GRAVITY RESEARCH FOUNDATION
NEW BOSTON, NEW HAMPSHIRE
03070

Abstracts of Award Winning and
Honorable Mention Essays for 1972

Award Winning Essays

First Award - Gravitational Radiation as a Stellar Engineering Device by John Faulkner, Lick Observatory, Board of Studies in Astronomy and Astrophysics, University of California, Santa Cruz, California.

Abstract - Gravitational radiation losses, by continuously reducing the scale size of the system, induce mass transfer in the cataclysmic variables, or dwarf novae of type U Geminorum. The mass transfer proceeds at a rate that is equal to that observed, and equal to that apparently required by theoretical studies of mass accretion as the cause of dwarf nova outbursts. An origin is suggested for the recently discovered binary AM CVn (= HZ 29) of unusually low period ~1051 seconds. In the model the secondary is a degenerate helium star of mass ~0.04 $M_\odot$, the remnant core of a main sequence star.

Second Award - Are Weber's Pulses Illegal? by Peter Kafka, Max-Planck-Institut für Physik und Astrophysik, 8 München 23, Föhringer Ring 6, Germany.

Abstract - Implications of Weber's experiment on the detection of gravitational radiation are reconsidered. A way is sketched, along which one arrives at an unprejudiced estimate of the mass loss at the galactic center, if the radiation mechanism is roughly isotropic. Instead of the usually quoted thousand or less solar masses per year, a mass loss estimate of several million solar masses per year results. Since Weber's results pose severe limitations to all source models which favor the galactic plane, it seems nearly impossible to find a reasonable physical picture.

Third Award - Observations of the Curvature of Space-Time by P.E. Roe, Institute of Theoretical Astronomy, University of Cambridge, Cambridge, England.

Abstract - The author describes a practical method of observing the curvature of space-time due to gravity based on the scattering of light away from null geodesics. The theory of the method is based on a perturbation technique developed by de Witt and de Witt. Calculations show that events in the near neighborhood of dense massive objects give rise to multiple images. These multiple images can be exploited to measure the mass of the dense objects. The method is used to interpret the light curve of the Crab Pulsar. The mass of the Pulsar turns out to be about three solar masses.

Fourth Award - The Case for a Chaotic Cosmogony by Joseph Silk, Berkeley Astronomy Department, University of California, Berkeley, California.

Abstract - It is argued that galaxy formation is an inevitable consequence of sufficiently chaotic initial conditions within the constraints implied by Einstein's field equations. Anisotropic rotation-free universes are shown to generate vorticity when, at early epochs, neutrino viscosity dissipates the anisotropic expansion. The vorticity becomes turbulent within the particle horizon, and the nonlinear density fluctuations thereby induced lead to the eventual formation of galaxies. Present limits on global vorticity restrict the primordial turbulence to velocities of a few percent of the speed of light. This nevertheless enables the present theory to account for many observed properties of galaxies.

Fifth Award - A New Method of Planetary Gravimetry by P.M. Muller and W.L. Sjogren, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California.

Abstract - Before 1968, it had been impossible to make high-resolution global gravimetric maps of planetary bodies. To be sure, gravimetry traverses had been run over limited regions of the earth, and spacecraft perturbations had revealed the basic shapes of both the earth and moon. It had not been possible, however, to gravitationally map the earth or any other planetary body well enough to reveal the detailed local gravity variations so important to geophysical research and planetology. This essay describes the new and unique method of direct gravimetry invented by the authors, and demonstrates how this technique was applied to making the first detailed gravity mapping of another planetary body (the moon). The consequent discovery of mass concentrations under the lunar ringed seas has had considerable impact on our understanding of lunar structure and history.

Honorable Mention Essays (Alphabetical Order)

1. Black Holes and the Second Law by J.D. Bekenstein, Joseph Henry Laboratories, Princeton, New Jersey.

Abstract - Entropy can disappear down a black hole, thus leading to an apparent transcendence of the second law of thermodynamics. Yet, black holes are known to exhibit a tendency to irreversibly increase their areas, a phenomenon reminiscent of the second law. The author proposes a generalized form of the second law, "common entropy plus black-hole entropy never decreases", which is not transcended when entropy goes down a black hole, and which shows the tendency of the area to increase to be a consequence of the second law. He also arrives at the expression for the entropy of a black hole.

2. Gravitational Effects in the Vapor-Liquid Critical Region by Bill C. Dobbs, University of Kentucky, Lexington, Kentucky and Paul W. Schmidt, University of Missouri, Columbia, Missouri.

Abstract - A model of a fluid near its vapor-liquid critical point is discussed. The fluid, constrained to constant average sample density, is represented by a static scaling equation of state. It is found that gravitational effects may cause the sample density to vary by about 14% over the cell height, 3.15 cm. The small angle x-ray scattering from the sample is calculated considering gravitational and collimation effects. Gravitational effects upon the coexistence curve and the critical exponent β are evaluated. As expected, the fluid coexistence curve has a flat top.

3. Planetary Gravitational Constants Determined From Spacecraft Flybys by Pasquale B. Esposito, Mail Stop CPB-201, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California.

Abstract - The masses of the sun, the planets and the satelites of the planets are fundamental physical quantities in the scientific study of the solar system. Before the "Space Age", planetary masses were deduced by analyzing decades of classical astronomical data. With the advent of interplanetary spacecraft missions, a spacecraft flyby of a planet enabled the planet's mass to be determined several orders of magnitude better than its previous value. This was accomplished by analyzing only several days to several weeks of data. Consequently, the introduction of the interplanetary spacecraft as a modern scientific tool in planetary exploration has resulted in the knowledge of highly accurate parameters characterizing the solar system.

4. The Scalar-Tensor Theory and General Relativity by E.R. Harrison, Department of Physics and Astronomy, University of Massachusetts, Amherst, Massachusetts.

Abstract - The various versions of the scalar-tensor theory (e.g. the theories of Jordan, Hoyle, and Brans-Dicke) are derived from a general variational principle. It is shown that scalar-conformal transformations not only interconvert the various current versions of the scalar-tensor theory (i.e. Brans-Dicke theory $\rightleftharpoons$ Hoyle steady-state theory), but also convert the scalar-tensor variational principle into the variational principle of general relativity. The scalar-tensor formalism is therefore implicitly embodied in the theory of general relativity, thus illustrating the considerable freedon available in specifying the nature and physical content of the "matter tensor" in the Einstein equation.

5. Deflection of Polarized Radiation Passing Near the Sun by Martin Harwit, David L. Jauncey and Richard V.E. Lovelace, Cornell University, Ithaca, New York.

Abstract - Current theories of gravitation tacitly assume that two orthogonally polarized beams of radiation will be deflected by equal amounts on passing near the sun's limb. This hypothesis has never been tested, even though current techniques should permit us to measure a differential deflection a thousand times smaller than the total deflection suffered by the radiation.

In October 1972, the authors propose to measure the difference -- if any -- of the deflection of orthogonally polarized radiation from the unresolved cosmic radio source 3C279. Such a difference would be in violation of the equivalence principle, but it would come about if clocks run at rates dependent on their orientation with respect to the curvature of a gravitational field.

6. Solar Oblateness: A New Interpretation by David Layzer, Harvard College Observatory, Cambridge, Massachusetts.

Abstract - Dicke has argued that the oblateness of the solar disk as measured by Dicke and Goldenberg implies the existence of a solar gravitational quadrupole moment large enough to spoil the agreement between observations of the planet Mercury and calculations based on Einstein's theory of gravitation. This essay presents new observational and theoretical considerations suggesting that the solar surface may be corrugated in such a way as to produce the observed oblateness of the visible disk (bounded by a contour of constant optical depth) without affecting the shape of the physical disk (bounded by a contour of constant mean density).

7. X-Ray Sources -- A Transient State From Neutron Stars to Black Holes by Robert W. Leach and Remo Ruffini, Joseph Henry Physical Laboratories, Princeton, New Jersey.

Abstract - The latest theoretical results are here analyzed, and in the light of recent experimental discoveries the evidence is here presented that x-ray sources and pulsars are different aspects of the same evolutionary process: gravitational collapse of a star at the endpoint of thermonuclear evolution. Estimates and detailed predictions for further experimental observations are given. The case is made that x-ray sources are the key objects that will (for the first time) discriminate between a neutron star and a black hole. The importance of x-ray sources as sources of gravitational radiation is presented.

8. A Relationship between the Gravitational Constant and the Masses of Elementary Particles by Malcolm H. Mac Gregor, Lawrence Radiation Laboratory, Livermore, California.

Abstract - Examination of masses and lifetimes for elementary particles shows that they scale accurately in powers of $\alpha = e^2/\hbar c$. The disparity between gravitational forces and nuclear forces can be characterized by the ratio of the Planck mass to the proton mass, $m^*/m_p \sim 10^{19}$, which is comparable to $\alpha^{-9} \sim 10^{19}$. Using a model for the mu meson, α is written as a ratio between electrostatic and centrifugal forces. A similar ratio between electrostatic and gravitational forces permits the mass of the mu meson to be written as $m_\mu = \sqrt{3/G}\, e\alpha^9$ which is dimensionally correct and accurate to 0.3%.

9. New Relativistic Effect by J. Pachner, Department of Physics, University of Saskatchewan Regina, Saskatchewan, Canada.

Abstract - On the basis of Einstein equations an exact proof is given that rotation can stop the contraction of incoherent matter and revert it to a new expansion even along the axis of rotation. In terrestrial physics the axial acceleration is negligeably small, but it may play an essential role in cosmology.

10. The Gravitational Red Shift: A Three-Body Effect by Asher Peres, Department of Physics, Israel Institute of Technology, Haifa, Israel.

Abstract - The nonlinearity of Einstein's gravitational equations produces three-body forces in the equations of motion. One of their consequences is that the motion of an electron around a nucleus (or a satellite around a planet) is slowed down by the existence of a distant massive body. This is the familiar gravitational red shift, which can thus be derived without invoking the equivalence principle.

11. Is Newton's Law of Gravity a Consequence of the Cosmological Principle? by I.W. Roxburgh, Applied Mathematics Department, Queen Mary College, University of London, Mile End Road, London, E1 4NS.

Abstract - Starting from the cosmological principle and choosing to describe physics in Minkowski space the author shows that gravitation is a necessary consequence of his description. Newton's law of gravity is the necessary consequence of superposing a body on the cosmic background.

12. Quasi-Stellar Objects and Gravitational Lenses by N. Sanitt, Institute of Theoretical Astronomy, University of Cambridge, Cambridge, England.

Abstract - The gravitational lens effect applied to Quasi-stellar objects is investigated. Unusual effects which can occur when galaxies act as lenses are detailed. Particular problems of QSOs that can be explained employing the lens effect are: (a) components of QSOs, which appear to be moving faster than light, and (b) discrepant redshifts between QSOs and apparently associated compact clusters of galaxies. Also a consistent lens image model is proposed for 3C147.

13. Shock Formation from Weak Discontinuities in Relativistic Fluids by M. Sommerfield, University of Michigan, Ann Arbor, Michigan.

Abstract - The author considers a relativistic fluid obeying Einstein's equations and a disturbance which propagates into a uniform region of the fluid. The main objective is to calculate explicitly the proper time at which a shock forms. This is done using the full non-linear system by deriving and solving a system of three ordinary differential equations along the bicharacteristic curves. Two of these equations determine the Gaussian and mean curvatures of the wave front. The third equation, which depends on the mean curvature, governs the formation of the shock. The author finds the amount that the curvature of space-time decreases the critical time below its Newtonian and Minkowskian values.

14. Gravity as a Synchroniser by H. Tittmar, Department of Psychology, 1, Lennoxvale, Queen's University, Belfast 9, N. Ireland.

Abstract - Biological rhythms are phased by synchronisers. While obvious ones like light, temperature, and magnetism are well investigated, gravity has been somewhat ignored. It is proposed that gravity is not only an aid to navigation, but also to orientation and that it may act as a circadian synchroniser. Two assumptions are made: (a) That an organism is able to detect changes in the gravitational and centrifugal vectors of the earth; (b) that organisms respond either basically to periodic changes in the gravitational field - showing lunar day cycles; or that they do so, but strongly modify their rhythms to suit the day/night cycle. A selected number of experiments are offered in evidence toward this, and the next step in testing the hypothethis is broadly hinted at.

15. The Gravitational Spin Interaction by Robert Wald, Joseph Henry Laboratories, Princeton University, Princeton, New Jersey.

Abstract - The author investigates the gravitational spin interaction by studying the deviation from geodesic motion of spinning test bodies. Expressions for the gravitational spin-spin and spin orbit forces are derived and compared with the corresponding expressions in electromagnetism. It is found that the sign of the spin-spin force agrees with that predicted by Hawking on the basis of the fact that less energy can be extracted from colliding black holes if their spins are parallel rather than antiparallel. Furthermore, it is shown that the spin interaction energy quantitatively accounts for the angular momentum dependence in Hawking's formula for the upper limit for energy released from colliding black holes.

16. Experimental Evidence Against "Machian" (Preferred-Frame) Metric Theories of Gravity by Clifford M. Will, California Institute of Technology, Pasadena, California and Kenneth Nordtvedt, Jr., Montana State University, Bozeman, Montana.

Abstract - The authors have recently shown that among the metric theories of gravity (gravitational theories compatible with fundamental empirical evidence such as the gravitational "red shift", Eötvös-type experiments, etc.) there exist theories which possess a Machian-like preferred universal rest frame. Here they show that because the solar system probably moves at about 200 km/sec through the universe several observable but unseen solar system gravitational effects should result in such theories: (a) Anomalous annual variations in the Earth's rotation rate, (b) Anomalous 12-hour period variations in Earth-gravimeter readings, (c) Anomalous perihelion shifts of the inner planets. They then use existing experimental evidence to rule out most such theories of gravity. These results complement those of Hughes and Drever, and Michelson and Morley: their experiments put limits on the strengths of coupling of any cosmological fields to nuclear or electromagnetic energy (i.e. show no aether or preferred frame for non-gravitational physics), while the present analysis limits any cosmological fields coupling to matter's gravitational energy (i.e. shows no aether or preferred frame for gravitational physics).

17. Electrical Coupling to Fluid Dynamic Gravity Waves by Markus Zahn, Department of Electrical Engineering, University of Florida, Gainesville, Florida.

Abstract - Gravitational forces, which have many applications in various fluid mechanical flow structures, can be augmented, diminished or even replaced by electrical forces if the liquids are charged or polarizable, since there is a direct analogy between the gravitational acceleration to the electric field, and between the mass and charge densities. In stratified liquids the characteristics of the usual small signal gravity waves are altered by electrical terms which have the same form as the gravitational effect. This allows experiments whereby the "effective gravity" is controlable and can be made a function of time and space.