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Abstracts of Award Winning and Honorable Mention Essays for 1993

Award Essays

First Award - Gravity's Rainbow - by George F. Smoot* and Paul J. Steinhardt*, *Lawrence Berkeley Laboratory, Space Sciences Laboratory & Center for Particle Astrophysics, University of California, Berkeley, CA 94720, *Department of Physics, University of Pennsylvania, Philadelphia, PA 19104.

Abstract - The temperature anisotropy of the cosmic microwave background may be partially the imprint left by gravitational waves. Measuring the gravitational wave component and spectral shape of the anisotropy is a critical test of inflationary cosmology and theories of large-scale structure formation.

Second Award - Horned Particles as the Endpoint of Hawking Evaporation - by Thomas Banks, Department of Physics and Astronomy, Rutgers University, Piscataway, NJ 08855-0849.

Abstract - This essay reviews recent developments in the theory of Hawking evaporation of black holes. Study of near extremal magnetically charged black holes using a two plus four dimensional effective field theory has led to the concept of horned particles or *cornucopions* as the endpoint of Hawking evaporation. Horned particles are geometries containing two large asymptotic regions connected by microscopic necks. They look like point particles to an observer in any given asymptotic region, but in many ways behave like macroscopic objects. In particular, it is very difficult to pair produce them in external fields and their contribution to virtual loops is highly suppressed. They can serve as the remnants necessary to account for the information apparently lost in Hawking evaporation. The information simply goes into the new asymptotic region formed when the black hole collapses and evaporates.

Third Award - A New Test of the Equivalence Principle: A Null Phase-Delay Experiment - by T. P. Krisher, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109.

Abstract - The author proposes a new test of the Einstein Equivalence Principle (EEP) called a null phase-delay experiment, in which the phase-delay of a signal propagated over a coil of optical fiber is monitored as the gravitational field at the coil is varied. Any variation of the phase-delay would signal a violation of the EEP. An interesting test of the EEP in the solar gravitational field can be performed in the laboratory under carefully controlled conditions. With presently available technology, the author shows that such an experiment could provide a 0.01% test.

Fourth Award - Black Hole Memory - by John D. Barrow, Astronomy Centre, University of Sussex, Brighton, BN1 9QH, U.K.

Abstract - The author discusses the formation of black holes during the very early stages of a universe in which the gravitational 'constant' evolves with time. He argues that black holes will retain 'memory' of the value of the gravitational 'constant', G, at the time of their formation. Their horizon size and their thermal characteristics are determined by the value of G when they form, not by the value we measure in the external universe today. The observational effects of primordial black hole explosions are therefore radically altered.

Fifth Award - Two Essays share the Fifth Award.

1. No More Spacetime Singularities? - by V. Alan Kostelecký[+] and Malcolm Perry[*], [+]Physics Department, Indiana University, Bloomington, IN 47405, [*]D.A.M.T.P., University of Cambridge, Silver Street, Cambridge, CB3 9EW, England.

Abstract - The authors discuss the possibility that the issue of spacetime singularities in general relativity is solved by their stringy extensions.

2. What Have We Learned from Two-Dimensional Models of Quantum Black Holes? - by Edward Teo, Department of Applied Mathematics and Theoretical Physics, University of Cambridge, Silver Street, Cambridge CB3 9EW, England.

Abstract - The two-dimensional black hole provides a theoretical laboratory in which the quantum nature of black holes may be probed without the complications of four-dimensional dynamics. It is therefore natural to ask, what have we learned from this model? Much recent work has focused on the semi-classical limit where the black hole is similar to the Schwarzschild solution. However, in this essay, the author demonstrates that the *exact* two-dimensional quantum black hole is non-singular. Instead the singularity is replaced by a surface of time reflection symmetry in an extended space-time. The maximally extended space-time thus consists of an infinite sequence of asymptotically flat regions connected by timelike wormholes, rather analogous to the Reissner-Nordström space-time. The implications of this to the apparent loss of quantum information arising from black hole evaporation are also briefly discussed.

Honorable Mention Awards (Alphabetical Order)

1. Critical Phenomena and Relativistic Gravitational Collapse - by Andrew M. Abrahams[+] and Charles R. Evans[*], [+]Center for Radiophysics and Space Research, Cornell University, Ithaca, NY 14853, [*]Department of Physics and Astronomy, University of N. Carolina, Chapel Hill, NC 27599.

Abstract - Recent calculations have shown the existence of critical phenomena in general relativity associated with the collapse of wavepackets of massless fields that are near, in parameter space, the onset of black hole formation (the critical point). Two physically distinct systems have been explored: collapse of spherically-symmetric massless scalar field and collapse of vacuum, axisymmetric gravitational waves. Nonlinear effects dominate near the critical point. Black-hole mass serves as an order parameter and has a power-law dependence on critical separation in the supercritical region of parameter space. Remarkably, the values of the critical exponent of the power law are nearly identical in the two systems. The nonlinearity induces the fields to oscillate. Each successive oscillation is an echo, obeying a spatial and temporal scaling relation.

2. Instability of the Re-heated Primordial Baryonic Medium - by Hongguang Bi[+,*], Qibin Li[+], [+]Beijing Astronomical Observatory, Chinese Academy of Sciences, Beijing 100080, China, [*]Department of Physics, University of Arizona, Tucson, AZ 85721.

Abstract - After the epoch of massive quasar formation in the standard big-bang universe ($z \sim 6$), the diffuse baryonic medium left over from the primordial nucleosynthesis would be ionized and re-heated to the temperature about 10^4 K evidenced by the Gunn-Peterson effect. The authors investigate the Jeans type of instability of the hot medium and its observational implications in this essay. They find that the density distribution of the medium is filtered from, and smoother than, that of background dark matters. The temperature distribution is proportional to the density like a $\gamma = 1.60$ polytropic gas. The absorption of the medium at the Lyα transition frequency produces many weak Lyα absorption lines (the Lyα forest) as observed in all quasar spectra.

3. Concept of a Resonant Antennae Observatory for Gravitational Wave Bursts - by Massimo Cerdonio[+], Pierluigi Fortini[*], Antonello Ortolan, Giovanni Andrea Prodi[+] and Stefano Vitale[+], INFN Laboratori Nazionali di Legnaro - Collaborazione AURIGA, via Romea 4, I-35020 Legnaro (Padova), Italy, [+]Department of Physics, University of Trento and INFN Gruppo Collegato di Trento, I-38050 Povo (Trento), Italy, [*]Department of Physics, University of Ferrara and INFN Sezione di Ferrara, via Paradiso, 12 I-44100 Ferrara, Italy.

Abstract - The authors propose a novel approach to the autonomous detection and reconstruction of gravitational wave bursts by an intercontinental network of six resonant antennae. Their method consists in recombining the responses of all the six antennae to the same wavefront, in order to test, besides velocity of light propagation, the transversality and traceless properties of the Riemann tensor of a gravitational wave. In addition the method allows to estimate the amplitude, direction of propagation and polarization of the burst.

4. The Discovery of Critical Behaviour in Massless Scalar Collapse - by Matthew Choptuik, Center for Relativity, Department of Physics, University of Texas at Austin, Austin, TX 78712-1081.

Abstract - The author presents an account of the recent discovery of critical behaviour in the spherically symmetric gravitational collapse of a massless scalar field. Detailed numerical investigations (using an adaptive mesh-refinement/finite-difference algorithm) of the strong-field dynamics of the scalar field in cases where black hole formation occurs, or is imminent, have revealed a variety of non-linear phenomena which are summarized here. These results (particularly in light of recent work by Abrahams and Evans) suggest that at least some types/aspects of black hole formation may be analyzed in terms of standard critical phenomena theory.

5. Is There a Scalar Contribution to Gravity? - by Thibault Damour[+], Gilles Esposito-Farèse[*], and Kenneth Nordtvedt[0], [+]Institut des Hautes Etudes Scientifiques, 91440 Bures-sur-Yvette, France, [*]Centre de Physique Théorique, 13288 Marseille Cédex 9, France, [0]Montana State University, Bozeman, MT 59717.

Abstract - The tight bound on the possible admixture of a scalar component to gravity ($\alpha^2 < 0.001$) obtained in solar-system experiments, has been generally interpreted as reducing the likelihood that a massless scalar field exists. It is also widely felt that if such a field exists, it is so weakly coupled that it will have anyway nearly no observable consequences, even in systems involving strong gravitational fields. The authors show that both conclusions are premature in view of the existence of two different mechanisms, taking place within wide classes of tensor-scalar theories. These mechanisms can naturally reconcile a very small value of α^2 in solar-system experiments with the expectation that the coupling of the scalar to matter involves only parameters of order unity, or with the existence of sizable strong-field deviations from general relativity in neutron star systems.

6. A Theory of Cosmological Models - Arthur E. Fischer, Department of Mathematics, University of California, Santa Cruz, CA 95064.

Abstract - In this paper a theory of cosmological model is proposed. A *cosmological model* is defined as an Einstein-inextendible Einstein spacetime. A cosmological model is *absolute* if it is a Lorentz-inextendible Einstein spacetime, *predictive* if it is globally hyperbolic, and *non-predictive* if it is non-globally-hyperbolic. The author discusses several features of these models in the study of cosmology. As an example, any compact Einstein spacetime is always a non-predictive absolute cosmological model, whereas a non-compact complete Einstein spacetime is an absolute cosmological model which may be either predictive or non-predictive.

The author discusses the important role played by maximal Einstein spacetimes. In particular, he examines the possible proper Lorentz-extensions of such spacetimes, and shows that a spatially compact maximal Einstein spacetime is exclusively either a predictive cosmological model or a proper sub-spacetime of a non-predictive cosmological model. Provided the Strong Cosmic Censorship Conjecture is true, a generic spatially compact maximal Einstein spacetime must be a predictive cosmological model.

It is *conjectured* that the Strong Cosmic Censorship Conjecture is not true, and, making a virtue out of a vice, it is argued that the failure of the Strong Cosmic Censorship Conjecture would point to what may be general relativity's greatest prediction of all, namely, *that general relativity predicts that general relativity cannot predict the entire history of the universe.*

7. Quantum Squeezing and Cosmological Entropy Production - by M. Gasperini and M. Giovannini, Dipartimento di Fisica Teorica dell'Università, Via P. Giuria 1, 10125 Torino, Italy and Istituto Nazionale di Fisica Nucleare, Sezione di Torino.

Abstract - The entropy growth in a cosmological process of pair production is completely determined by the associated squeezing parameter and is insensitive to the number of particles in the initial state. The total produced entropy may represent a significant fraction of the entropy stored today in the cosmic black-body radiation, provided pair production originates from a change in the background metric at a curvature scale of the Planck order.

8. (In)stability of Minkowski Space Versus Inflation: A Spontaneous Symmetry Breakdown Mechanism - by E. Gunzig, R. Laura and P. Nardone, Université Libre de Bruxelles, CP 231, Faculté des Sciences, 1050, Bruxelles, Belgium.

Abstract - The sign of the gravitational coupling constant, hence the corresponding universal attractive character of this interaction, may unexpectedly be affected by a subtle interplay between classical general-relativistic gravity and its interaction with quantum sources, in the context of semi-classical gravity. Some phenomena, such as the (in)stability of Minkowski space, or the Inflationary expansion, owe their origin to this property.

9. The Laws of Black-Hole Dynamics - by Sean A. Hayward, Max-Planck-Institut für Astrophysik, Karl-Schwarzschild-Strasse 1, 8046 Garching bei München, Germany.

Abstract - Definitions of marginal surfaces and apparent horizons are given which distinguish between inner and outer horizons, and between future and past horizons. Outer marginal surfaces have spherical topology. Outer horizons are spatial and inner horizons are Lorentzian, excluding the stationary case where they are null. Future outer horizons have non-decreasing area form, constant only in the null case - the 'second law'. A definition of the surface gravity of an outer marginal surface is given. The average surface gravity of an outer marginal surface has an upper bound, attained if and only if the surface gravity is constant - the 'zeroth law'. The variation of the area form along an outer horizon is determined by the surface gravity and an energy flux - the 'first law'.

10. Can Semi-Classical Wormholes Solve the Cosmological Horizon Problem? - by David Hochberg and Thomas W. Kephart, Department of Physics and Astronomy, Vanderbilt University, Nashville, TN 37235.

Abstract - Measurements of the cosmic microwave background (CMB) radiation provide the strongest evidence for the isotropy of the observable Universe on the largest scales. However, the CMB is received from regions which were not in causal contact at the time of last scattering. This is the horizon problem and the generally accepted solution is to invoke an inflationary period in the early Universe. The authors consider the possibility that the Universe did not necessarily inflate, but was filled with a network of evolving wormholes connecting otherwise causally disjoint regions. These wormholes emerged naturally from the Planck epoch and need only have stayed open for a very brief time ($\delta t < 10^{-34}$ sec) in order to have thermalized the early Universe.

11. From Quantum Fluctuations to Large-Scale Structures - by Jai-chan Hwang, Korea Astronomy Observatory, San 36-1, Whaam-dong, Yusung-gu, Daejon, Korea.

Abstract - An acceleration phase in the early universe allows microscopic quantum fluctuations inside a causal domain to expand into macroscopic ripples in the spacetime metric. These, in turn, can evolve into large-scale structures in the universe. After its generation from quantum fluctuations, a ripple in the metric spends a long period outside the causal domain where its evolution is characterized by a conserved amplitude, a fact closely related to the large-scale Friedmann-like evolution of the perturbed Friedmann universe. The author shows that, under the assumption of linear processes, the generation and evolution of large-scale structures can be described quite simply.

12. The Cosmic Censorship Hypothesis in Black Hole Physics - by P.S. Joshi and I.H. Dwivedi, Tata Institute of Fundamental Research, Homi Bhabha Road, Bombay 400 005, India.

Abstract - After reviewing the present status of the cosmic censorship hypothesis in black hole physics briefly, the authors argue that before a rigorous formulation and a proof for the same can be arrived at, a physical formulation needs to be developed which captures the basic spirit of censorship. Specifically, they point out that the occurrence of naked singularities in gravitational collapse need not necessarily be due to the form of the matter used to model the collapse such as the dust, perfect fluid or collapsing radiation in that these could occur for a wide variety of matter satisfying the positivity of energy density. Nor are such features confined to spherically symmetric collapse as may be seen by perturbing the spherical self-similar collapse models. Possibilities towards a physical formulation of censorship are discussed.

13. Cylindrically Symmetric Thin Walls in General Relativity - by M. Khorrami and R. Mansouri, Department of Physics, Sharif University of Technology, P.O. Box 11365-9161, Tehran, Iran.

Abstract - Assuming a continuous ansatz for the metric the authors solve the Einstein equations for a thin wall with cylindrical symmetry. The solution can correspond to a collapsing matter shell leading to a naked, without any horizon, singularity.

14. Black Holes in Two and Four Dimensions - by José P. Sande Lemos, Departamento de Física, Instituto Superior Técnico, Av. Rovisco Pais 1, 1096 Lisboa, Portugal, and Departamento de Astrofísica, Observatório Nacional-CNPq, Rua General José Cristino 77, 20921 Rio de Janeiro, Brazil.

Abstract - Black holes play an important role in the quantization of gravity. Two-dimensional theories admit black hole solutions, which in turn are being used to test evanescence in the semi-classical regime. Whether or not these models make contact with physics in four dimensions is not a closed issue. This scene changes when we consider a two-dimensional theory derived from General Relativity. The theory admits black holes and free dilaton solutions, and can be the key to bring two-dimensional results into the four-dimensional real world.

15. The Fourth Law of Black Hole Thermodynamics - by C.O. Lousto, Universität Konstanz, Fakultät für Physik, Postfach 5560, D-7750, Konstanz, Germany.

Abstract - The author shows that black holes fulfill the scaling laws arising in critical transitions. In particular, he finds that in the transition from negative to positive values the heat capacities C_{JQ}, C^{QQ} and $C_{J\Phi}$ give rise to critical exponents satisfying the scaling laws. The three transitions have the same critical exponents as predicted by the universality Hypothesis. The author also briefly discusses the implications of this result with regards to the connections among gravitation, quantum mechanics and statistical physics.

16. Parity Violation and Arrow of Time - by Anne Magnon, Départment de Mathématiques, Université Blaise Pascal, Complexe Scientifique des Cézeaux, B.P.45, 63177 Aubière Cédex, France.

Abstract - It is shown that PT invariance can be experimentally confirmed within the framework of General Relativity. The author suggests that an evidence for the asymmetric flow of time (arrow of time) in the Universe could be traced back, at the quantum level, to PT violation in presence of non trivial space-time topology and related charges.

17. D=3 General Relativity Is not D=3 Gravity - by N.K. Nielsen[+] and Y. Verbin[*], [+]Fysisk Institut, Odense University, DK-5230 Odense M, Denmark, [*]Physics Group, The Open University of Israel, Tel Aviv 61392, Israel.

Abstract - Three-dimensional General Relativity has many intriguing properties. Among them is a vanishing Newtonian potential which disqualifies this theory to serve as a theory for three-dimensional gravity. The proper description of three-dimensional gravity is obtained by dimensional reduction of four-dimensional General Relativity, and shown to be a scalar-tensor theory. This theory admits a Newtonian limit and can further incorporate all the non-Newtonian objects like gauge strings and global strings as well.

18. The Space-Time Manifold as a Critical Solid - (Dedicated to the memory of Robert E. Marshak) - by Peter Orland, The City University of New York, Baruch College, 17 Lexington Avenue, New York, New York 10010.

Abstract - It is argued that the problems of the cosmological constant, stability and renormalizability of quantum gravity can be solved if the space-time manifold is not fundamental, but arises through spontaneous symmetry breaking. A "pre-manifold" model is presented in which many points are connected by random bonds. A set of D real numbers is assigned to each point. These numbers are coupled between points connected by bonds. It is then found that the dominant configuration of bonds is a flat D-dimensional manifold, on which there is a massless matter field. Adjusting the parameters of the model leads to fluctuations which at large distances describe quantized massless gravity if $D = 4,6,8....$ These fluctuations do not destabilize the manifold. An approach to include Lorentzian signature is presented.

19. Physical Solutions of Semiclassical Gravity - Leonard Parker[+] and Jonathan Z. Simon[*], [+]Department of Physics, University of Wisconsin-Milwaukee, Milwaukee, WI 53201, [*]Department of Physics, University of Maryland, College Park, MD 20742.

Abstract - Semiclassical gravity is an effective low energy theory with time derivatives higher order than the usual two, due to its curvature-squared corrections. Not all solutions are physical, and non-physical solutions must be excluded before predictions are made. Because semiclassical gravity is derived as a low-energy perturbative approximation to full quantum gravity (first order in $\hbar$), the most natural method of obtaining physical solutions is to only consider solutions perturbatively expandable in $\hbar$. For many forms of matter, the semiclassical equations can be consistently reduced to second order, automatically removing the unphysical solutions. Two simple examples are demonstrated: a Friedmann-Robertson-Walker solution illustrating the properties of typical semiclassical solutions, and a Schwarzschild interior solution demonstrating how semiclassical corrections can bypass classical theorems constraining the interior structure of compact objects.

20. Gamma-Ray Bursts from Coalescing Neutron Stars - a New Cosmological Indicator - by Tsvi Piran, Harvard-Smithsonian Center for Astrophysics, Cambridge, MA 02138, and Racah Institute for Physics, The Hebrew University, Jerusalem, Israel, 91904.

Abstract - Coalescing neutron star binary are rare events, only 10^4 such events took place in our Galaxy since it was formed. Still, being amongst the strongest energy sources in the Universe, their γ-ray signals and gravitational radiation pulses can be observed from cosmological distances. The author suggests that these observations provide new tools to measure the parameters of the Universe and its evolution.

21. Centrifugal Reversal and Internal Structure of Ultra Compact Objects - by A.R. Prasanna, Physical Research Laboratory, Ahmedabad 380 009, India.

Abstract - It is conjectured that there could be states of equilibrium configurations wherein the pressure gradient forces could counterbalance both gravitational and centrifugal forces, for rotating configurations, arising out of centrifugal reversal an effect purely general relativistic. If such compact bodies exist without ending up as black holes, they can sustain extremely large angular velocities without the fear of centrifugal break up as is usually considered in all discussions of rapidly rotating compact objects.

22. Evolution of Kaluza's Five-Dimensional Unified Field Theory - by Jerzy Rayski, Uniwersytet Jagielloński, Instytut Fizyki, 30-059 Kraków 16, Poland.

Abstract - Preceded by a historical introduction the problem of a multi-dimensional extension of the geometrical framework of physical reality is discussed. Both metrical spacetime and superspace are taken into account. Arguments in favour of a six-dimensional spacetime D=6 are presented. A conviction that - according to "the spirit of Kaluza's theory" - all vector fields should be incorporated into the metric is a prejudice: some are ingredients of metric, but some other are genuine multivectors. The idea of supersymmetry is taken into account only in so far that fundamental fields form a supermultiplet of highest extension N=8, but supersymmetry is only global whereas local interactions do not need to be fully supersymmetric but locally gauge invariant and generally relativistic (replacing partial by covariant derivatives). Even a global supersymmetry may soften convergence difficulties so that super-strings may be dispensed with. The set of all fields including 3 families of quarks and leptons may be arranged into a table resembling Mendelejev's one. A generalized Higgs mechanism explains the large values of masses including that of the top quark.

23. Recovering Information Borne by Quanta that Crossed the Black Hole Event Horizon - by M. Schiffer, CERN, CH-1211 Geneva 23, Switzerland.

Abstract - In this essay, the author discusses, in the framework of communication theory, his recent results which show that the information borne by quanta that cross the black-hole event horizon is partially transferred to the black hole radiation. The mechanism responsible for the correlation between incoming and outgoing radiations are stimulated emission (bosons) and the exclusion principle (fermions).

24. Testing The Gravitational Origin of Galaxy Clustering - by István Szapudi and Alexander Szalay, Department of Physics and Astronomy, The Johns Hopkins University, Baltimore, MD 21218.

Abstract - The authors present a novel method to test the gravitational origin of the galaxy correlations. The two point correlation function is an important and intuitive statistic, but with a limited discriminating power. Higher order correlation functions test whether the clustering is caused by gravity, but are difficult to measure and interpret. The authors propose a new statistic which captures the relevant information in the higher order correlations without any of their disadvantages, and is easily measurable from existing the future galaxy catalogs. Using this statistic, an extremely simple clustering hierarchy emerges from the data, fully consistent with gravity, also providing useful clues to solve the BBKGY equations which describe gravitating statistical systems.

25. Mach's Principle Revisited - by K.P. Tod, Mathematical Institute and St. John's College, Oxford, OX 1 3JP, England.

Abstract - In this essay, the author reviews first Mach's Principle and then the notion of an isotropic singularity. He gives evidence to support a formulation of the cosmological part of Mach's Principle as the requirement that the initial singularity of space-time is an isotropic singularity, and he suggests that Mach's Principle may become a 'theorem' of quantum gravity.

26. Observables and Local Symmetries - by C.G. Torre, Department of Physics, Utah State University, Logan, UT 84322-4415.

Abstract - Using a recent classification of local symmetries of the vacuum Einstein equations, it is shown that there can be no observables for the vacuum gravitational field (in a closed universe) built as spatial integrals of local functions of Cauchy data and their derivatives.

27. Naked Singularities in Spherically Symmetric Gravitational Collapse: A Critique - by C.S. Unnikrishnan, Gravitation Experiments Group, Tata Institute of Fundamental Research, Homi Bhabha Road, Bombay - 400 005, India.

Abstract - One of the most important questions in physics of gravitation phenomena is whether gravitational collapse can lead to the formation of singularities which are not hidden by an event horizon. The Cosmic Censorship Conjecture (CCC) represents the hope that such a drastic event cannot happen in realistic physical situations. However, in the recent past several counter examples to the CCC were demonstrated by several researchers in situations of spherically symmetric gravitational collapse. The disturbing aspect about these counter examples is that they are strong naked singularities - they can crush matter to zero volume and can have disastrous influence on causal physics. The author examines these counter examples for their physical content by working through the dynamical collapse of inhomogeneous dust and argues that these are not physically acceptable counter examples. His main result is that the singularities when naked are weak and when strong, strongly censored. The strong naked singularities in the counter examples do not arise from dynamical collapse; they result from the intrinsically singular nature of the initial density distributions chosen. The CCC seems to remain robust as far as spherically symmetric collapse is concerned.

28. The Expanding Universe - by Wang Mian[+] and Cheng Bao Liang[*], [+]Department of Physics, Henan Normal University, Xinxiang, Henan, China 453002, [*]Department of Astronomy, University of Illinois at Urbana, Urbana, IL 61801.

Abstract - The authors propose a model of an expanding universe. For a closed universe, after its inflation, it will expand forever. The underlying gravity theory is the scalar-tensor gravity with the coupling function $\omega(\phi)$ and cosmological function $\lambda(\phi)$. The gravitational scalar field ϕ plays the role of inflaton. The $\lambda(\phi)$ behaves as a large cosmological constant in the early universe so that it drives inflation and it becomes very small after inflation. The $\omega(\phi)$ and $\lambda(\phi)$ together prepare a double-well potential for the motion of ϕ. The model is free of the horizon problem, of the entropy problem, and of the monopole problem; it requires no fine-tuning of the Ω value of the very early universe, it explains the large amount of dark matter and the small value of cosmological constant today. Especially, it predicts consistency between the Jeans mass and the mass of the present galaxies.

29. Theory Independent Birkhoff Theorem - by James T. Wheeler, Utah State University Department of Physics, Logan, UT 84322.

Abstract - Without assuming any field equation for gravity, the author shows that the vanishing of R_{π} in a well-specified class of coordinate systems is a necessary and sufficient condition for the existence of a unique, timelike, hypersurface orthogonal Killing field. He shows that these static solutions generically have singularities at the origin of the spatial coordinates, finds the general form of their metrics, and proves a theorem concerning the occurrence of horizons.