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Abstracts of Award Winning and Honorable Mention Essays for 1987

Award Winning Essays

First Award - The Gravity of Cosmic Loops by Tanmay Vachaspati, Bartol Research Foundation, University of Delaware, Newark, DE 19716.

Abstract - The author demonstrates that the gravitational field of a loop of cosmic string can repel particles. This leads to a very interesting pattern of accretion of matter around a cosmic loop.

Second Award - Coalescing Binaries - Probe of the Universe by A. Krolak and Bernard F. Schutz, Department of Applied Mathematics and Astronomy, University College Cardiff, Cardiff, Wales, U.K.

Abstract - At present the coalescing binary systems containing neutron stars or black holes are thought to be the most likely sources of gravitational waves to be detected by long baseline laser interferometers being currently designed. In this essay the authors calculate the characteristics of the signal from a coalescing binary to the first post-Newtonian order. They show that at coalescence the eccentricity of the orbit, tidal effects and magnetic interactions can be neglected. They also consider the effects of the expansion of the Universe on the signal. They show that observations of gravitational waves from coalescing binaries by a network of detectors will provide a wealth of astrophysical information, e.g. determination of the Hubble constant, new rungs in the cosmic distance ladder, estimates of the masses of components of the binary; information about mass distribution in the Universe, highly accurate tests of general relativity, and constraints on neutron-star equation of state. Further development of laser interferometers may enable determination of the deceleration parameter, provide new information about evolution of the Universe and even enable observation of such effects as gravitational lensing.

Third Award - Are There Topological Black Hole Solitons in String Theory? by Pawel O. Mazur, Syracuse University, Physics Department, Syracuse, N.Y. 13244.

Abstract - The author points out that the celebrated Hawking effect of quantum instability of black holes is a purely classical but nonperturbative effect in string theory. Studying quantum dynamics of strings in the gravitational background of black holes he finds classical instability due to emission of massless string excitations.

The topology of a black hole seems to play a fundamental role in developing the string theory classical instability due to the effect of sigma model instantons. The author argues that string theory allows for a qualitative description of black holes with very small masses and it predicts topological solitons with quantized spectrum of masses. These solitons would not decay into string massless excitations but could be pair created and may annihilate also. Semiclassical mass quantization of topological solitons in string theory is based on the argument showing existence of nontrivial zeros of beta function of the renormalization group.

Fourth Award - Present Time Variation of Newton's Gravitational Constant in Superstring Theories by Yong-Shi Wu, Department of Physics, University of Utah, Salt Lake City, Utah 84112, and Zi Wang, Department of Physics, Utah State University, Logan, Utah 84322.

Abstract - Superstring theories provide an appropriate framework for studying the time variation of fundamental coupling constants. The present time-variation of coupling constants in superstring theories with currently favorable internal backgrounds critically depends on the shape of the potential for the size of internal space. If the potential is almost flat, as in perturbation theory to all orders, the present value of $|\dot{G}/G|$ for Newton's gravitational constant is calculable and estimated to be $1 \times 10^{-11\pm1}\ yr^{-1}$ which is just at the edge of the present observational bound for $\dot{G}/G$. If the potential has a minimum with finite curvature due to unknown nonperturbative effects, $\dot{G}/G$ will become unobservably small. The improvement of the measurement of $\dot{G}/G$ of one or two orders of magnitude would discriminate between the two situations. Problems with the time variation of other coupling constants are also discussed.

Fifth Award - Self Similar Spherical Gravitational Collapse and the Cosmic Censorship Hypothesis by Amos Ori, Recah Institute of Physics, The Hebrew University, Jerusalem, Israel and Tsvi Piran, Racah Institute of Physics, The Hebrew University, Jerusalem, Israel and The Institute for Advanced Study, Princeton, New Jersey 08540.

Abstract - The authors show that a self-similar general relativistic spherical collapse of a perfect fluid with an adiabatic equation of state $p = (\gamma - 1)\rho$ and low enough γ values, results in a naked singularity. The singularity is tangent to an event horizon which surrounds a massive singularity and the redshift along a null geodesic from the singularity to an external observer is infinite. The authors believe that this is the most serious counter example to cosmic censorship that was obtained so far.

Honorable Mention Essays (Alphabetical Order)

1. Is Higher-Derivative Gravity A Good Therapy To The Causal Pathologies Of Godel-Type Universes? by A.J. Accioly, Instituto de Fisica Teorica, Rua Pamplona, n^{o} 145, Sao Paulo, CEP 01405, SP, Brazil.

Abstract - A completely causal vacuum solution with the symmetries of the Godel universe is obtained in the framework of higher derivative gravity. This very peculiar and rare result has no analogue in the context of standard general relativity. It relates the mass of the nontachyonic spin-0 particle (microphysics) and the cosmological constant (macrophysics).

2. The Renormalizability of Quantum Gravity: Why It Must Be Reexamined, by Scott B. Anderson, Department of Physics, Colorado State University, Ft. Collins, CO 80523.

Abstract - The author shows in this essay that previously accepted conclusions regarding the renormalizability of general relativity are probably incorrect. He demonstrates this by calculating the exact generating functional for a model theory of gravity that is conventionally non-renormalizable. Perturbation theory fails for this model because the zero coupling limit is not a free field theory. He argues that a very similar situation occurs in general relativity. Consequently the renormalizability of quantum gravity must be reexamined.

3. The Finite Action Principle or Singularities Without Singularities, by John D. Barrow, Astronomy Centre, University of Sussex, Falmer, Brighton BN1 9QH, UK and Frank J. Tipler, Department of Mathematics and Department of Physics, Tulane University, New Orleans, Louisiana 70118.

Abstract - Physical theories have their most fundamental expression as action integrals. This implies that the total action of the universe should be the most fundamental physical quantity, hence this universal action must be finite. The authors investigate the consequences of a finite universal action. They show that if a finite action universe obeys the Copernican Cosmological Principle, it must be spatially and temporally closed. Thus, the classical curvature singularities in cosmology are seen to be essential if an even more fundamental singularity, a singularity or rather an infinity in the universal action, is to be avoided. Finally, they show that finite universal action places constraints on the types of matter that can dominate the dynamics of the early universe.

4. Temperature in Friedmann Thermodynamics and its Generalization to Arbitrary Space-Times, by Selcuk Bayin, Middle East Technical University, Inonu Bulvari, Ankara, Turkey.

Abstract - In a recent article the author has introduced Friedmann thermodynamics, where certain geometric quantities in Friedmann models were treated like their thermodynamic counterparts; Temperature, entropy and so on. In this essay he concentrates on the definition of temperature and evaluates the dimensionless constant that appears in its definition by considering the quantum vacuum fluctuations of massless conformal scalar field in closed, and critically open (flat) Friedmann models. He also generalizes the results to the gravitational field of a spherically symmetric star. He shows that in the black hole limit i.e. as the surface of the star approaches its horizon, the gravitational temperature of the star, at its surface, reduces to the Hawking temperature, precisely. He concludes by suggesting a method for defining the gravitational temperature for arbitrary space-times granted that they are sufficiently smooth.

5. Constraints on the Higgs Field from Blackhole Physics, by M.I. Beciu, Department of Physics, Institute of Constructions, Republicii 176 73232 - Bucharest, Romania.

Abstract - The author considers the connection between the thermal effect of a blackhole and the restoration of a broken symmetry. It appears that the second law of thermodynamics could be violated in a special circumstance. It is shown that this does not happen if some constraints are imposed on the Higgs field.

6. Monte Carlo Simulation of a Quantized Universe, by Beverly K. Berger, Physics Department, Oakland University, Rochester, MI 48063, Institute of Geophysics and Planetary Physics, Lawrence Livermore National Laboratory, Livermore, CA 94550.

Abstract - A Monte Carlo simulation method which yields ground state wavefunctions for multi-electron atoms is applied to quantized cosmological models. In quantum mechanics, the propagator for the Schroedinger equation reduces to the absolute value squared of the ground state wavefunction in the limit of infinite Euclidean time. The wavefunction of the Universe as the solution to the Wheeler-DeWitt equation may be regarded to be the zero energy mode of a Schroedinger equation in coordinate time. The simulation evaluates the path integral formulation of the propagator by constructing a large number of paths and computing their contribution to the path integral using the Metropolis algorithm to drive the paths toward a global minimum in the path energy. The result agrees with a solution to the Wheeler-DeWitt equation which has the characteristics of a nodeless ground state wavefunction. Oscillatory behavior cannot be reproduced although the simulation results may be physically reasonable. The primary advantage of the simulations is that they may easily be extended to cosmologies with many degrees of freedom. Examples with one, two, and three degrees of freedom are presented.

7. Dragging of Inertial Frames by the Rotating Earth: Proposal and Feasibility for a Ground Based Detection, by Massimo Cerdonio, Giovanni A. Prodi and Stefano Vitale, Department of Physics, University of Trento, Trento, Italy.

Abstract - The authors are proposing a ground based experiment to detect the Lense-Thirring drag due to the rotating earth by an off-line comparison between an astrometric measurement of the earth rotation and an inertial measurement of the angular velocity of the laboratory. It is shown that the former, by means of routine observations of Very Long Baseline Interferometry, has already reached the accuracy needed to perform a 3% experiment on a time span of ~1 year. The authors propose to perform the latter by a dynamical detector of local rotation of novel conception, the Gyromagnetic Electron Gyroscope. Its principle of operation is briefly discussed together with its response to rotation-like gravitational fields.

8. Primordial Nucleosynthesis and $\Omega_B \sim 1$ Cosmologies With Interacting Radiation and Matter, by A.A. Coley, Department of Mathematics, Statistics and Computing Science, Dalhousie University, Halifac, Nova Scotia, Canada B3H 4H8.

Abstract - The constraints on the present baryon density from primordial nucleosynthesis in universes with interacting radiation and matter are investigated. For illustration, a class of exact cosmological models is studied in which two separate, interacting fluids act as the source of the gravitational field, a radiative perfect fluid modelling the cosmic microwave background and a second perfect fluid modelling the observed material content of the universe. Although the two fluid models under consideration are found to predict primordial element abundances similar to those predicted in the standard model (and consequently in general accord with observed values), the upper limit on the present baryon density inferred from the observed abundances of the light elements is found to be greater than that in the standard model due to the different evolution of the baryon density in the models. From this result, and using the fact that the upper limit on Ω_B (the ratio of the present value of the baryon density to the value of the critical density) is further weakened in inhomogeneous cosmological models, it is found that unlike the situation in the

standard model, cosmologies with $\Omega_B \sim 1$ are permitted without violating the constraints of nucleosynthesis, thereby allowing the possibility that the universe could be closed by baryonic matter alone.

9. The Structure and Shape of Rotating Self-Gravitating Discs, by John Bruce Davies, Department of Geophysics and Astronomy, U.B.C., Vancouver, B.C., Canada.

Abstract - Previously, the only self-gravitating bodies whose density structure could be rigorously analyzed were those with small deviations from a spheroidal shape due to axisymmetric rotation, c.f. ellipsoidal galaxies. The other commonly observed self-gravitating body is the flat disc whose thickness is much smaller than its radial extent, c.f. spiral galaxies. The author has developed asymptotic boundary-layer techniques that yield self-consistent density solutions and boundary shapes for these self-gravitating discs with axisymmetric rotation. An unique result of this approach is the explanation of the spherical bulge found at the central rotation axis which is mathematically represented by a density boundary layer. This method is applicable with all equations of state and variable angular velocity profiles. The disc's shape and density structure are shown to depend on its mass, moment of inertia and angular velocity function. Two dimensionless parameters, namely the ratios of gravitational potential energy and rotational kinetic energy to thermal energy, constrain the allowable solution space. Spherical central bulges are fundamental elements of all such self-consistent discs.

10. The Light From the Other Side of the Universe, by R.L. Davis, Stanford Linear Accelerator Center, Stanford University, Stanford, California 91305.

Abstract - The isotropic cosmic microwave background may come from the antipode of a spatially closed, but seemingly open, textured universe.

11. Gravitational Theories with Torsion: Newtonian Trajectories in Supergravity, by G. Domenech, M.Levinas, and N. Umerez, Grupo de Teorias Quanticas Relativistas y Gravitation, IAFE, C.C. 67, Suc. 28 (1428) Buenos Aires, Argentina.

Abstract - Any good quantum theory should have a well behaved low energy limit. The most promising quantum theories of gravitation are supersymmetric so the introduction of torsion becomes necessary. The authors are interested in the problem of finding trajectories of test particles in manifolds with torsion. To that end conservation laws are obtained from invariance under the General Change of Coordinate Group. The results differ, even in the Newtonian limit, from the ones of General Relativity. The authors apply them to N=1 Supergravity and, using a non-pure gauge solution for the gravitini, they find a Newtonian order non-conservative force. They give an alternative interpretation of the energy loss in a particular physical system.

12. The Stability of Hot Curved Space, by John F. Donoghue, Philip S. Gribosky and Barry R. Holstein, Department of Physics and Astronomy, University of Massachusetts, Amherst, MA 01003.

Abstract - The stability of a universe uniformly filled with hot fluid is examined from the framework of finite temperature quantum field theory, extending a program originally begun by Jeans. The authors find that, as expected from Jean's result,

Minkowski and de Sitter space ($\Lambda \neq 0$) are unstable. However, the possibility of a stable solution exists for anti de Sitter space.

13. Topologically Stable Black Holes, by Joshua A. Frieman, Stanford Linear Accelerator Center, Stanford University, Stanford, California 94305 and Christopher T. Hill, Fermi National Accelerator Laboratory, P.O. Box 500, Batavia, Illinois 60510.

Abstract - The authors show that magnetic monopoles with mass greater than $M_{crit} \simeq M_{pl}\sqrt{\alpha}$, corresponding to a grand unification scale $M_x \geq \sqrt{\alpha}M_{pl}$, are unstable to gravitational collapse: they will form magnetic black holes. They evaporate via Hawking radiation until they reach $M_{mon} \simeq M_{crit}$ and thereafter remain as extreme Reissner-Nordstrom holes with zero Hawking temperature. Since they cannot radiate away their magnetic charge, these black holes are 'topologically stable' solitons, satisfying the cosmic censorship condition, and they could be a component of the dark matter. The authors also point out a striking analogy between the structure of monopoles and the mechanics of black holes. For magnetic black holes, this analogy becomes an identity.

14. Experimental Tests on Unified Theories of the Scalar-Vector-Tensor Type, by M. Gasperini, Dispartimento di Fisica Teorica dell'Universita, Corso M.D.'Azeglio 46, 10125 Torino, Italy and Istituto Nazionale di Fisica Nucleare, Sezione di Torino, Italy.

Abstract - It is shown that the interaction between the electromagnetic field and an eventual scalar component of the gravitational force induces changes in the polarization state of a light wave travelling through a constant magnetic field, and it is then suggested that, using a laser beam, one could obtain significant information on the scalar coupling strength for ranges of the scalar interaction of order 1 cm and smaller.

15. The Quantum Creation of the Universe Can Be Observationally Verified, by L.P. Grishchuk, Sternberg Astronomical Institute, 119899 V-234, Moscow, U.S.S.R. and Tata Institute of Fundamental Research, Homi Bhabha Road, Bombay 400 005, India.

Abstract - It is shown that the properly formulated notion of the quantum birth of the universe can be observationally confirmed or rejected. The idea is that the energy density and spectrum of the relic gravitational wave background is determined by a wavefunction of the universe not only in classically allowed but also in classically forbidden regimes. Although the notion of creation of the world exists as long as man thinks it seems that only now it can be put on a scientific ground. We begin to see how to formalize this notion and give it a mathematical description. The purpose of this essay is to show that, in principle, the properly formulated notion of creation of the universe can even be observationally confirmed or rejected.

16. Wormholes, Entropy and Extra-Dimensions, by E.I. Guendelman and David A. Owen, Department of Physics, Ben Gurion University of the Negev, Beer Sheva 84105, Israel.

Abstract - Gravitational bags are found to be the solutions of some higher dimensional theories. They contain a domain wall outside of which they look compact, but inside there is a Davidson-Owen type solution where the extra dimensions explode at the center. The quantum numbers of matter associated with motion in the extra dimensions inside these objects, can become very large for some geometries at small energy cost. This is allowed by the Bekenstein entropy bound $S/E<2\pi R$ where R is the largest linear dimension associated with the system (here infinite). By the collapse of the wall towards the center, particles with high quantum numbers become very massive. However, through wormhole formation this is seen to be an energetically allowed process, leading to the creation of a huge universe.

17. Thermodynamics of the Universe and Early Cosmology, by E. Gunsig and P. Nardone, Universite Libre de Bruxelles, Campus Plaine, C.P. 238, 1050 Bruxelles, Belgium.

Abstract - A General-Relativistic cosmological model is proposed, in which the Entropy Content of the Universe - the specific entropy per baryon, as well as the black body radiation temperature - is restricted to its correct observational value. It appears moreover to be solely dependent on three fundamental constants $\hbar$, c and the gravitational coupling constant κ. These thermodynamical cosmological properties result indeed from a Self-Consistent Genesis, which depends itself on these constants only. This Primordial Generic Event owes its roots to a spontaneous quantum emergence, out of the vacuum, of a mini black holes population together with an Inflationary space-time structure. It is precisely a subtle combination between the Self-Consistent constraints together with black hole thermodynamics, which uniquely fixes these properties.

18. The Curvature Problem in General Relativity by G.S. Hall, W. Kay and A.D. Rendall, Department of Mathematics, University of Aberdeen, Edward Wright Building, Dunbar Street, Aberdeen AB9 2TY, Scotland, U.K.

Abstract - This essay investigates the relationships between the metric, the connection, the curvature and the covariant curvature derivatives in general relativity. The extent to which the connection or the curvature together, possibly with certain curvature derivatives, determines the metric is considered as well as other related problems. Some topological aspects of the problem are included and some applications to holonomy and symmetry groups are given.

19. Quantum Field Theory in Curved Space-Time as the Semi-Classical Limit of Quantum Cosmology, by J.J. Halliwell, Department of Applied Mathematics and Theoretical Physics, Silver Street, Cambridge, CB3 9EW, U.K.

Abstract - The predictions of quantum field theory in curved space-time may depend quite crucially on how one chooses the vacuum state, and in most space-times there is no natural choice. In this essay the sense in which quantum field theory in curved space-time may be regarded as a semi-classical approximation to quantum cosmology is discussed. The Hartle-Hawking proposal for the boundary conditions on the wave function of the universe is shown to lead in the semi-classical limit to a choice of vacuum state. In the case of a de Sitter background, it is argued that this state is de Sitter invariant. It is suggested that this proposal provides a natural way of defining a very symmetric vacuum state for any matter field in a number of different space-times.

20. On Gravitational Spin-Spin Interaction, by C. Hoenselaers, Institut fur theoretische Physik, Universitat zu Koln, Zulpicher Str. 77, 5000 Koln 41 and W. Dietz, Institut fur Astrophysik, Universitat Wurzburg, Am Hubland, 8700 Wurzburg.

Abstract - Gravitational spin-spin interaction is a comparatively new relativistic effect which contributes to the force between rotating objects. The authors compare this effect with the Newtonian attraction for objects of laboratory dimensions and give numerical estimates which will be relevant if this effect is to be measured.

21. Mock Gravity and the Origin of Cosmological Structure, by C.J. Hogan, Steward Observatory, University of Arizona, Tucson, AZ 85721.

Abstract - Two absorbing particles immersed in an isotropic radiation field cast shadows on each other, so that radiation pressure causes an attractive $1/r^2$ force between them which mimics Newtonian gravity. If the pregalactic universe produced a population of bright stars, this force would lead to a rapidly-growing instability which could operate on sufficiently large scales to create galaxies and galaxy clusters. Primordial perturbations could therefore be much smaller than those usually considered necessary for forming large-scale structure.

22. Quantum Effects on Spacetime Singularities, by Viqar Husain, Department of Physics, Yale University, New Haven, CT 06511.

Abstract - In regions of strong gravitational fields, such as the regions near the initial singularities of cosmological models, quantum gravitational effects are expected to play an important role in determining deviations from classical spacetime structure. Such effects can be investigated either by constructing a quantum theory starting from classical relativity or by postulating a quantum theory of gravity which yields general relativity in the low energy limit. In this essay, the former approach is taken and a specific cosmological model with an initial singularity is canonically quantized. Since curvature scalars such as $R_{\mu\nu\alpha\beta}R^{\mu\nu\alpha\beta}$ are expected to be singular at spacetime singularities, this scalar is calculated as a quantum mechanical operator. Its expectation values in suitable quantum states are evaluated. It is shown that there exist no quantum states in which the expectation value of this operator is non-singular at the classical singularity. Thus in this approach, the classical singularity appears to be unaltered by quantum effects.

23. Quantum Effects Near Spacetime Singularities, by Pankaj S. Joshi, Faculty of Mathematical Studies, University of Southhampton, S09 5NH, England, and Tata Institute of Fundamental Research, Homi Bhabha Road, Colaba, Bombay 400 005, India and Sonal S. Joshi, Department of Mathematics, Bhavnagar University, Bhavnagar 364002, India.

Abstract - The authors incorporate quantum effects into the gravitational dynamics in the vicinity of singularity in the case of three important general relativistic spacetimes, namely the spherically symmetric dust-ball collapse, standard Friedmann models and a general cosmological scenario given by Belinskii et al. The quantum state of the universe is represented by a general wave function where the conformal degree of freedom is quantized. It is seen in each case that the spread around the classical state diverges in the limit of approach to the classically singular epoch. Thus, non-

classical, non-singular states can occur with finite probability. The authors show that including quantum effects radically changes the usual singularity scenario.

24. Newton's Theorem and Geophysical Prospecting with Underground Gravity Measurements by Yeong E. Kim and David J. Klepacki, Purdue University, Department of Physics, West Lafayette, IN 47907.

Abstract - In honor of the 300th anniversary of Newton's Principia, the authors describe a very recent newfound application of a theorem he originally introduced in that work back in 1687. This theorem, here referred to as Newton's theorem, established the null contribution to the gravitational acceleration for points inside ellipsoidal shells of uniform mass density. The salient feature is that only certain types of ellipsoidal shells allow this property, and the authors label them as "Newton Ellipsoids" in this essay. Presently, these ellipsoids have been used to construct improved theoretical models of the earth which can be useful for "geophysical prospecting". For a specific location on the globe, a knowledge of the variation of gravitational acceleration with depth in the earth's crust is sufficient to determine the corresponding local mass density distribution from these models. Thus, oil and other useful mineral deposits may be located by merely-measuring such a gravity gradient, hence justifying the term "geophysical prospecting".

25. Supergravity Theory Beyond 11 Dimensions, by Wang Mian, Henan Normal University, Xinxiang, Henan, China.

Abstract - Supergravity theory beyond 11 dimensions is investigated. It is shown that in a 12-dimensional space with signature (2,10) there exists a Majonara-Weyl spinor, the number of independent components of such a spinor is 16 as a Majorana spinor in 11-dimensional space. A supergravity theory is proposed.

26. Angular Momentum and Variational Techniques in General Relativity, by E. Nahmad-Achar, Department of Applied Mathematics and Astronomy, University College, Cardiff, U.K.

Abstract - The author develops variational principles for the angular momentum of gravitating systems in general relativity, both at spatial and null infinity, as well as for the angular momentum flux. These offer alternative ways for studying the initial value problem on spacelike hypersurfaces and on characteristics, and for the study of axisymmetric collapse. He shows that the angular momentum is well defined at null infinity for solutions of Einstein's field equations, in the Newtonian approximation, and that the angular momentum flux is well defined and free from the supertranslation ambiguity in this approximation. The formalism allows a derivation of the quadrupole formula for gravitational radiation and relates quantities defined at spatial infinity to those defined at null infinity.

27. The Weight of the Vacuum, by T. Padmanabhan, Institute of Astronomy, Madingley Road, Cambridge, CB3 OHA, England and T.P. Singh, Astrophysics Group, TIFR, Homi Bhabha Road, Bombay 400005, India.

Abstract - The authors study simple detector models which couple to the components of the stress-tensor $T^{1}{}_{k}$ of a quantum field, linearly and locally. They show that

these detectors do get excited if put on an accelerated trajectory. They compute the rate of excitation for the simple case when the coupling is to the trace of $T^i{}_k$. This result arises from the fact that the detector responds to the power spectrum of $\langle 0|T_{ik}(x)\, T_{\ell m}(y)\, |0\rangle$ rather than to $\langle 0|T_{ik}|0\rangle_{reg}$. The consequences are discussed.

28. A New Causal Boundary for Space-Times, by Istvan Racz, Central Research Institute for Physics, H-1525 Budapest 114, P.O.B. 49, Hungary.

Abstract - A new causal boundary construction for general relativistic space-times is suggested which in a sense generalizes both the Geroch-Kronheimer-Penrose and the Budic-Sachs completions. An identification rule is defined on the set of 'ideal' points of the space-time which coincides with the identification rule generated by the null pair equivalence for causally continuous space-times.

29. Cosmic Strings and Inflation, by Qaisar Shafi, Bartol Research Institute, University of Delaware, Newark, DE 19716.

Abstract - A variety of extended stringlike structures are predicted by grand unified and other particle physics models. In an astrophysical setting they are often referred to as 'cosmic strings'. If their mass per unit length is about 10^{22} g cm^{-1} cosmic strings can seed galaxy formation and produce other interesting gravitational and astrophysical effects. This scenario assumes that the initial universe was extremely homogeneous, which is possible if the early universe underwent an inflationary epoch. This poses, however, the following dilemma: How can superheavy strings, which are topological defects, survive inflation which tends to homogenize the universe? In the essay the author discusses how one might reconcile the string scenario with the inflationary paradigm through examples based on grand unification, superstring models, and higher dimensional models of inflation.

30. Gravitational Modulation of Particle Clustering: A New Class of Gravitationally-Induced Quantum Interference, by M.P. Silverman, Department of Physics, Trinity College, Hartford, Connecticut, 06106.

Abstract - A gravitational potential difference between the two components of a split fermion or boson beam in a particle interferometer modulates the cross-correlation in particle fluctuations and the variance in difference counts of the two output beams received at two detectors. The proposed effects are particle analogues of the optical Hanbury Brown-Twiss experiments; they represent a new kind of intrinsically nonrelativistic gravitationally-induced quantum interference different in concept and in observational procedure from that of the Colella-Werner-Overhauser experiment. The effects should be observable with present field-emission electron beams and eventual cold neutron beams of higher brightness.

31. Symmetries of Einstein's Field Equations, by H. Stephani, Sektion Physik der Friedrich-Schiller-Universitat, DDR - 6900 Jena.

Abstract - Every class of solutions which depend on arbitrary constants or functions admits, and is a result of, a symmetry of the field equations and a properly chosen set of constraints. The symmetry conditions and possible ways to solve them are

discussed in particular for the example of vacuum solutions admitting a null or non-null Killing vector.

32. General Covariance and Quantum Field Theory, by David J. Toms, Department of Theoretical Physics, University of Newcastle-Upon-Tyne, Newcastle-Upon-Tyne, U.K. NE1 7RU.

Abstract - Some aspects of a geometrical approach to quantum field theory which regards the fields as the local coordinates of points in a field space as advocated by Vilkovisky are discussed. It is possible to introduce a metric and a connection and to define a curvature for the space of fields. Familiar theories such as Yang-Mills and general relativity have a field space which is not flat. Just as in general relativity results should be independent of the choice of coordinates. It is shown how the measure for functional integration for quantum field theory in curved spacetime emerges in a very natural manner. A simple way of deriving Vilkovisky's proposal for the effective action is also described.

33. Is the "Missing Mass" Really Missing?, by Matt Visser, Physics Department, University of Southern California, Los Angeles, CA 90089-0484.

Abstract - There is no experimental evidence for the validity of the inverse square law for gravitation at distances significantly larger than the diameter of the solar system. This raises the very real possibility that the "missing mass" ("dark matter") may not exist. Instead, the inverse square law may be breaking down at distances of the order of tens of kiloparsecs. The author discusses this possibility within the framework of Scalar-Vector-Tensor (SVT) theories of gravity. It appears to be relatively easy to account for up to approximately 10% of the galactic halo dark matter via SVT theories of gravity. With some fine tuning of parameters it is conceivable that all of the dark matter be accounted for in this way.

34. Suppression of Inverse Compton Catastrophe in a Black Hole - Magnetic Field System, by Sanjay M. Wagh, Theoretical Astrophysics Group, Tata Institute of Fundamental Research, Homi Bhabha Road, Bombay 400005, India.

Abstract - In this paper the author shows that the inverse Compton losses of relativistic electrons near a black hole in a magnetic field are suppressed as a result of the collisional magnetic Penrose process no matter how the electrons are accelerated to relativistic speeds.

35. 26-Dimensional String from 4-Dimensional Geometry, by James T. Wheeler, Department of Physics and Astronomy, The University of North Carolina at Chapel Hill, Chapel Hill, North Carolina 27514.

Abstract - A study of 4-dimensional volume preserving covariant changes of the metric leads directly to string theory in 26-dimensions. In any conformally invariant theory of such metric distortions, a new principle of relativity is shown to imply that the maximum number of independent components of the distortion tensor is 26. Within the simplest such theory allowing metric compatible spaces as trivial solutions, the author shows that this maximum is realized by a solution equivalent to the 26-dimensional bosonic string.