*a*>m$ - this singularity can be interpreted to be the final product of collapse of a rapidly rotating object. Based on certain very general and physically reasonable assumptions, and applying the global techniques, the author shows that a physically realistic gravitational collapse of any rotating object, which develops from a regular initial state in an asymptotically flat spacetime, can never lead to the formation of a final state resembling, in some well-defined sense, the Kerr solution with a naked singularity. This result gives a strong support to the validity of the cosmic censorship hypothesis.

29. Mass for the Graviton - by Matt Visser, Physics Department, Washington University, Saint Louis, MO 63130-4899.

Abstract - Can the graviton be given a mass? Does it even make sense to speak of a massive graviton? The author answers these questions in the affirmative. He outlines an alternative to Einstein Gravity that satisfies the Equivalence Principle and automatically passes all classical weak-field tests $(GM/r \sim 10^{-6})$. It also passes medium-field tests ($GM/r \sim 1/5$), but exhibits radically different strong-field behavior ($GM/r \sim 1$). Black holes in the usual sense do not exist in this theory, and large-scale cosmology is divorced from the distribution of matter. Furthermore, the cosmological constant is a non-issue in this theory. To do all this something must be sacrificed: the theory exhibits *prior geometry*, and depends on a non-dynamical background metric.

30. Neutrino Oscillations from Cosmic Sources: A Nu Window to Cosmology - by DJ Wagner and Thomas J. Weiler, Department of Physics and Astronomy, Vanderbilt University, Nashville, TN 37235.

Abstract - Neutrino astrophysics promises a wealth of information about neutrinos and the history of the universe through which they have traveled. The authors extend the standard neutrino oscillation discussion to neutrinos propagating through expanding curved space. This extension introduces a new cosmological parameter in the oscillation phase. The new parameter I records cosmic history in much the same manner as the red-shift variable z or the apparent luminosity distance D_L. Measuring I through neutrino oscillations may help determine cosmological parameters and distinguish between different cosmologies.

31. Quanta without Quantization - by James T. Wheeler, Department of Physics, Utah State University, Logan, UT 84322.

Abstract - The dimensional properties of fields in classical general relativity lead to a tangent tower structure which gives rise directly to quantum mechanical and quantum field theory structures without quantization. The author derives all of the fundamental elements of quantum mechanics from the tangent tower structure, including fundamental commutation relations, a Hilbert space of pure and mixed states, measurable expectation values, Schrödinger time evolution, "collapse" of a state and the probability interpretation. He derives the most central elements of string theory, including an operator valued mode expansion like that in string theory as well as the Virasoro algebra with central charges.

32. Quantum Black Hole - by Wu Zhong Chao, Specola Vaticana, Vatican City State, and Department of Physics, Beijing Normal University, Beijing, P.R. China.

Abstract - Creation of a black hole in quantum cosmology is the third way of black hole formation. In contrast to the gravitational collapse from a massive body in astrophysics or from the quantum fluctuation of matter fields in the very early universe, in the quantum cosmology scenario the black hole is essentially created from nothing. The black hole originates from a generalized gravitational instanton. The probability of creation for all kinds of single black holes in the Kerr-Newman family, at the semi-classical level, is the exponential of the total entropy of the universe, or one quarter of the sum of both the black hole and the cosmological horizon areas. The de Sitter spacetime is the most probable evolution at the Planckian era.