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Abstracts of Award Winning and Honorable Mention Essays for 1988

Award Essays

First Award - Is There A Unique Consistent Theory of Quantum Gravity? by Itzhak Bars and Christopher N. Pope, Department of Physics, University of Southern California, Los Angeles, CA 90089-0484.

Abstract - Superstrings have been proposed as a quantum-theoretical framework for unifying all the fundamental forces, including gravity. The authors consider the question of whether there might be more general supersymmetric possibilities, based on higher extended objects such as membranes, jellies, etc. They argue that all the possible extended objects in all possible spacetime dimensions are quantum-mechanically inconsistent except for the ten-dimensional superstring and the eleven-dimensional supermembrane. These are also the only two such theories that contain massless gravitons, and thus that can describe gravity at low energies. It is remarkable that the range of possibilities can be narrowed down to this extent. Whether these can be further narrowed down to just one consistent theory remains open to further research.

Second Award - An Interacting Geometry Model and Induced Gravity by Pawel O. Mazur, Department of Physics, Syracuse University, Syracuse, N.Y. 13244, and V. P. Nair, Department of Physics, Columbia University, New York, N.Y. 10027.

Abstract - The authors propose the theory of quantum gravity with interactions introduced by topological principle. The fundamental property of such a theory is that its energy-momentum tensor is an BRST anticommutator. Physical states are elements of BRST cohomology group. The model with only topological excitations, introduced recently by Witten, is discussed from the point of view of induced gravity program. The authors find that the mass scale is induced dynamically by gravitational instantons. The low energy effective theory has gravitons, which occur as the collective excitations of geometry, when the metric becomes dynamical. Applications of cobordism theory to QG are discussed.

Third Award - On the Phase Transition to Space-Time in String Cosmology by Minos Axenides, Department of Physics, FM-15, University of Washington, Seattle, Washington 98195.

Abstract - Closed string models have recently been constructed in lower than their critical space-time dimensions $D \leq D_{cr}$. An ideal gas of closed strings with $D \geq 4$ undergoes a phase transition at a universal point (Hagedorn temperature). The author argues that non-trivial configurations on the string world-sheet (vortices) drive the system into a high temperature phase where the vacuum is dominated by vortex condensates. Flat space-time is identified with the dipole low-temperature phase of vortex anti-vortex pairs. This is a "Kosterlitz-Thouless" transition on the string world-sheet. It is suggestive of a "stringy" realization of the inflationary universe paradigm.

Fourth Award - Black Hole Evaporation and Higher-Derivative Gravity by Robert C. Myers, Institute for Theoretical Physics, University of California, Santa Barbara, CA 93106, and Jonathan Z. Simon, Department of Physics, University of California, Santa Barbara, CA 93106.

Abstract - The authors examine the role which higher-derivative gravity interactions may play in black hole evaporation. The thermodynamic properties of black holes in Lovelock gravity are described. In certain cases, the specific heat of a black hole becomes positive at small mass. This results in an infinite lifetime for the black hole (and also allows it to achieve stable equilibrium with a thermal environment). Thus no conflict with unitary time evolution would arise in such theories.

Fifth Award - Thermodynamics and Cosmology by I. Prigogine, Center for Studies in Statistical Mechanics, The University of Texas, Austin, TX 78712, and the Free University of Brussels, Brussels, Belgium, and J. Geheniau, E. Gunzig and P. Nardone, The Free University of Brussels, Brussels, Belgium.

Abstract - A new type of cosmological history which includes large-scale entropy production is proposed. These cosmologies are based on a reinterpretation of the matter-energy stress tensor in Einstein's equations. This modifies the usual adiabatic energy conservation laws, thereby leading to a possible irreversible matter creation. This creation corresponds to an irreversible energy flow from the gravitational field to the created matter constituents. This new point of view results from the consideration of thermodynamics of open systems in the framework of cosmology.

It appears that the usual initial singularity is structurally unstable with respect to irreversible matter creation. The corresponding cosmological history therefore starts from an instability of the vacuum rather than from a singularity. The universe evolves through an inflationary phase. This appears to be an attractor independent of the initial vacuum fluctuation.

Honorable Mention Essays (Alphabetical Order)

1. Isomonodromy Deformation Approach to the Einstein-Maxwell Fields with Isometries by G. A. Aleksejev, Steklov Mathematical Institute, Moscow, USSR.

Abstract - A new approach is suggested for the description of the space of local solutions of electrovacuum Einstein-Maxwell field equations, if the space-time possesses an Abelian group of isometries G_2 with non-null orbits, orthogonal to 2-surfaces.

This approach, differs from all others, known before, and it is the most general and it seems to be the simplest one. It is applicable for the stationary axially symmetric fields as well as for the cosmological-type solutions and different wave fields without any additional restrictions (such as regularity conditions on the symmetry axes or absence of initial singularity).

The beautiful intrinsic structure of the Einstein-Maxwell field equations itself leads to the natural way of their integration. As a result, the problem may be straightforwardly reduced to the classical one - the scalar linear singular integral equation. A wide class of exact solutions with any number of arbitrary parameters (more wide, than the class of solitons) have been found explicitly. Moreover, it becomes possible to give a purely linear algorithm for constructing the solution of Cauchy-, Gursa, and other boundary problems for this class of fields. Different examples of new families of exact solutions have been constructed.

2. Spacetimes with Affine and Projective Group Symmetries. I. Einstein Spacetimes. H-Spacetimes. by A. V. Aminova, Department of Relativity and Gravitation, Kazan State University, Kazan, USSR 420008.

Abstract - An exact solution search program in general relativity can be essentially extended at the expense of including spacetimes with symmetries in the form of affine and projective transformations which preserve trajectories of test bodies and lead to fundamental field and particle conservation laws. Determination of Riemann spaces with affine and projective group symmetries is a difficult mathematical problem formulated by S. Lie and still unsolved for pseudo-Riemannian spaces. This problem is solved in the present work for spacetimes. This paper is the first part of the work. In this part all spacetimes admitting non-trivial solutions $h \neq c\,g$ of Eisenhart equation (and hence Killing tensors $h - 4\phi g$) to be called h-spacetimes are found with the help of skew-frame technique and necessary and sufficient conditions in order that spacetime admit one-parameter projective (affine) group are determined. Following parts will be devoted to integrating the Killing equation and finding maximal affine and projective group generators in h-spacetimes.

3. The Generation of Polarization - Acoustical Waves in Piezo-Electric Crystals by Gravitational Wave Field Near the Point of Second Type Phase Transition by V. I. Bashkov, A. B. Balakin and A. V. Gusev, Department of Physics and Gravitation, Kazan State University, Kazan, USSR, 420008.

Abstract - An excitation mechanism for the piezoelectrically bounded transverse and longitudinal polarized sound waves in finite size crystals of RS, KDP type near the second type phase transition points by the plane gravitational wave is considered. It is shown that acoustic waves can be excited only on the bound of the crystal or on the inhomogeneities like domain bounds and may appear anomalous near the phase transition point.

4. Friedmann Thermodynamics and the Definition of Temperature by Selcuk Bayin, Middle East Technical University, Inonu Bulavri, Ankara, Turkey.

Abstract - The author presents a physical derivation of the "gravitational" temperature for closed and critically open Friedmann universes. Also, by using the concept of local thermodynamic equilibrium he generalizes the definition of temperature to the gravitational field of a spherically symmetric star. He concludes by suggesting a method for defining the "gravitational" temperature of arbitrary space-times granted that they are sufficiently smooth.

5. A Computer Game for Quantum Cosmology by Beverly K. Berger and Phillip Kerr, Department of Physics, Oakland University, Rochester, MI 48309.

Abstract - A computer game is adapted from atomic physics to simulate quantized cosmological models. The Wheeler-DeWitt equation is treated as a ground state mode of an imaginary time Schroedinger equation which has the form of a diffusion equation. Probability particles (psips) undergo steps of a random walk to simulate the kinetic energy operator and are created or destroyed to simulate the source term behavior of the potential energy operator. After many steps in imaginary time, the psip distribution relaxes to trace the ground state wave function. Results are presented for the wave functions of three cosmological models---a Robertson-Walker model containing a massive scalar field, a Robertson-Walker model containing a self-interacting scalar field, and the mixmaster (vacuum Bianchi Type IX) cosmology.

6. Are Massive Singularities Trapped? by Piotr Bizon and Edward Malec, Institute of Physics, Jagellonian University, Krakow, Poland, and Niall O Murchadha, Department of Physics, University College, Cork, Ireland.

Abstract - This essay discusses a newly derived sufficient condition for the existence of trapped surfaces in a spherically symmetric spacetime. This condition shows that the so-called Trapped Surface Conjecture: 'Any mass that is concentrated in a region of sufficiently small diameter can be surrounded by a trapped surface' is correct (in the spherical case), and gives an explicit relationship between the amount of matter and the size of the diameter.

7. Gravitational Fields and the Casimir Energy by Steve Blau and Matt Visser, Theoretical Division, Los Alamos National Laboratory, Los Alamos, New Mexico 87545 and Andreas Wipf, Max Planck Institut fur Physik and Astrophysik, Werner Heisenberg Institut fur Physik, Munich, Federal Republic of Germany.

Abstract - The authors show, via zeta function techniques, how to construct an unambiguous finite definition for the Casimir Energy of an arbitrary static spacetime, with or without a gravitational field, and with or without boundaries. They advocate the adoption of this method as an alternative to the many ad hoc techniques currently in use. They show that the Casimir Energy is intimately related to, (but not identical to), the one-loop Effective Energy.

8. Accelerated Observers' Coordinate Frames and the Bounced Observer's Particle Spectrum by B. Broda, Institute of Physics, University of Lodz, Nowotki 149/153, PL-90236 Lodz, Poland.

Abstract - A physically motivated definition of the coordinate frame for an accelerated observer is proposed. The particle spectrum detected by a bounced observer is calculated.

9. Detection of Gravitational Fields by Josephson Junctions by Alexandru C. V. Ceapa, Poste Restante, Bucharest 1, Romania.

Abstract - Supercurrents caused by gravitational fields interacting with the Cooper pairs of Josephson junctions are rigorously estimated. Spinning systems of Josephson junctions overcoming the weakness of the interaction are proposed for detecting gravitational waves, as well as constant and dynamic gravitational fields.

10. Invariant Mass Conjecture in General Relativity by Piotr T. Chrusciel, Department of Physics, Yale University, New Haven, CT 06511.

Abstract - The author discusses the results of a previous analysis where an asymptotic symmetries theorem is proved under hypotheses on the behavior of the metric at spatial infinity compatible with the boost theorem. This implies that the Einstein-von Freud-ADM mass can be invariantly assigned to an asymptotically flat four dimensional end of an asymptotically empty solution of Einstein equations if the metric is a no-radiation metric or if the end is defined in terms of a collection of boost-type domains.

11. The Electromagnetic Self-Interaction of a Charged Superconducting Test Loop by Aharon Davidson and Kameshwar C. Wali, Department of Physics, Syracuse University, Syracuse, NY 13244-1130.

Abstract - Using dimensional reduction technique, the authors derive the reparametrization-invariant electromagnetic self-interaction of a charged superconducting cosmic test string. This self-interaction has a non-trivial effect even in a flat background with no external potentials. It prevents dynamically the generic collapse of a closed string. The authors offer an exact non-singular solution: The loop radius oscillates according to $r^2(t)=a^2+b^2\cos 2\omega t$, where $a^4-b^4=n^2_e n^2_m$, and $n_e(n_m)$ count the total number of electric charges (magnetic fluxons). The time-periodicity of the world-sheet triggers the selection rule $|n_e|+|n_m|=2N$ (N-integer). The fundamentally-charged loop must thus carry current and hence acquire spin. This is in accord with $n^2_e=n^2_m$, which is required if the 'inertial mass' is a constant of motion. The non-Abelian generalization is briefly noted.

12. Fragmentation and Gravitational Collapse by John Bruce Davies, W.R.I., 3016 140th Street, Surrey, B.C., Canada V4A 4J6.

Abstract - The evolution of an unstable gas spheroid is controlled by its initial fragmentation. Mathematically, the author explores the subsequent pressure-free collapse subject to conservation of angular momentum. Various solution approaches for material flow show that oscillations and jets may be present. For galaxies, collapse evolution is shown to be from protosystem through possible quasar-like systems to normal disc and spheroidal systems. The present distribution of globular clusters and disc angular velocity is shown to be a consequence of the fragmentation and collapse. Recent infrared observations indicate the presence of such protogalaxies at extreme redshifts.

13. If There Are More Than Four Dimensions of Spacetime, Why Have Only Three Space Dimensions Inflated? - by John J. Dykla, Department of Physics, Loyola University of Chicago, Chicago, Il.

Abstract - If one adopts the view that the additional dimensions of spacetime appearing in present attempts to construct a unified theory of all the fundamental interactions have physical reality, a natural question is why only three dimensions of space appear to have inflated significantly beyond the Planck scale. This essay suggests that the existence of a unique universal gravitational attraction which may be associated with dynamical degrees of freedom of the curvature tensor requires the inflation of exactly three dimensions of space, independent of the total number of spacetime dimensions in any "theory of everything".

14. Gravitation with Torsion and The Early Universe by Giampiero Esposito, Department of Applied Mathematics and Theoretical Physics, University of Cambridge, Silver Street, Cambridge CB3 9EW, U.K.

Abstract - The gravitational action of a theory of gravity with torsion is found to split up into the one of general relativity plus three correction terms involving torsion, contortion and its spatial derivatives, Christoffel symbols, the metric of the spacelike three-surface and the extrinsic curvature tensor of general relativity. Two surface terms are also found to arise, one of them being related to the torsion field. A $R+R^2$ model of gravity with torsion in a closed Friedmann-Robertson-Walker universe is then studied. The model is cast in Hamiltonian form using Dirac's method; the conditions under which it describes an exponentially expanding early universe are finally derived.

15. Slow Motion Scattering and Coalescence of Maximally Charged Black Holes by Robert C. Ferrell, Department of Physics, University of California, Santa Barbara, CA 93106.

Abstract - The author presents an approximate, n-body solution to the coupled Einstein-Maxwell field equations. The bodies are maximally charged black holes, without rotation. The approximation is that they move slowly. The author does not restrict the masses of the sources. For the two-body case he gives an analytic description of the dynamics. In particular, he finds both scattering orbits, and orbits which result in coalescence.

16. Simple Description of the Lense-Thirring Effect by David H. Frish, Department of Physics, M.I.T., Cambridge, MA 02139.

Abstract - The isotropic transformation $ds' = ds\ (1 - GM/c^2r)$ of Newtonian space, and that of $dt' = dt\ (1 + GM/c^2r)$, account well for the main contributions to the first order post-Newtonian effects predicted by General Relativity. Here the author shows that the Lense-Thirring Effect (Earth-gyro spin-spin coupling) can be calculated as the sum, over all mass elements in the earth, of the refractive toe-ins of any object moving relative to each of those mass elements.

Since both of the first order post-Newtonian "spin" effects---DeSitter and Lense-Thirring---are simply described as familiar geodesic prograde precessions in a simply perturbed velocity field, experimental tests of these effects will not show anything that has not already been measured in the standard tests.

17. Non-Abelian Baldness Conjecture for Black Holes by D. V. Gal'tsov and A. A. Ershov, Department of Theoretical Physics, Moscow State University, Moscow 117234, USSR.

Abstract - The well-known no-hair and uniqueness theorems for black holes can not be applied directly to the case of non-abelian matter fields coupled to gravity. However, an analysis of some generic non-abelian models seems to support "non-abelian baldness conjecture" rejecting the possibility of any essentially non-abelian matter fields structures outside the event horizon. The validity of this conjecture is explicitly demonstrated for the SU(2) Yang-Mills spherically symmetric fields.

18. Testing the Principle of Equivalence with Neutrino Oscillations by M. Gasperini, Dipartimento di Fisica Teorica dell'Universita, Corso M. D'Azeglio 46, 10125 Torino, Italy, and Instituto Naxionale di Fisica Nucleare, Sezione di Torino, Torino, Italy.

Abstract - If the equivalence principle is violated, and gravity is not universally coupled to all leptonic flavours, a gravitational field may contribute to neutrino oscillations. The laboratory limits on the oscillation process can thus be interpreted as tests of the equivalence principle in the quantum-relativistic regime, and put severe constraints on a maximal violation of this principle in the case of massless neutrinos coupled to the Earth gravitational field.

19. A New Look at the Light Cone Inside the Schwarzschild Radius by Ronald Gautreau, Department of Physics, New Jersey Institute of Technology, Newark, NJ 07102.

Abstract - The light cone inside the Schwarzschild radius R_S is looked at using reference systems constructed from radially moving geodesic clocks. These reference systems are the geodesic clock analogues of the well known Eddington-Finkelstein and Kruskal coordinate systems that are widely used to discuss the interior of the Schwarzschild radius. It is shown that inside R_S a light cone is divided by a "limiting" timelike geodesic into two parts. In one part trajectories of geodesics can be followed in the reference systems from $R < R_S$ to $R > R_S$ with no difficulty. The geodesic trajectories in the other portion of the light cone, however, cannot be followed to $R > R_S$ from the location of the light cone inside R_S. The dividing line in the light cone between the followable and non-followable parts is the timelike geodesic trajectory of the particle whose turning radius is R_S, i.e., the "last" particle that can be dropped from, or rise to, R_S.

20. Gravity, Global Geometry, Neutrino by M. E. Gertsenshtein, Institute of Nuclear Physics, Moscow State University, Moscow 119899, USSR.

Abstract - During the gravitational collapse the topological structure of space-time is rather complicated and should be obtained by solving the field equations with the physically realizable source on the complete atlas of maps and not assumed beforehand. The spherically-symmetric self-similar solution is oscillatory, the matter periodically goes out beyond the gravitational radius, the process can be observed from outside. The mass defect is ~60%. Each of the two neutrino pulses of the supernova SN 1987a agrees, in duration and intensity, with the oscillatory solution and contradicts the theory by which the gravitational collapse is irreversible. The extendability of the solution through the physical singularity such as the infinite density is proved by the direct variational methods. The geodesic is extended through the singularity on the gravitational radius by means of the pole shift onto the complex plane. The topological structure of the exact spherically-symmetric solutions is discussed.

21. Supernovae: Where do They Break Off? How Many Times Do They Bang? by L. Herrera, Departamento de Fisica, Facultad de Ciencias, Universidad Central de Venezuela, and L. Nunez, Departamento de Fisica, Facultad de Ciencias, Universidad Central de Venezuela and Laboratorio de Fisica Teorica, Departmento de Fisica, Facultad de Ciencias, Universidad de Los Andes.

Abstract - The precise mechanism whereby gravitational collapse leads to a Type II supernova event is one of the most controversial points in understanding of the final stages of stellar evolution. The "bounce'shock" mechanism and the recently proposed "long-term neutrino mediated" processes compete to explain the ejection of the outer envelopes of the star. Despite their differences, both descriptions consider the shock as the surface where separation of the inner compact core from the expanding outer mantle takes place. In this essay we discuss results from a collapse calculation which indicate that fragmentation does not occur at the shock itself but elsewhere, closer to the boundary of the mantle. The resulting picture enhances the plausibility of the recently proposed two neutrino-burst scenario for the supernova SN 1987-A.

22. On Singularity Avoidance in Quantum Gravity by P. S. Joshi, Theoretical Astrophysics Group, Tata Institute of Fundamental Research, Homi Bhabha Road, Bombay 400 005, India.

Abstract - The quantum effects near singularity are studied here within a very general spacetime framework. The possibility for singularity avoidance is examined. This generalizes the earlier conclusions that non-classical, non-singular states can occur with finite probability in quantum gravity.

23. The Equivalence Principle and Supernova 1987a by Lawrence M. Krauss, Department of Physics, Yale University, New Haven, CT 06511.

Abstract - The nearly coincident observation of neutrinos and photons from Supernova 1987a in the L M C provides the first test of the Weak Equivalence Principle for different relativistic elementary particles, and indeed for any elementary particle without known constituents. The author describes here the test and its implications, and suggests that to unambiguously test an updated Equivalence Principle which is both consistent with our present knowledge and which still probes the relationship between gravity and space-time, relativistic test particles may be required.

24. A Test of the Principle of Equivalence for the Second Generation by Bernhard Lesche, Instituto de Fisica, Universidade Federal do Rio de Janeiro, Ilha do Fundao, Rio de Janeiro, Brazil.

Abstract - It is pointed out that the principle of equivalence has never been tested with matter of the second and third generation of Fermions. A test of the principle of equivalence with muons is proposed.

25. A Feynman Prescription for the Hartle-Hawking Proposal by Jorma Louko, Department of Applied Mathematic and Theoretical Physics, University of Cambridge, Silver Street, Cambridge CB3 9EW, UK.

Abstract - The author discusses the definition of the Hartle-Hawking path integral in a class of spatially homogeneous minisuperspace models. Building on a detailed analysis of the classical variational principle, he constructs a lorentzian path integral between fixed final values of the scale factors and fixed initial values of their proper time derivatives, and then argues that the Hartle-Hawking wave function can be obtained by analytically continuing the initial lorentzian proper time derivatives to the corresponding euclidean proper time derivatives. In the de Sitter minisuperspace model this prescription is shown to yield the wave function obtained by Hartle and Hawking.

26. Back Reaction Effects in Black Hole Space Times by Carlos O. Lousto, I.A.F.E.-CONICET, c.c.67 suc.28, 1428 Buenos Aires, Argentina and Norma G. Sanchez, ER176-CNRS, DARC-Observatoire de Paris, Section de Meudon, 92195 Meudon Principal Cedex, France.

Abstract - The authors solve the semiclassical Einstein equations for the static spherically symmetric case. Using expressions for the $\langle T^{\nu}{}_{\mu} \rangle$ renormalized, they study the effects of the back reaction on black holes space times at 1-loop level. Two different situations appear depending on the graviton-matter balance. If matter is relevant, the temperature is increased and thus the life time decreased from their standard values $T_H = 1/8\pi M$ and $\tau_H = CM^3$. If the graviton is dominant T is smaller than T_H and, more important, it can have a maximum at $M \sim M_p$ and then go to zero, The connection with string theory is discussed.

27. The Topology of Superclusters: A Window on the Early Universe by Adrian L. Melott, Department of Physics, University of Kansas, Lawrence, KS 66045.

Abstract - Analysis of the topology of the distribution of matter in the universe provides information not found in correlation functions. Quantitative measures of the topology can be used to test the hypothesis that structure in our universe grew by gravitational amplification of Gaussian fluctuations.

28. The Origin of Double Inflation by V. Muller and H. J. Schmidt, Akademie der Wissenschaften der DDR, Zentralinstitut fur Astrophysik, 1591 Potsdam, DDR.

Abstract - Double inflation is a typical solution of fourth order gravity

$$L_{grav} = M^2 R - R^2/6,$$

minimally coupled to a scalar field with mass m, and $0 < m << M << M_{pl}$. For equipartition of initial conditions at the Planck era, being equivalent to the Gibbons-Hawking-Stewart measure, we get the probability of double inflation to be about

$$p = 1 - m M/M_{pl}^2.$$

For $t \to \infty$ and a scalar field or ideal fluid as source, the solutions oscillate around $a \sim t^{2/3}$, thus, the R^2 term gives effectively dust, the dark matter of the universe. The big bang is generically of $a(t) \sim t^{1/2}$ type, independent of the matter.

For $M = 0$ and radiation as source the exact solution $a(t) = [\sinh(2H_0 t)]^{1/2}$ for the scale factor supports the attractor-property of the de Sitter solution.

29. On the Dynamics of Long-Distance Geometry by I. J. Muzinich, Mission Research Corporation, Santa Barbara, CA 93102 and M. Soldate, Center for Theoretical Physics, Yale University, New Haven, CT 06520.

Abstract - In any theory of gravity, the Arnowitt-Deser-Misner energy should provide a good notion of energy. One implication is that compactification can change the Hamiltonian; then, standard arguments of energetics can not give a complete description of compactification. It is also inferred that compactification dynamics should be associated with arbitrarily long distances. Physical reasoning suggests that the relevant dynamics involves the interactions of mixed hard and soft virtual momentum components. This suggestion is studied in the context of superstrings using the heuristic of high-energy scattering, initially at small or fixed momentum transfer. An argument based on the eikonal approximation and partial-wave unitarity indicates the possibility that Hamiltonians which describe gravitational interactions at long distances on spaces of more than four asymptotically flat, uncompactified dimensions are in some sense too singular to define consistent theories. The unique status of energy as an effective charge in gravitational theories is emphasized as the common link among these arguments.

30. Perfect Geometrical Detection Volumes in Gravitational Lensing by Robert J. Nemiroff, Racah Institute of Physics, Hebrew University of Jerusalem, Jerusalem, 91904, Israel.

Abstract - Detection volumes are defined and calculated for possible lens and source placements in gravitational lensing. These volumes are found to be perfect, three-dimensional, geometric shapes. Comparison of these volumes to known densities of astronomical objects allows the most accurate calculations of the probability of measuring gravitational lens interactions to date, since they are fully three-dimensional and directly incorporate observational detection thresholds.

31. Quasigroups of Transformations - Asymptotic Symmetries and Conservation Laws in General Relativity - by A. I. Nesterov and L. V. Kirensky, Institute of Physics, University Krasnoyarsk 660036, U.S.S.R.

Abstract - The paper is devoted to the application of quasigroup methods for the problem of conservation laws in General Relativity. The more important differences between the groups of transformations and the quasigroups is in the violation of associative compositional law for the latter ones. A ten-parameter Poincare quasigroup is obtained. The group of motion is a sub-group of the Poincare quasigroup and in the flat spacetime it is reduced to the Poincare group.

Quasi-local conserved quantities based on the Poincare quasigroup are defined and a new definition of energy-momentum and angular momentum at future null infinity (free of super-translational ambiguities) is proposed. For energy-momentum the definition gives Bondi 4-momentum and for angular momentum a new one is obtained. The loss of energy-momentum and angular momentum are found for radiating systems.

32. The Physical Mechanism of Black Hole Evaporation by R. M. Nugayev, Kazan State Pedagogical Institute, Kazan, 420021, U.S.S.R.

Abstract - To understand the mechanism of black hole evaporation the program of Minkowski spacetime results is developed and applied. Hawking's flow of blackbody radiation appears to be a manifestation of the effect of Levin, Polevoy, and Ritov for a vacuum gap between two media with different temperatures. A tentative step towards an attack on the back-reaction problem is made. It is conjectured that in the process of evolution the black hole should transform into the "nether" one with infinite negative energy surrounded by an impenetrable potential barrier.

33. The Role of Time In a Quantum Version of Mach's Principle - by T. Padmanabhan, Astrophysics Group, Tata Institute of Fundamental Research, Homi Bhabha Road, Bombay 400005, India.

Abstract - Mach's principle is interpreted in terms of the global nature of quantum theory. The role of the time coordinate in the definition of particles and consequently in the microscopic description of Mach's principle is highlighted. The author speculates that quantum cosmology may provide a useful version of Mach's principle.

34. Is The Universe Infinitely Old? - by Don N. Page, Department of Physics, The Pennsylvania State University, University Park, PA 16802.

Abstract - The Hartle-Hawking no-boundary proposal for the wavefunction of the universe suggests, via a minisuperspace calculation, that the universe may have had an infinite period of inflation. If the classical spacetime is said to have an edge or singularity where the semiclassical approximation breaks down, that would be at an infinite amount of comoving time in the past, though at only a finite proper time for geodesics with nonzero momentum, so the spacetime would still be singular even if infinitely old.

35. Effects of a Superconductor on Gravitomagnetic Fields and the Potential Effect on the Gyroscope Experiment - by Huei Peng, Department of Physics, The University of Alabama in Huntsville, Huntsville, AL 35899, and D. G. Torr, Institute of Applied Mathematics, Academia Sinica, Beijing, P.R. of China.

Abstract - The authors propose a new class of effects of a superconductor on gravitomagnetic fields. These effects involve an interplay between gravitomagnetism, electromagnetism and quantum mechanics. The authors show that in the presence of both applied magnetic and gravitomagnetic fields, both fields have the same penetration depths on a microscopic scale, i.e., the London and type I superconductors will shield both fields on a macroscopic scale. Therefore, the London or type I superconductor surrounding orbiting gyroscopes will simultaneously shield both the magnetic and gravitomagnetic fields of the earth, i.e., a gyroscope surrounded by a superconductor will not experience a gravitomagnetic spin-spin precession or a dragging of inertial frames, but will distinguish between different explanations.

36. Strong Curvature Singularities in Spacetimes by Istvan Racz, Central Research Institute for Physics, H-1525 Budapest 114, P.O. B.49, Hungary.

Abstract - It is shown that the classical singularity theorems of Hawking and Penrose can be modified such that they state not only the existence of incomplete causal geodesics but that these geodesics in physically realistic situations, must terminate in a strong curvature singularity.

37. Can a Generic Strong Curvature Singularity Be Visible From Infinity? by Wieslaw Rudnicki, Institute of Physics, Pedagogical University, Rejtana 16 A, 35-310 Rzesnow, Poland.

Abstract - It is demonstrated that singularities of Tipler's strong curvature type can be characterized by a certain structure whose properties define in natural way a generic strong curvature singularity. It is shown that a weakly asymptotically simple and empty spacetime must be strongly future predictable if all incomplete causal geodesics, contained in a domain of dependence of a regular Cauchy surface, terminate in a generic strong curvature singularity. This result strongly supports the validity of the cosmic censorship hypothesis.

38. Dynamical Effects on a Composite Quantum System in a Noninertial Reference Frame by M. P. Silverman, Department of Physics, Trinity College, Hartford, CT 06106.

Abstract - The degenerate magnetic substates of an atomic system are split in a rotating reference frame. The splitting and ordering of the states can be experimentally demonstrated by means of laser-induced quantum interference in hydrogenic Rydberg states. This would be the first demonstration of dynamical consequences of a noninertial reference frame on the internal structure of a composite quantum system---in contrast to the recently observed neutron Sagnac effect which effectively involved only point particles. The level splitting is independent of constituent particle masses; thus, a composite quantum system in a noninertial reference frame exhibits effects inequivalent to those that would be engendered in an inertial frame by gravity.

39. Super d-Brane Defects in the Earth Universe by C. Sivaram, Indian Institute of Astrophysics, Bangalore 560034, India.

Abstract - Superstring theories have provided promising possibilities of a framework for unifying all forces of nature including gravity. The generalization of the covariant spacetime supersymmetric superstring action to d-dimensional extended objects (super d-branes) is discussed. These d-brane actions are related to superstring actions in different space-time dimensions by double dimensional reduction. For each super d-brane there is a supergravity multiplet in certain critical dimensions. It is pointed out that super d-branes can arise as higher dimensional topological defects in the early universe. The cosmological consequences of such structures for the early epochs of the universe is discussed especially in connection with their initiating a rapid expansion inflationary phase.

40. Implications of Inflationary and New Inflationary Models of the Universe by S. K. Srivastava, Department of Mathematics, NEHU, Bijni Camput, Bhagyakul, Shillong 793003, India.

Abstract - Using the results of inflationary and new inflationary models of the universe, it is explained how cosmological constant falls, at present, 10^{113} order below its value at GUT's phase transition. Without considering the closed model of the universe (where spatial curvature K = +1), it is discussed that the universe will cease to expand when it is 3.5×10^{772} years old and it will collapse after this epoch.

41. Gravitationally Squeezed Light by James T. Wheeler, Institute of Field Physics, University of North Carolina at Chapel Hill, Chapel Hill, NC.

Abstract - Normally, pure states of coherent light have equal uncertainties for pairs of conjugate variables. In recent years, however, it has become possible to produce and detect light which has unequal uncertainties for some pairs of variables. Such radiation is said to be in a squeezed state. The author explores the possibility that a strong gravitational field can produce a squeezed state of light. Such squeezing does in fact occur, and he derives an expression for the resulting uncertainties in a high frequency limit. These results comprise a new, testable prediction of general relativity.