## Abstracts of Award Winning and Honorable Mention Essays for 1995

### Award Essays

First Award - The Value of Singularities - by Gary T. Horowitz[*] and Robert Myers[+], [*]Department of Physics, University of California, Santa Barbara, CA 93106; [+]Department of Physics, McGill University, Montréal, Québec, H3A-2T8 Canada.

Abstract - The authors point out that spacetime singularities play a useful role in gravitational theories by eliminating unphysical solutions. In particular, they argue that any modification of general relativity which is completely nonsingular cannot have a stable ground state. This argument applies both to classical extensions of general relativity and to candidate quantum theories of gravity.

Second Award - Are All Static Black Hole Solutions Spherically Symmetric? - by S. Alexander Ridgway and Erick J. Weinberg, Physics Department, Columbia University, New York, NY 10027.

Abstract - The static black hole solutions to the Einstein-Maxwell equations are all spherically symmetric, as are many of the recently discovered black hole solutions in theories of gravity coupled to other forms of matter. However, counterexamples demonstrating that static black holes need not to be spherically symmetric exist in theories, such as the standard electroweak model, with electrically charged massive vector fields. In such theories, a magnetically charged Reissner-Nordström solution with sufficiently small horizon radius is unstable against the development of a nonzero vector field outside the horizon. General arguments show that, for generic values of the magnetic charge, this field cannot be spherically symmetric. Explicit construction of the solution shows that it in fact has no rotational symmetry at all.

Third Award - Echoes of Gravity - by Douglas Scott and Martin White, Center for Particle Astrophysics and Department of Astronomy, University of California, Berkeley, CA 94720-7304.

Abstract - The study of anisotropies in the Cosmic Microwave Background radiation is progressing at a phenomenal rate, both experimentally and theoretically. These anisotropies can teach us an enormous amount about the way that fluctuations were generated and the way they are subsequently evolved into the clustered galaxies which are observed today. In particular, on sub-degree scales the rich structure in the anisotropy spectrum is the consequence of gravity-driven acoustic oscillations occurring before the matter in the universe became neutral. The frozen-in phases of these sound waves imprint a dependence on many cosmological parameters, that astrophysicists may be on the verge of extracting.

Fourth Award - Another Glance at the Rainbow - by Pisin Chen, Stanford Linear Accelerator Center, Stanford University, Stanford, CA 94309.

Abstract - Inflationary cosmology predicts the generation of both density perturbation and relic gravitons. Tests of these predictions, especially the relic gravitons, will be very crucial to the verification of inflation. Efforts have been made to distinguish different inflation models using observed anisotropies of the cosmic microwave background radiation. However, the fact that both scalar and tensor modes contribute to the Sachs-Wolfe effect renders such determination difficult. The author points out that, mediated by the primordial magnetic field, the relic gravitons can resonantly convert into photons at the same frequencies. A measurement of the spectrum of these long wavelength EM waves can help to determine the power law index directly, which will distinguish different inflationary models. This opens up a new window for another glance at "gravity's rainbow".

Fifth Award - The Cosmological Constant is Back - by Lawrence M. Krauss[*] and Michael S. Turner[+], [*]Departments of Physics and Astronomy, Case Western Reserve University, Cleveland, OH 44106-7079; [+]Departments of Physics and of Astronomy and Astrophysics, Enrico Fermi Institute, The University of Chicago, Chicago, IL 60637-1433, NASA/Fermilab Astrophysics Center, Fermi National Accelerator Laboratory, Batavia, IL 60510-0500.

Abstract - A diverse set of observations now compellingly suggest that the Universe possesses a nonzero cosmological constant. In the context of quantum-field theory a cosmological constant corresponds to the energy density of the vacuum, and the wanted value for the cosmological constant corresponds to a very tiny vacuum energy density. The authors discuss future observational tests for a cosmological constant as well as the fundamental theoretical challenges - and opportunities - that this poses for particle physics and for extending our understanding of the evolution of the universe back to the earliest moments of the Big Bang.

1. Quantum Equivalence Principle and the Cosmic String - by J. Anandan, Department of Theoretical Physics, University of Oxford, 1 Keble Road, Oxford OX1 3NP, UK.

Abstract - A quantum equivalence principle is formulated by means of a gravitational phase operator which is an element of the Poincaré group. This is applied to the spinning cosmic string which suggests that it may contain gravitational torsion. A new exact solution of the Einstein-Cartan-Sciama-Kibble equations for the gravitational field with torsion is obtained everywhere for a cosmic string with uniform energy density, spin density and flux. A novel effect due to the quantized gravitational field of the cosmic string is used to show that spacetime points are not meaningful in quantum gravity.

2. Topology Change and Quantum Physics - by A.P. Balachandran[*], G. Bimonte[+#], G. Marmo[#%], and A. Simoni[#%] [*]Department of Physics, Syracuse University, Syracuse, NY 13244-1130; [+]International Centre for Theoretical Physics, P.O. Box 586, I-34100, Trieste, Italy; [#]INFN, Sezione di Napoli, Napoli, Italy; [%]Dipartimento di Scienze Fisiche, Università di Napoli, Mostra d'Oltremare, Pad. 19, I-80125, Napoli, Italy.

Abstract - The authors argue that attributes of classical spatial topology emerge from properties of state vectors with suitably smooth time evolution or, equivalently, from considerations on the domain of the quantum Hamiltonian. The latter is often specified by boundary conditions. Examples exist where classical topology is changed by smoothly altering this domain. When the parameters labeling the latter are treated as quantum variables, quantum states need not give a well-defined classical topology, but rather a superposition of such topologies. Using these results and existing arguments indicating the necessity of topology change in quantum gravity, it is suggested that Einstein gravity and its minor variants are effective theories of a deeper description with additional novel degrees of freedom. Other reasons for suspecting such a microstructure are also summarized.

3. How Anisotropic Can a Universe Be? - by John D. Barrow, Astronomy Centre, University of Sussex, Brighton BN1 9QH, UK.

Abstract - A solution is given to the problem of why the Universe is isotropic. No appeal to a period of inflationary expansion is required. It is shown that a physically natural boundary condition, for which the energy density residing in anisotropic modes of distortion must be of similar magnitude to that in isotropic forms of radiation at the Planck time, allows the present microwave background anisotropy arising from homogeneous anisotropies to be calculated exactly. By finding the most general evolution law for the anisotropies, including the effects of curvature anisotropies and collisionless particles, the predicted maximum level of microwave background temperature anisotropy lies between $8 \times 10^{-7}$ and $3 \times 10^{-5}$, depending upon the value of $\Omega_o$ and the last scattering redshift. An extension of this argument to include inhomogeneities is proposed.

4. String Theory and Cosmology - by M.C. Bento[*] and O. Bertolami[+], [*]CERN, Theory Division, CH-1211 Geneva 23, Switzerland; [+]INFN-Sezione Torino, Via Pietro Giuria 1, I-10125 Turin, Italy.

Abstract - String theory is expected to account for particle phenomenology at energies below the Planck scale and give rise to a consistent cosmological scenario. It is hence required that string low-energy models naturally generate inflation and that they are free from the cosmological constant and Polonyi problems. However, none of supersymmetry breaking mechanisms proposed so far, based on the condensation of gauginos, seem to be able to generate an inflationary potential for the dilaton; moreover, no workable mechanism has yet been put forward to explain the vanishing of the cosmological constant. In this essay the authors assume that supersymmetry is broken by a mechanism other than gaugino condensation and that a mass term for the dilaton is thus generated which dominates the dilaton potential. They consider the cosmological framework based on the lowest order string effective Lagrangian with homogeneous and isotropic field configurations for the dilaton, graviton and Yang-Mills fields and including string-loop effects. They show that inflationary chaotic-type solutions can be obtained and describe a mechanism that may provide a solution for the Polonyi problem by transferring the dilaton energy into coherent classical oscillations of Yang-Mills fields. They also present some ideas concerning the problem of the cosmological constant.

5. Factorization of Topology Changing Amplitudes in the Regge Calculus Approach to Quantum Cosmology -by Danny Birmingham, Universiteit van Amsterdam, Instituut voor Theoretische Fysica, Valckenierstraat 65, 1018 XE Amsterdam, The Netherlands.

Abstract - The author studies the form of topology changing amplitudes within the Regge calculus approach to four dimensional gravity. The four dimensional simplicial complex is chosen to be a cone over the disjoint union of a number of topologically distinct lens spaces. By restricting attention to a simplicial minisuperspace, the analytic properties of the Regge action can be identified explicitly. The classical extrema and convergent steepest descent contours defining these amplitudes are determined and a factorization property is established. In the cases studied, the author finds ground state wave functions which predict Lorentzian oscillatory behaviour in the late universe.

6. Initial Singularities in Inflationary Cosmology - by Arvind Borde and Alexander Vilenkin, Institute of Cosmology, Department of Physics and Astronomy, Tufts University, Medford, MA 02155.

Abstract - Inflation is known to be generically future-eternal. So it is natural to ask if inflationary models can be continued into the infinite past in a non-singular way. The authors show here that they cannot; inflationary models must, in general, have initial singularities. This means that inflation cannot be used as a way of avoiding the question of the birth of the Universe.

7. Possible Common Origin of Primordial Perturbations and of the Cosmic Microwave Background - by R. Brustein[*], M. Gasperini[+], and M. Giovannini[+#], [*]Department of Physics, Ben-Gurion University, Beer-Sheva 84105, Israel; [+]Dipartimento di Fisica Teorica, Via P. Giuria 1, 10125 Turin, Italy; [#]Theory Division, CERN, CH-1211, Geneva 23, Switzerland.

Abstract - The cosmic black-body radiation and the primordial density perturbations could have been produced by the same gravitational mechanism - a background transition from inflation to standard decelerated evolution - provided such a transition occurred at a Planckian curvature scale, and the primordial perturbation spectrum grows fast enough with frequency. Both conditions can be naturally implemented in inflationary scenarios based on the low-energy string effective action.

8. Torsion Intrinsic Spin Effects and Magnetic Inclination of the Binary Pulsar - by Zhang Chengmin[*+], L.C. Garcia de Andrade[#], Wu Xinji[*%], and Yang Guochen[*+], [*]CCAST (World Lab), P.O. Box 8730, Beijing-100080, P.R. China; [+]Box 146, Department of Physics, Hebei Institute of Technology, Tianjin-300130, P.R. China; [#]Departmento de Fisica, UERJ, Rua Sao Francisco, Xavier-524-Maracana-20550-RJ-Brasil; [%]Department of Geophysics, Peking University, Beijing-100080, P.R. China.

Abstract - New possible indirect evidence for torsion is proposed based on the interaction between torsion and Dirac spin. The interaction may explain the evolution of the magnetic field of the binary pulsars.

9. Probing the Cosmological Constant - by F.I. Cooperstock and V. Faraoni, Department of Physics and Astronomy, University of Victoria, P.O. Box 3055, Victoria, B.C. V8W 3P6 Canada.

Abstract - The cosmological constant in the Einstein equations has re-emerged with vital importance as a potential source for the "missing mass" in the universe and to necessarily carry a contribution from the zero-point energies of the normal modes of quantum fields. The tight observational constraints have been deemed the great current crisis of physics. The authors consider gravitational waves as perturbations of a spacetime with a cosmological constant and find that the trace $h$ of the perturbations cannot be eliminated by any infinitesimal coordinate transformation. Also, for positive cosmological constant, the propagation equation for $h$ reveals that the associated spin 0 particle is tachyonic and is intrinsically coupled to the spin 2 graviton. Thus, assuming that no real particle is tachyonic, the authors conclude that the cosmological constant is zero.

10. Getting the Measure of the Flatness Problem - by Guillaume Evrard[*+] and Peter Coles[+], [*]Groupe de Recherche en Astronomie et Astrophysique du Languedoc, URA 1368 CNRS/Montpellier II, c.c. 072, Université Montpellier II, place Eugène Bataillon, F-34095 Montpellier Cedex 05, France; [+]Astronomy Unit, School of Mathematical Sciences, Queen Mary and Westfield College, Mile End Road, London E1 4NS, UK.

Abstract - The problem of estimating cosmological parameters such as $\Omega$ from noisy or incomplete data is an example of an inverse problem and, as such, generally requires a probabilistic approach. The authors adopt the Bayesian interpretation of probability for such problems and stress the connection between probability and information which this approach makes explicit. This connection is important even when information is "minimal" or, in other words, when it is necessary to argue from a state of maximum ignorance. The authors use the transformation group method of Jaynes to assign minimally-informative prior probability measure for cosmological parameters in the simple example of a dust Friedman model, showing that the usual statements of the cosmological flatness problem are based on an inappropriate choice of prior. The authors further demonstrate that, in the framework of a classical cosmological model, there is no flatness problem.

11. Quantum Conformal Superspace - by Arthur E. Fischer[*] and Vincent Moncrief[+], [*]Department of Mathematics, University of California, Santa Cruz, CA 95064; [+]Departments of Mathematics and Physics, Yale University, New Haven, CT 06511.

Abstract - The problem that the authors are concerned with in this paper is the structure of superspace and conformal superspace when the underlying manifold $M$ is compact and has degree of symmetry zero. Their results are applicable to questions involving the problem of the *reduction of Einstein's vacuum equations* and to problems involving quantization of the gravitational field. The problem of reduction involves writing Einstein's vacuum equations as an *unconstrained* dynamical system where the variables are the *true degrees of freedom* of the gravitational field, and where the Hamiltonian is the *true* or *reduced* Hamiltonian of the dynamical degrees of freedom. In turn, reduction is necessary in the ADM approach to canonical quantization, inasmuch as in that approach it is necessary to eliminate all the constraints before quantizing. In this essay, the authors are interested in the structure of the configuration spaces that arise in these theories.

12. The Canonical Superenergy Tensors in General Relativity - by Janusz Garecki, Institute of Physics, University of Szczecin, Wielkopolska 15, 70-451 Szczecin, Poland.

Abstract - In the essay, the author presents a concept of the superenergy tensors in the framework of the General Relativity (GR). These tensors were introduced constructively by the author years ago and they were obtained by a suitable averaging of the energy-momentum tensors or pseudotensors. Because in GR the Einstein canonical energy-momentum pseudotensor ${}_Et_i^k$ of the gravitational field and the canonical energy-momentum complex ${}_EK_i^k = \sqrt{g}\,/(T_i^k + {}_Et_i^k)$, matter and gravitation, *are physically distinguished*, the author has confined in the essay to the *canonical superenergy tensor* ${}^gS_i^k$ of the gravitational field $\Gamma_{kl}^i$ and to the canonical total superenergy tensor $S_i^k = {}^gS_i^k + {}^mS_i^k$ of matter and gravitation only. These superenergy tensors can be obtained by the above mentioned averaging of the pseudotensor ${}_Et_i^k$ and complex ${}_EK_i^k$. In the essay, the author gives the analytic forms of these two canonical superenergy tensors and shows some of their possible applications in GR. In the author's opinion, the canonical superenergy tensor ${}^gS_i^k$ of the gravitational field $\Gamma_{kl}^i$ can be used as a *substitute* for the non-existing energy-momentum tensor of this field.

13. Gravitation, Torsion, and String Theory - by Richard Hammond, North Dakota State University, Physics Department, Fargo, ND 58105.

Abstract - The low energy effective Lagrangian of string theory presents us with, not only gravity, but the dilaton and the antisymmetric field as well. In this essay, it is shown that gravitation with torsion that is derived as the exterior derivative of a potential is equivalent to the low energy string theory Lagrangian in the case of a constant dilaton. A generalization of this theory is equivalent to the full low energy Lagrangian if the gravitational constant is assumed to be a scalar function. This gives all the fields a physical interpretation in four dimensions and provides an indication that the dilaton represents *small* corrections to general relativity at large distances.

14. Positive-Frequency Fields in Curved Space-Time - by Adam D. Helfer, Department of Mathematics, University of Missouri, Columbia, MO 65211.

Abstract - Attempts to construct quantum field theories in curved space-time have been balked by the lack of a satisfactory definition of positive-frequency fields: it has not been possible in any generality to specify the Hilbert space of the theory. Here a proposal is given for the definition of massless positive-frequency fields, and hence of quantum particles, in curved space-time. This results in general-relativistic corrections to the quantization of fields, whose effects might be measurable in the near future by an instrument like LIGO.

15. Thermodynamics of Spacetime: The Einstein Equation of State - by Ted Jacobson, University of Maryland, College Park, MD 20742-4111.

Abstract - The four laws of black hole mechanics, analogous to those of thermodynamics, were originally derived from the classical Einstein equation. With the discovery of the quantum Hawking radiation, it became clear that the analogy is in fact an identity. How did classical General Relativity know that horizon area would turn out to be a form of entropy, and that surface gravity is a temperature? In this essay the author answers that question by turning the logic around and deriving the Einstein equation from the form of black hole entropy together with the fundamental relation $\delta Q = TdS$ connecting heat $Q$ entropy $S$ and temperature $T$. Viewed this way, the Einstein equation is an equation of state. It is born in the thermodynamic limit as a relation between thermodynamic variables, and its validity is seen to depend on the existence of local equilibrium conditions. As such there is no reason to think the gravitational field equations should be quantized, i.e., promoted to operator relations.

16. Non-Stationary Generalization of the Kerr-Newman Metric - by Jiliang Jing and Yongjiu Wang, Institute of Physics and Physics Department, Hunan Normal University, Changsha, Hunan 410081, The People's Republic of China.

Abstract - A new metric depending on three arbitrary parameters is presented by the method of complex coordinate transformations. It gives a gravitational field of a radiating rotating charged body. The metric is algebraically special of Petrov type II according to classification of the Weyl tensor with a twisting, shear-free, null congruence identical to that of the Kerr-Newman metric. The new metric bears the same relation to the Kerr-Newman metric as does generalized Kerr metric (for a radiating rotating body) to the Kerr metric. The energy-momentum tensor in the present case, however, can be divided into three parts, the first part is the energy-momentum tensor of the electromagnetic field which is equal to that of the Kerr-Newman metric, the second one describes a Bonnor-Vaidya type radiative field, and the third one is a residual contribution. Due to the presence of the residual term in this case, however, the energy-momentum tensor becomes Bonner-Vaidya-like asymptotically only.

17. A Cauchy Horizon Stability Conjecture - by D.A. Konkowski[*] and T.M. Helliwell[+], [*]School of Mathematical Sciences, Queen Mary and Westfield College, University of London, Mile End Road, London, E1 4NS, UK, and Department of Mathematics, U.S. Naval Academy, Annapolis, MD 21402; [+]Department of Physics, Harvey Mudd College, Claremont, CA 91711.

Abstract - A stability conjecture for Cauchy horizons is presented. The conjecture predicts the stability of Cauchy horizons based upon the behavior of test-fields, and in the case of instability it also predicts the nature of the singularities produced. Cauchy horizons in Reissner-Nordström, Kerr, and anti-de Sitter spacetimes are considered for a variety of test fields. The predictions of the conjecture are compared with the results of exact back-reaction calculations for several different field configurations. In each case the prediction agrees with the exact solution.

18. The Gravitational Redshift in a Local Freely-Falling Frame: A New Null Test of the Equivalence Principle - by Timothy P. Krisher, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109.

Abstract - The author considers the gravitational redshift effect measured by an observer in a local freely falling frame (LFFF) in the gravitational field of a massive body. For purely metric theories of gravity, the metric in a LFFF is expected to differ from that of flat spacetime by only "tidal" terms of order $(GM/c^2R)(r'/R)^2$, where R is the distance of the observer from the massive body, and r′ is the coordinate separation relative to the origin of the LFFF. A simple derivation shows that a violation of the Equivalence Principle for certain types of "clocks" could lead to a larger apparent redshift effect of order $(1 - \alpha)(GM/c^2R)(r'/R)$, where $\alpha$ parameterizes the violation ( $\alpha = 1$ for purely metric theories, such as general relativity). Therefore, redshift experiments in a LFFF with separated clocks can provide a new null test of the Equivalence Principle. With presently available technology, it is possible to reach an accuracy of 0.01% in the gravitational field of the Sun using an atomic clock orbiting the Earth. A 1% test in the gravitational field of the galaxy would be possible if an atomic frequency standard were flown on a space mission to the outer solar system.

19. Quantum Cosmology on the Line - by James E. Lidsey, Astronomy Unit, School of Mathematical Sciences, Queen Mary & Westfield, Mile End Road, London, E1 4NS, UK.

Abstract - The quantum cosmology of a generalized class of two-dimensional dialton-gravity models is investigated. A supersymmetric extension of the string-inspired cosmology is performed at the quantum level. The third-quantization procedure is also applied to a wide class of two dimensional models.

20. Membrane Effective Model for Quantum Black Holes - by Carlos O. Lousto, IFAE-Grupo de Física Teórica, Universidad Autónoma de Barcelona, E-08193 Bellaterra (Barcelona), Spain.

Abstract - The author studies the proposal of representing a quantized black hole by a relativistic membrane. From the point of view of a fiducial observer at infinity the black hole's quantum degrees of freedom can be considered as localized on the "stretched" horizon. Consistently, for the first order fluctuations of the membrane's radial coordinate in the curved background of a black hole, the author obtains a massive Klein-Gordon equation in the 2+1 dimensional world-volume coordinates. Quantization of these fluctuations leads to a discrete black hole mass spectrum and to one-loop corrections to the thermodynamical entropy.

21. Is There a Problem with Quantum Wormhole States in N=1 Supergravity? - by P.V. Moniz, Department of Applied Mathematics and Theoretical Physics, University of Cambridge, Silver Street, Cambridge, CB3 9EW, UK.

Abstract - The issue concerning the existence of wormhole states in locally supersymmetric minisuperspace models is addressed. Wormhole states are apparently absent in models obtained from the more general theory of N=1 supergravity with supermatter. The possible causes are investigated in this essay. The author theorizes that the solution for this problem requires supersymmetric quantum wormholes to be invested with a Hilbert space structure associated with a maximal analytical extension of the corresponding minisuperspace.

22. Gravitational and Electroweak Unification - by Dave Pandres, Jr., Department of Mathematics and Computer Science, North Georgia College, Dahlonega, GA 30597.

Abstract - Schrödinger considered the simplest general relativistic variational principle that exists, i.e., $\delta\int\sqrt{-g}\,d^4x = 0$, where $g$ is the determinant of the space-time metric $g_{\mu\nu}$. He noted that if one varies $g_{\mu\nu}$, one obtains Euler-Lagrange equations which suffer from the difficulty that they cannot serve as field equations. This difficulty persists if one writes $g_{\mu\nu} = g_{ij}h^i_\mu h^j_\nu$, where $g_{ij} = diag\,(-1,1,1,1)$, and varies the $h^i_\mu$. If, however, one expresses the $h^i_\mu$ as derivatives $\kappa^i_{,\mu}$ of "nonintegrable functions" $\kappa^i$, one obtains field equations that imply the validity of Einstein's equations for general relativity with a Yang-Mills stress-energy tensor that is just what one expects for the electroweak field (with massive quanta) and associated currents.

23. Is There a Connection Between No-hair Behavior and Universality in Gravitational Collapse? - by Jorge Pullin, Center for Gravitational Physics and Geometry, Department of Physics, 104 Davey Lab, The Pennsylvania State University, University Park, PA 16802.

Abstract - The author applies linear perturbation theory to the study of the universality and criticality first observed by Choptuik in gravitational collapse. Since these are essentially nonlinear phenomena this approach provides a rough approximation. In spite of this, universal behavior of the final black hole mass is observed with an exponent only slightly higher than the observed value of 0.367. The universal behavior is based on the unique form that in-falling perturbations on black holes have at the horizon.

24. Can We Compute Transition Amplitudes in Quantum Gravity? - by Carlo Rovelli, Department of Physics, University of Pittsburgh, PA 15260.

Abstract - The author studies how physical diffeomorophism invariant transition amplitudes could be defined and computed in a generally covariant quantum field theory. The theory he considers describes the gravitational field and a minimally coupled scalar field; it is based on the loop representation, and on a certain number of quanitization choices. Four-dimensional diffeomorphism-invariant quantum transition probabilities can be computed from the theory. The author presents the explicit calculation of the transition probability between two volume eigenstates as an example.

25. The Nature of Cosmic Time - by D.S. Salopek, Department of Physics, University of Alberta, Edmonton, Canada T6G 2J1.

Abstract - Hamilton-Jacobi theory provides a natural starting point for a covariant description of the gravitational field. Using a spatial gradient expansion, one may solve for the phase of the wavefunction by using a line-integral in superspace. Each contour of integration corresponds to a particular choice of time-hypersurface, and each yields the same answer. In this way, one can describe all time choices simultaneously. In an interesting application to cosmology, the author computes large-angle microwave background anisotropies and the galaxy-galaxy correlation function associated with the scalar and tensor fluctuations of power-law inflation.

26. String Theory and a Microscopic Basis for Black Hole Entropy - by C. Sivaram, IInd Block, Kor Amangala, Bangalore 560034, India.

Abstract - Connection is made with gravity of string theory in discussing the paradox of information loss in black holes. The nature of the microstates associated with the tremendous entropy when an object collapses to a black hole is obscure, unlike in other physical contexts where statistical mechanical entropy counts the number of accessible microstates. It is pointed out that the striking similarity between the huge number of microstates implied by the black hole entropy on the one hand and the exponentially rising degeneracy of string modes (currently invoked in superstring theories) rising with mass, does indeed provide such microscopic basis. Other striking analogies between strings and black holes are pointed out and in particular the information diffusion time for an outside observer is shown to be proportional to the cube of the hole mass.

27. A Model for Baryogenesis at Reheating - by I. Damião Soares, Centro Brasileiro de Pesquisas Físicas - CPBF/CNPq, Rua Dr. Xavier Sigaud, 150, 22290-180 - Rio de Janeiro, RJ - Brazil.

Abstract - By using transformation properties of the Hamiltonian of homogeneous and isotropic cosmologies, the author derives a model describing the transition of the universe from the inflationary phase into the radiation-dominated phase, during the process of reheating. The baryon excess produced in the transition is in a fixed ratio to the radiation content of the radiation-dominated phase. He derives an expression for the baryon asymmetry $n_B/n_\gamma$ as a function of known thermodynamic constants, the gravitational constant, the radius of the present universe and the present temperature of the cosmic background radiation. The only parameter in the formula is the total number of (massless) degrees of freedom of relativistic particles composing the radiation density. He obtains $n_B/n_\gamma \sim 5.49 \times 10^{-10}$. Further physical consequences are discussed.

28. Time, Causality Preservation and Gravity - by C.S. Unnikrishnan, Gravitation Experiments Group, Tata Institute of Fundamental Research, Homi Bhabha Road, Bombay- 400 005, India.

Abstract - Fundamental laws of physics are expected to be invariant under the CPT symmetry and except for a small violation in the decay of K-mesons they are also found to be invariant under Time reversal. The macroscopic arrows of time are thought to originate from coarse graining of processes where many degrees of freedom are involved. One remaining question is the microscopic physical basis for the preservation of time ordering of events: Given a time sequence of events, the time ordering of this sequence is preserved with respect to all observers. This is equivalent to the observation that there are no closed time-like curves. The author explores this aspect of time and proposes a fundamental reason for this. The main finding is that it is the positivity of energy which preserves the one-way flow of time and this is obtained by directly linking two facts we know - 1) Local energy is the generator of translations in time, 2) energy density is positive as measured by a local observer. Therefore if the generator is constrained to have only one sign then the corresponding translation necessarily has to be in the time direction. This is supported by several examples where the existence of closed time-like curves and time travel is linked to the existence of negative energy density of superluminal motion giving rise to negative energy density. The author also makes the important observation that in situations like the Casimir effect there is no time reversal in this sense though the energy density is negative. But there is one situation, though not directly linked to gravity where such ideas have some experimental support. The author discusses these examples involving tunneling of particles and also discusses an experiment to test some of these ideas.

29. The Inflaton Field - by Mian Wang, Department of Physics, Henan Normal University, Xinxiang, Henan, China 453002.

Abstract - The tensor-scalar theory of gravity is used to describe the early universe and the gravitational scalar $\varphi$ is ascribed to play the role of inflaton. The theory is specified by the chosen coupling function $\omega(\varphi)$ and the cosmological function $\lambda(\varphi)$. The function $\lambda(\varphi)$ is nearly constant for $0 < \varphi < 0.01$ and $\lambda(1) = 0$. The functions $\lambda(\varphi)$ and $\omega(\varphi)$ provide a double-well potential for the motion of $\varphi(t)$. Inflation commences and ends naturally. The temperature at the end of inflation is of the order of $10^{14}$ GeV, the magnetic monopoles would have been dashed away if any. The density perturbations result in a $n_3 = 0.67$ nonflat power spectrum

30. Quenching the Hawking Radiation with a Uniform Acceleration of the Black Hole - by Piljin Yi, Physics Department, Columbia University, New York, NY 10027.

Abstract - It is demonstrated that a uniform acceleration can stabilize certain charged black holes against Hawking's quantum evaporation process. As seen by the co-moving observers, the acceleration introduces a heat bath of finite size that balances Hawking radiation exactly. To freely falling observers, on the other hand, neither the heat bath nor the black hole radiance is observable. Thus, all observers agree that the black hole in question becomes stable quantum mechanically, despite the nonzero Hawking temperature. It is also argued that this effect simply shifts the final ground state from the extremal to the appropriate near-extremal variety of the charged black hole and does not cause runaway behavior.

31. Can a Relativistic Gravity Theory Resolve the Mystery of the Galactic Observations? - by Vadim V. Zhytnikov[*] and James M. Nester[+], [*]Physics Department, Faculty of Mathematics, Moscow State Pedagogical University, Davydovskii per. 4, Moscow 107140 Russia; [+]Department of Physics, National Central University, Chung-Li, Taiwan 32054, R.O.C.

Abstract - The authors compare the predictions of a large class of relativistic gravity theories with various observations: the Newtonian limit, light deflection and retardation, the rotation of galaxies, galactic gravitational lensing and the equivalence principle tests. The general conclusion is that is seems to be rather unlikely that, without a radical change in fundamental principles, a satisfactory alternate gravity theory can be constructed which can explain the dynamical behavior of galaxies without dark matter.