Abstracts of Award Winning and Honorable Mention Essays for 1999

Award Essays

First Award - Search for Quantum Gravity - by John Ellis[*], N.E. Mavromatos[+] and D.V. Nanopoulos[#], [*]CERN, Theory Division, CH-1211 Geneva 23, Switzerland; [+]University of Oxford, Department of Physics, Theoretical Physics, 1 Keble Road, Oxford OX1 3NP, U.K.; [#]Center for Theoretical Physics, Department of Physics, Texas A&M University, College Station, TX 77843-4242, Astroparticle Physics Group, Houston Advanced Research Center (HARC), The Mitchell Campus, The Woodlands, TX 77381, Academy of Athens, Chair of Theoretical Physics, Division of Natural Sciences, 28 Panepistimiou Ave., Athens GR-10679, Greece.

Abstract - A satisfactory theory of quantum gravity may necessitate a drastic modification of our perception of space-time, by giving it a foamy structure at distances comparable to the Planck length. It is argued in this essay that the experimental detection of such structures may be a realistic possibility in the foreseeable future. After a brief review of different theoretical approaches to quantum gravity and the relationships between them, the authors discuss various possible experimental tests of the quantum nature of space-time. Observations of photons from distant astrophysical sources such as Gamma-Ray Bursters and laboratory experiments on neutral kaon decays may be sensitive to quantum-gravitational effects if they are only minimally suppressed. Experimental limits from the Whipple Observatory and the CPLEAR Collaboration are already probing close to the Planck scale, and significant increases in sensitivity are feasible.

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

Abstract - The recognition that the cosmological constant may be non-zero forces us to reevaluate standard notions about the connection between geometry and the fate of our Universe. An open Universe can recollapse, and a closed Universe can expand forever. As a corollary, the authors point out that there is no set of cosmological observations we can perform that will unambiguously allow us to determine what the ultimate destiny of the Universe will be.

Third Award - Compactification, Vacuum Energy and Quintessence - by M.C. Bento and O. Bertolami, Instituto Superior Técnico, Departamento de Física, Av. Rovisco Pais 1, 1096 Lisboa Codex, Portugal.

Abstract - The authors study the possibility that the vacuum energy density of scalar and internal-space gauge fields arising from the process of dimensional reduction of higher dimensional gravity theories plays the role of quintessence. They show that, for the multidimensional Einstein-Yang-Mills system compactified on a $\mathbf{R} \times S^3 \times S^d$ topology, there are classically stable solutions such that the observed accelerated expansion of the Universe at present can be accounted for without upsetting structure formation scenarios or violating observational bounds on the vacuum energy density.

Fourth Award - Quantum Gravity Experimental Physics? - by Rodolfo Gambini[*] and Jorge Pullin[+], [*]Instituto de Física, Facultad de Ciencias, Iguá 4225, esq. Mataojo, Montevideo, Uruguay; [+]Center for Gravitational Physics and Geometry, Department of Physics, The Pennsylvania State University, 104 Davey Lab, University Park, PA 16802.

Abstract - Canonical quantum gravity theories predict a polymer-like structure for space time at the Planck size. This granularity can be probed using gamma ray burst observations. Quantum gravity effects typically amount to corrections of Planck length size per wavelength. Because the distance to gamma ray burst is very large as measured in the wavelength of gamma rays, the effects accumulate and are on the brink of being observable. These observations can constrain certain aspects of the quantum state underlying out universe.

Fifth Award - Gravitation, the Quantum, and Bohr's Correspondence Principle - by Shahar Hod, The Racah Institute for Physics, The Hebrew University, Jerusalem 91904, Israel.

Abstract - The black hole combines in some sense both the "hydrogen atom" and the "black-body radiation" problems of quantum gravity. This analogy suggests that black-hole quantization may be the key to a quantum theory of gravity. During the last twenty-five years evidence has been mounting that black-hole surface area is indeed *quantized*, with *uniformly* spaced area eigenvalues. There is, however, no general agreement on the *spacing* of the levels. In this essay we use Bohr's correspondence principle to provide this missing link. We conclude that the fundamental area unit is $4\hbar \ln 3$. This is the unique spacing consistent both with the area-entropy *thermodynamic* relation for black holes, with Boltzmann-Einstein formula in *statistical physics* and with *Bohr's correspondence principle.*

Honorable Mention Awards (Alphabetical Order)

1. On Gravity and the Uncertainty Principle - by Ronald J. Adler and David I. Santiago, Gravity Probe B, W.W. Hansen Experimental Physics Laboratory and Department of Physics, Stanford University, Stanford, CA, 94312.

Abstract - Heisenberg showed in the early days of quantum theory that the uncertainty principle follows as a direct consequence of the quantization of electromagnetic radiation in the form of photons. As the authors show here the gravitational interaction of the photon and the particle being observed modifies the uncertainty principle with an additional term. From the modified or gravitational uncertainty principle it follows that there is an absolute minimum uncertainty in the position of any particle, of order of the Planck length. A modified uncertainty relation of this form is a standard result of superstring theory, but the derivation given here is based on simpler and rather general considerations with either Newtonian gravitational theory or general relativity theory.

2. Quantum Nature of Black-Hole Spacetime - by D.V. Ahluwalia, Escuela de Fisica, Univ. Aut. de Zacatecas, Apartado Postal C-580, Zacatecas, ZAC 98068, Mexico.

Abstract - Atoms and the planets acquire their stability from the quantum mechanical incompatibility of the position and momentum measurements. This incompatibility is expressed by the fundamental commutator $[x, p_x] = i\hbar$, or equivalently, via the Heisenberg's uncertainty principle $\Delta x \Delta p_x \sim \hbar$. A further stability-related phenomenon where the quantum realm plays a dramatic role is the collapse of certain stars into white dwarfs and neutron stars. Here, an intervention of the Pauli exclusion principle, via the fermionic degenerate pressure, stops the gravitational collapse. However, by the neutron-star stage the standard quantum realm runs dry. One is left with the problematic collapse of a black hole. This essay is devoted to a concrete argument on why the black-hole spacetime itself should exhibit a quantum nature. The proposed quantum aspect of spacetime is shown to prevent the general-relativistic dictated problematic collapse. The quantum nature of black-hole spacetime is deciphered from a recent result on the universal equal-area spacing $[= \lambda^2_P\, 4\ln(3)]$ for black holes. It is shown that astrophysical black holes can fluctuate to $[\pi/\ln(3)]^{1/2}$ ($\approx$1.7) times their classical size, and thus allow radiation and matter to escape to the outside observers. These fluctuations the author conjectures provide a new source, beyond Hawking radiation, of intense radiation from astrophysical black holes and may be the primary source of observed radiation from those galactic cores what carry black hole(s).

3. An Entropic Cosmological Principle - by John D. Barrow, Astronomy Centre, University of Sussex, Brighton BN1 9QJ, UK.

Abstract - The author shows why there is a huge disparity between the radiation and Bekenstein-Hawking entropies of the universe today. He explains why this disparity does not tell us that the Universe is in a highly improbable state. The coincidence of the classical and quantum entropies for black holes with Hawking lifetime equal to the age of the universe, and hence of radius equal to the proton size, is shown to be a consequence of observing the universe at the main-sequence lifetime.

4. Origin of the Inflationary Universe - by Andrei O. Barvinsky[*], Alexander Yu. Kamenshchik[+], and Claus Kiefer[#], [*]Theory Department, Levedev Institute and Lebedev Research Center in Physics, Leninsky Prospect 53, Moscow 117924, Russia; [+]L.D. Landau Institute for Theoretical Physics, Russian Academy of Sciences, Kosygin Street 2, Moscow 117334, Russia; [#]Fakultät für Physik, Universität Freiburg, Hermann-Herder-Straße 3, D-79104 Freiburg, Germany.

Abstract - The Authors give a consistent description of how the inflationary Universe emerges in quantum cosmology. This involves two steps: Firstly, it is shown that a sensible probability peak can be obtained from the cosmological wave function. This is achieved by going beyond the tree level of the semiclassical expansion. Secondly, due to decoherence interference terms between different semiclassical branches are negligibly small. The results give constraints on the particle content of a unified theory.

5. Beyond the Horizon to Unknown Territories: The Singularity Inside Black Holes – by Lior M. Burko, Theoretical Astrophysics 130-33, California Institute of Technology, Pasadena, CA 91125.

Abstract - The author studies the Cauchy horizon singularity inside a spherical charged black hole, coupled to a self-gravitating scalar field. He shows that all the radial casual geodesics terminate at a weak singularity according to the Tipler classification. The result is valid anywhere along the singularity, in particular in the regime where non-linear effects are crucial.

6. Formation of Massive Dark Galactic Haloes - by John Bruce Davies, Department of Physics, University of Colorado, Boulder, CO 80309.

Abstract - One of the most perplexing questions in Cosmology is the origin and composition of the dark massive haloes inferred from observations to be surrounding the luminous cores of the Milky Way and other galaxies. Other observations have shown that, on the largest scales, much of the luminous matter in the Universe is clumped closely together with large dark voids between these galactic clusters. The author demonstrates that these dark massive haloes are the consequence of this inhomogeneous distribution of matter in the early Universe out of which subsequently formed the luminous galaxies by fragmentation and gravitational collapse of proto-galactic gas spheroids. Results from the model with respect to halo size and mass are confirmed by analyses of observations.

7. The Bright Side of Dark Matter - by Ariel Edery, Department of Physics, McGill University, 3600 University Street, Montreal, PQ, Canada, H3A 2T8.

Abstract - The author shows that it is not possible in the absence of dark matter to construct a four-dimensional metric that explains galactic observations. In particular, by working with an effective potential it is shown that a metric which is constructed to fit flat rotation curves in spiral galaxies leads to the wrong sign for the bending of light i.e. repulsion instead of attraction. Hence, without dark matter the motion of particles on galactic scales cannot be explained in terms of geodesic motion on a four-dimensional metric. This reveals a new bright side to dark matter: it is indispensable if we wish to retain the cherished equivalence principle.

8. Darkholes: Blackholes' Better Behaved Cousins - by Homer G. Ellis, Department of Mathematics, University of Colorado at Boulder, Boulder, CO 80309-0395.

Abstract - An elementary construction produces on the 4-manifold of 2-spheres in a riemannian 3-space a space-time metric invariant under uniform conformal transformations of the 3-space. When the 3-space is Euclidean, the metric reduces to de Sitter's expanding universe metric. Generalization yields a space-time metric that retains the 'exponential expansion property' of the de Sitter metric. Field equations are derived from an action whose integrand is the difference between the curvature scalar and its 'residual', defined as its limiting value in the infinitely distant future. Because they do not adhere to Einstein's early confounding of inertial mass and energy with gravitating mass, these completely geometrical equations admit solutions that escape the Penrose-Hawking singularity theorems. A spherically symmetric solution that is asymptotic to the Schwarzchild blackhole metric has, in place of a horizon and a singularity, an Einstein-Rosen 'bridge' connecting two asymptotically Euclidean regions. In one the gravitational center attracts, in the other it repels. Travel and signaling from either region to the other is possible. A topological hole in space gravitating in such a way is a 'darkhole', not a blackhole.

9. The Coupling of Gravity to Spin and Electromagnetism - by Felix Finster[*], Joel Smoller[+], and Shing-Tung Yau[#], [*]Max Planck Institute for Mathematics, 04103 Leipzig, Germany; [+]Mathematics Department, The University of Michigan, Ann Arbor, MI 48109; [#]Mathematics Department, Harvard University, Cambridge, MA 02138.

Abstract - The coupled Einstein-Dirac-Maxwell equations are considered for a static, spherically symmetric system of two fermions in a singlet spinor state. Stable soliton-like solutions are shown to exist, and the authors discuss the regularizing effect of gravity from a Feynman diagram point of view.

10. Einstein's Equivalence Principle and the Gravitational Red Shift - by Petros S. Florides, School of Mathematics, Trinity College, Dublin 2, Ireland.

Abstract - Long before the general theory of relativity was finally formulated in 1916, arguments based on Einstein's equivalence principle predicted the well-known phenomenon of gravitational red shift. Precisely the same arguments are widely being used today to derive the same phenomenon. Indeed, it is often claimed that the observed gravitational red shift is a verification of the equivalence principle rather than a verification of general relativity. Here we show that, contrary to these claims, the arguments referred to above are false and that only the full theory of general relativity can correctly predict the gravitational red shift. As a consequence of the result established here serious questions are raised as to the validity of Einstein's equivalence principle and as to its status as the cornerstone of the general theory of relativity.

11. Remarks on Physical Meaning of the Bel-Robinson Tensor - by Janusz Garecki, Institute of Physics, University of Szczecin, Wielkopolska 15, 70-451 Szczecin, Poland.

Abstract - In this essay the author gives some remarks about physical interpretation of the so-called Bel-Robinson tensor in the framework of the standard General Relativity (**GR**), i.e., in the framework of the **GR** without supplementary elements like arbitrary vector field, distinguished tetrads field or second metric. He shows that this tensor is a consequence of the Bianchi identities and, in a natural manner, linked to the differences of the canonical gravitational energy-momentum calculated in normal coordinates.

12. Looking Back in Time Beyond the Big Bang - by M. Gasperini, Dipartimento di Fisica, Università di Bari, Via Amendola 173, 70126 Bari, Italy and Istituto Nazionale di Fisica Nucleare, Sezione di Bari, Bari, Italy.

Abstract - String theory can (in principle) describe gravity at all curvature scales, and can be applied to cosmology to look back in time beyond the Planck epoch. The duality symmetries of string theory suggest a cosmological picture in which the imprint of a primordial, pre-big bang phase could still be accessible to present observations. The predictive power of such a scenario relies, however, on our ability to connect in a smooth way the pre-big bang to the present cosmological regime. Classical radiation back reaction seems to play a key role to this purpose, by isotropizing and turning into a final expansion any state of anisotropic contraction possibly emerging from the pre-big bang at the string scale.

13. Newton's Absolute Time and Space in General Relativity - by Ronald Gautreau, Physics Department, New Jersey Institute of Technology, Newark, NJ 07102.

Abstract - The author describes a reference system in a spherically symmetric gravitational field that is built around times recorded by radially moving geodesic clocks. The geodesic time coordinate t and the curvature spatial coordinate R result in spacetime descriptions of the motion of the geodesic clocks that are *exactly identical* with equations built on the notion of absolute time and space that follow from Newton's inverse square law. The author shows how to use the resulting relativistic/Newtonian equations to generate *exact* relativistic metric forms, from which the motion of light can be determined. He illustrates the (R, t) methodology by starting from a Newtonian picture and solving exactly the general relativistic problem of gravitational collapse of a zero-pressure perfect fluid.

14. Schwarzschild Atmospheric Processes: A Classical Bridge to the Quantum - by E.N. Glass and J.P. Krisch, Department of Physics, University of Michigan, Ann Arbor, MI 48109.

Abstract - The authors develop some classical descriptions for processes in the Schwarzschild string atmosphere. These processes suggest relationships between macroscopic and microscopic scales. The classical descriptions developed in this essay highlight the fundamental quantum nature of the Schwarzschild atmospheric processes.

15. Traveling into the Past with Superfluid ^{3}He - by Pedro F. González-Díaz, Centro de Física "Miguel Catalán", Instituto de Matemáticas y Física Fundamental, Consejo Superior de Investigaciones Científicas, Serrano 121, 28006, Madrid, Spain.

Abstract - Stable time machines which are solutions of Einstein equations are currently thought to exist only in the rather unaccessible realm of the quantum spacetime foam. In this essay, the author argues, nevertheless, that we could well be at the verge of already possessing the condensed-matter technology required to send short messages into the past by using suitably configured thin films of superfluid ^{3}He. This rather unconventional material can be characterized by a spacetime metric that allows the existence of closed timelike curves, provided symmetric vortices with the viscous phase are created at a sufficiently high density during the phase transition. Messages being sent this way can only reach a time in the past which is separated from the present by a time interval much smaller than the time which is biologically required by the experimenter to execute his or her decision, so that any violation of causality is ruled out.

16. Scale Invariance and Vacuum Energy - by E.I. Guendelman, Physics Department, Ben Gurion University, Beer Sheva, Israel.

Abstract - The possibility of mass in the context of scale-invariant, generally covariant theories, is discussed. Scale invariance is considered in the context of a gravitational theory where the action, in the first order formalism, is of the form $S = \int L_1 \Phi d^4 x + \int L_2 (-g)^{1/2} d^4 x$ where M is a density built out of degrees of freedom independent of the metric. For global scale invariance, a "dilaton" *N* has to be introduced, with non-trivial potentials $V(\phi) = f_1 e^{\alpha\phi}$ in L_1 and $U(\phi) = f_2 e^{2\alpha\phi}$ in L_2. This leads to non-trivial mass generation and a potential for *N* which is interesting for new inflation. Scale invariant mass terms for fermions lead to a possible explanation of the present day accelerated universe and of cosmic coincidences.

17. Strings Have Spin - by Richard T. Hammond, North Dakota State University, Physics Department, Fargo, ND 58105.

Abstract - If a string source is used to replace the conventional point-like source of gravitation in spacetime with torsion, then intrinsic spin arises naturally as an attribute of the string. This spin stems from the structure of the string, and not from internal motions.

18. What is the Fate of a Black Hole? - by Adam D. Helfer, Department of Mathematics, University of Missouri, Columbia, MO 65211.

Abstract - Hawking famously computed the expected stress-energy outside a black hole, and predicted on the basis of that computation that the black hole evaporates. The author shows that the background-field approximation that underlies the computation is not compatible with conservation of energy at the level of quantum operators. When this conservation is required, because of the severe blue shift of modes near the hole, there are "selection rules" which severely limit the production of quanta. The picture of the evaporative process is substantially altered.

19. Phase Transition in Quantum Gravity? - by Viqar Husain and Sebastian Jaimungal, Department of Physics and Astronomy, University of British Columbia, 6224 Agricultural Road, Vancouver, BC V6T 1Z1, Canada.

Abstract - A fundamental problem with attempting to quantize general relativity is its perturbative non-renormalizability. However, this fact does not rule out the possibility that non-perturbative effects can be computed, at least in some approximation. We outline a quantum field theory calculation, based on general relativity as the classical theory, which implies a phase transition in quantum gravity. The order parameters are composite fields derived from spacetime metric functions. These are massless below a critical energy scale and become massive above it. There is a corresponding breaking of classical symmetry.

20. Collapsing String Loops: Can Naked Singularity be Found? - by Xin-zhou Li, East China Institute for Theoretical Physics, East China University of Science and Technology, Shanghai 200237, China.

Abstract - The cosmic string loop equation is studied analytically in the expanding universe. If the circular loops expand with the Hubble flow at the time of formation of the loops, the loops collapse to form black holes. The author also shows that the elliptic loop never collapses to one nakedly singular and this prolate object get more and more circular. The cosmic censorship conjecture is supported by the motion of string loop under its own tension.

21. Non-universal Gravitational Couplings of Neutrinos in Matter – by José F. Nieves[*] and Palash B. Pal[+], *Laboratory of Theoretical Physics, Department of Physics, University of Puerto Rico, Río Piedras, Puerto Rico 00931-3343; [+]Saha Institute of Nuclear Physics 1/AF Bidhan-Nagar, Calcutta 700064, India.

Abstract - When neutrinos travel through a normal matter medium, the electron neutrinos couple differently to gravity compared to the other neutrinos, due to the presence of electrons in the medium and the absence of the other charged leptons. The matter-induced gravitational couplings of the neutrinos under such conditions are calculated and their contribution to the neutrino index of refraction in the presence of a gravitational potential is determined.

22. Probing the Quantum Microstructure of Spacetime - by T. Padmanabhan, IUCAA, Post Bag 4, Ganeshkhind, Pune 411 007, India.

Abstract - The author addresses the question of how tightly one can constrain the microscopic theory of quantum gravity from the known features of low energy gravity. To begin with, from the very fact that our universe made a transition from a quantum regime to classical one, it is possible to conclude that infinite number of degrees of freedom had to be integrated out from the fundamental theory to obtain the low energy Einstein lagrangian. Further constraints can be imposed from the fact that the quantum state describing a blackhole has to possess certain universal form of density of states, in any microscopic description of spacetime, which can be ascertained from general considerations. Since a blackhole can be formed from the collapse of and physical system with a low energy ($E \ll E_p$) Hamiltonian H, it is possible to obtain the form the effective high energy ($E \gg E_p$) hamiltonian from general consideration. These results provide the physical reasons for some of the mathematical features underlying string theories and other models for quantum gravity.

23. Cosmic Acceleration: Inhomogeneity Versus Vacuum Energy - by J.F. Pascual-Sánchez, Dept. Matemática Aplicada Fundamental, Sección Facultad de Ciencias, Universidad de Valladolid, 47011, Valladolid, Spain.

Abstract - In this essay, the author presents an alternative explanation for the cosmic acceleration which appears as a consequence of recent high redshift Supernova data. In the usual interpretation, this cosmic acceleration is explained by the presence of a positive cosmological constant or vacuum energy, in the background of Friedmann models. Instead the author will consider a Local Rotational Symmetric inhomogeneous spacetime, with a barotropic perfect fluid equation of state for the cosmic matter. Within this framework the kinematical acceleration of the cosmic fluid or, equivalently, the inhomogeneity of matter, is just the responsible of the Sne Ia measured cosmic acceleration. Although in this model the Cosmological Principle is relaxed, it maintains local isotropy about our worldline in agreement with the CMBR experiments.

24. A Rather Superior Method of Determining the Hubble Constant - by Yi-Ping Qin, Yunnan Observatory, Chinese Academy of Sciences, Kunming, Yunnan 650011, P.R. China; Chinese Academy of Science-Peking University joint Beijing Astrophysical Center, Department of Geophysics, Peking University, Beijing 100871, P.R. China; Yunnan Astrophysics Center, Department of Physics, Yunnan University, Kunming, Yunnan 650091, P.R. China.

Abstract - Bidirectional relativistic proper motions of radio components of nearby extragalactic sources provide a strong constraint on the determination of the Hubble constant. With only one weak assumption the value of the constant is able to be estimated within a narrow range. Since the required preconditions are common or weak and the uncertainties concerned are very few and small, this method is rather superior to many other approaches and then is hopeful to play an important role for finally fixing the value of the constant. With the data available so far, the constant is estimated to be within 27.08 $kms^{-1}Mpc^{-1} < H_0$ # 53.15 $kms^{-1}Mpc^{-1}$ by this method.

25. Generating 7 From the Vacuum - by Varun Sahni, IUCAA - Inter-University Centre for Astronomy & Astrophysics, Post Bag 4, Ganeshkind, Pune 411007, India.

Abstract - The close relationship between the cosmological constant and the vacuum has been emphasised in the past by Zeldovich amongst others. The author briefly discusses different approaches to the cosmological constant issue including the possibility that 7 could be generated by vacuum polarization in a static Universe. Fresh possibilities occur in an expanding Universe. An Inflationary Universe generically leads to particle creation from the vacuum, the nature and extent of particle production depending upon the mass of the field and its coupling to gravity. For ultra-light, non-minimally coupled scalar fields, particle production can be large and the resulting vacuum energy-momentum tensor will have the form of an effective cosmological constant. The Inflationary scenario therefore, could give rise to a Universe that is *both* flat *and* 7-dominated, in agreement with observations.

26. (Super)^n-Energy for Arbitrary Fields and its Interchange: Conserved Quantities - by José M.M. Senovilla, Department de Física Fonamental, Universitat de Barcelona, Diagonal 647, 08028 Barcelona, Spain.

Abstract - Inspired by classical work of Bel and Robinson, a natural purely algebraic construction of super-energy tensors for *arbitrary* fields is presented, having good *mathematical* and *physical* properties. Remarkably, there appear quantities with mathematical characteristics of energy densities satisfying the *dominant property*, which provides super-energy estimates useful for global results and helpful in other matters. For physical fields, higher order (super)^n-energy tensors involving the field and its derivatives arise. In Special Relativity, They provide infinitely many conserved quantities. The *interchange* of super-energy between different fields is shown. The discontinuity propagation law in Einstein-Maxwell fields is related to super-energy tensors, providing quantities conserved along null hypersurfaces. Finally, conserved super-energy currents are found for any minimally coupled scalar field whenever there is a Killing vector.

27. A Non-Anthropic Origin For a Small Cosmological Constant - by C. Sivaram, Indian Institute of Astrophysics, Bangalore 560034, India.

Abstract - An impressive variety of recent observations which include luminosity evolutions of high red shift supernovae strongly suggest that the cosmological constant (7) is not zero. Even though the 7-term may dominate cosmic dynamics at the present epoch, such a value for the vacuum energy is actually unnaturally small. The difficulties in finding a suitable explanation (based on fundamental physics) for such a small residual value for the cosmological term has led several authors to resort to an anthropic explanation for its existence. Here the author presents a few examples some based on phase transitions in the early universe involving strong or electro weak interactions and others on gravitational spin interactions to show how the cosmical term of the correct observed magnitude can arise from fundamental physics involving gravity.

28. Stellar Footprints of a Variable *G* - by Diego F. Torres, Departamento de Física, Universidad Nacional de La Plata, C.C. 67, 1900 La Plata, Argentina.

Abstract - Theories with varying gravitational constant G have been studied since long time ago. Among them, the most promising candidates as alternatives of the standard General Relativity are known as scalar-tensor theories. They provide consistent descriptions of the observed universe and arise as the low energy limit of several pictures of unified interactions. Therefore, an increasing interest on the astrophysical consequences of such theories has been sparked over the last few years. In this essay the author comments on two methodological approaches to study evolution of astrophysical objects within a varying-G theory, and the particular results we have obtained for boson and white dwarf stars.

29. What is the Homogeneity of our Universe Telling Us? - by Mark Trodden and Tanmay Vachaspati, Particle Astrophysics Theory Group, Department of Physics, Case Western Reserve University, 10900 Euclid Avenue, Cleveland, OH 44106-7079.

Abstract - The universe we observe is homogeneous on super-horizon scales, leading to the "cosmic homogeneity problem." Inflation alleviates this problem but cannot solve it within the realm of conservative extrapolations of classical physics. A probabilistic solution of the problem is possible but is subject to interpretational difficulties. A genuine deterministic solution of the homogeneity problem requires radical departures from known physics.

30. Collapse of Rotating Radiation Dust and Cosmic Censorship Hypothesis - by Sanjay M. Wagh[*] and Pradeep S. Muktibodh[*+], [*]Central India Research Institute, Post Box 606, Laxminagar, Nagpur 440 022, India; [+]Department of Mathematics, Hislop College, Temple Road, Civil Lines, Nagpur 440 001, India.

Abstract - Recently, the authors obtained a non-static generalization of the Kerr metric representing a rotational flow of radiation. It can be used to describe the collapse of rotating shells of radiation dust. In this paper, the authors show that, for a linear growth of collapsed radiation-mass with advanced null-time, there always exists an outgoing future-directed tangent to an equatorially confined null geodesic originating at the singularity. Thus, the singularity of the collapse of rotating radiation dust is always a (locally) naked singularity. We emphasize here that this is the *first* exact example of any collapse of rotational nature leading to a naked singularity. The singularity is then naked for spherical as well as for rotational collapse (here) of radiation dust. Hence, the symmetry of the collapse is not an important aspect of the formulation of the Cosmic Censorship.

31. Can Black Holes be Created at the Birth of the Universe? - by Zhong Chao Wu, Department of Physics, Beijing Normal University, Beijing 100875, China.

Abstract - The author studies the quantum creation of black hole pairs in the (anti-) de Sitter space background. These black hole pairs in the Kerr-Newman family are created from constrained instantons. At the WKB level, for the chargeless and nonrotating case, the relative creation probability is the exponential of (the negative of) the entropy of the universe. Also for the remaining cases of the family, the creation probability is the exponential of (the negative of) one quarter of the sum of the inner and outer black hole horizon areas. In the absence of a general no-boundary proposal for open universes, the author treats the creations of the closed and the open universes the same way.

32. Gravity Waves Goodbye - by J.P. Zibin[*], Douglas Scott[*], and Martin White[+], [*]Department of Physics and Astronomy, University of British Columbia, 6224 Agricultural Road, Vancouver, BC V6T 1Z1 Canada; [+]Departments of Astronomy and Physics, University of Illinois at Urbana-Champaign, 1110 West Green Street, Urbana, IL 61801-3080.

Abstract - The detection of a stochastic background of long-wavelength gravitational waves (tensors) in the cosmic microwave background (CMB) anisotropy would be an invaluable probe of the high-energy physics of the early universe. Unfortunately a combination of factors now makes such a detection seem unlikely: the vast majority of the CMB signal appears to come from density perturbations (scalars) - detailed fits to current observations indicate a tensor-to-scalar quadruple ratio of $T/S < 0.5$ for the simplest models; and on the theoretical side the best-motivated inflationary models seem to require very small T/S. Unfortunately CMB temperature anisotropies can only probe a gravity wave signal down to $T/S \sim 10\%$ and optimistic assumptions about polarization of the CMB only lower this another order of magnitude.