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SELECTED ESSAYS FOR 1966

Braden, Charles H.      SPECULATIONS ON KINEMATICS

Taking the validity of the Lorentz transformations for distances of atomic size and larger as the point of departure, a kinematics is suggested in which a group of observers in a given Lorentz frame find a probability distribution for the space-time coordinates of an event. The form of the probability distribution is inferred to be Gaussian and a relationship suggests itself between two parameters that measure the spreads of the probability distributions in space and in time. Dynamical consequences of the kinematics are not investigated except to estimate an upper limit on the remaining parameter.

Carter, Brandon      A GRAVITATIONAL TIME - MACHINE

Few solutions of Einstein's equations seem more likely to be of physical significance than the one discovered by Kerr in 1963. Yet it has the remarkable property that one could travel through the central ring and return before setting out. It has not yet been demonstrated that a gravitational field such as this would develop in natural circumstances. However, if this can be shown, then General Relativity will have to be abandoned or modified because the idea of backward time travel is contrary to the whole philosophy of modern physics.

Desbrandes, Dr. Robert      QUANTUM EMITTER OF GRAVITATIONAL RADIATION

The emission of gravitational waves is much smaller than that of electromagnetic waves. A process is proposed to enhance the gravitational emission by use of quantum processes in which a two-quanta simultaneous annihilation occurs giving rise to spontaneous gravitational radiation. A very monochromatic radiation is anticipated if the emitter is maintained at very low temperature. In an array of emitters conveniently spaced a stimulated emission could be initiated resulting in a relatively powerful monochromatic and coherent gravitational beam. Detecting means based on the same principles could be imagined to make UHF terrestrial communications feasible possibly through solid rock.

DeWitt, Bryce S.      SUPERCONDUCTORS AND GRAVITATIONAL DRAG

It is shown that the magnetic field inside a superconductor is nonvanishing whenever a Lense-Thirring field is present. The quantity which does vanish is a linear combination of the magnetic and Lense-Thirring fields. Moreover, it is the flux of the latter quantity through any superconducting circuit which gets quantized in virtue of the Cooper pairs.

Forward, Robert L. and Miller, Larry R.  
OF DYNAMIC GRAVITATIONAL GRADIENT FIELDS

GENERATION AND DETECTION

We have constructed a generator of dynamic Newtonian gravitational force gradient fields and used it as a signal generator to calibrate the response of the gravitational gradient detectors being developed in our research work on gravitational mass sensors....A simple vacuum system, an iron shield plate, and spring mounts suffice for acoustic and magnetic isolation since most of the nongravitational noises were generated at 44 Hz, the rotational gradient frequency, rather than at 88 Hz the gravitational frequency....Data taken with four different mass distributions agree well with the theory, indicating negligible gravitational coupling.

Greyber, Howard D.

GRAVITATIONALLY BOUND CURRENT LOOPS

Going down the size scale from the whole Universe, the deviations from spherical morphology that appear as spiral, radio and "peculiar" galaxies and quasars are explained in my theory by the presence of gravitationally bound current loops and their associated large dipole magnetic fields in objects of galactic dimensions and smaller. Applications of this idea to current problems in astrophysics are described.

Harrison, E. R.

ORIGIN OF THE UNIVERSE AND QUANTUM COSMOLOGY

In classical cosmology the expanding universe originates from a space-time singularity of infinite density. But, if the universe consists of elementary particles, then prior to a critical epoch the classical view encounters a paradox. The dilemma is resolved at the cost of sacrificing the classical view of the universe in its earliest stages. The existence of limiting quanta of energy, the 'archeons', also makes it impossible for the universe to originate from a state of infinite density. The study of the inchoate universe opens up a new field of physics - quantum cosmology - whose development awaits improvements in our knowledge of gravitation.

Havlicek, Vitezslav  
ON THE LOWERING OF THE ORDER OF THE LAST GRAVITATIONAL MASS-INTERPOSITION EXPERIMENTS FROM  $10^{-6}$  to  $10^{-13}$  or  $10^{-14}$  GAL

A conceptual account is given of high resolution power-torsion gravimeter, including a variation of the interposition method...The resolution power of  $10^{-13}$  or  $10^{-14}$  gal may be reached. The disturbing influences can be suppressed by accessible means, some of which are mentioned in the text.

Hawking, Stephen W.

SINGULARITIES IN SPACE-TIME

The conditions under which Einstein's theory of gravity predicts singularities of space-time are examined. It seems that they might all reasonably be expected to be satisfied. The alternatives are then discussed : that the theory breaks down or that singularities actually occur and might be observable.

Hsu, L.

UNIFIED FIELD THEORY

A unified field theory of gravitation and electromagnetism different from the ones known is proposed. The basic field variables are taken as the matrices  $G_\mu \equiv \{G_{\mu}^{\nu}\}_{\mu\nu}$ . The traceless parts are assumed to describe gravitation. The trace:  $\text{tr } G_\mu$  is taken to be proportional to the electromagnetic four-potential  $A_\mu$ . A metric  $a$  defined by  $O_{\mu\nu} \equiv \text{tr } \tilde{G}_\mu \tilde{G}_\nu$ . Field equations have been chosen. A group theoretical interpretation of the  $\tilde{G}_\mu$  is also given.

Israel, Werner

IS GRAVITATIONAL COLLAPSE IRREVERSIBLE?

The current doctrine of the irreversibility of gravitational collapse is subjected to a critical examination. It is concluded that irreversibility is not, as is generally believed, a consequence of general relativity, but arises from an implicit ad hoc assumption. A more natural interpretation of general relativity leads to a picture of gravitational pulsation which is much more in accord with the observed features of quasi-stellar sources.

Levy-Leblond, Jean-Marc and Thurnauer, Peter     A SIMPLIFIED APPROACH TO NON-LINEAR GRAVITATIONAL THEORY, OR IS THE UNIVERSE STABLE?

A simplified method is presented for finding an approximate solution to a general gravitational problem, arising from a paradox concerning the stability of the universe. The essential non-linearity of present gravitational theories is given a physically intuitive interpretation, and the basic features of the simplified approach are seen to agree with certain results of the more precise theory. The confidence in the approximate analysis is correspondingly enhanced, and it is expected that the approach presented here may have a wider range of applicability for attacking general gravitational problems.

Melosh, H. J.

INERTIA AND GRAVITATIONAL PHENOMENA

In this essay inertia is taken to be a two-point scalar function generated by matter, from which it is possible to derive the forces of gravitation and predict the three classic tests of general relativity. The inertia field and its measurement are rigorously treated to show that the theory derived is essentially that of general relativity, and the conclusion is reached that any mechanistic model for the inertial interaction will also describe gravitational forces.

Motz, Lloyd

A GRAVITATIONAL THEORY OF THE MU MESON AND LEPTONS IN GENERAL

The gravitational theory of elementary particles, previously proposed by the author, is used to obtain the masses of the electron-muon system. According to this theory, an elementary particle such as an electron is a region of space-time of very large Gaussian curvature, at the boundary of which the Newtonian gravitational constant changes discontinuously from its classical value to the value  $\hbar c/m^2$ . With this value of the gravitational constant there are two singularities on the light cone which are obtained as the roots of a simple quadratic equation. One of these gives the mass of the electron and the other gives the mass of the mu-meson. The two singularities are related by the fine structure constant.

Newman, Ezra T. and Penrose, Roger     SOME NEW GRAVITATIONALLY CONSERVED QUANTITIES

It has been commonly believed that there were no absolutely conserved quantities in the Einstein theory of gravity and that only charge was absolutely conserved in the Einstein-Maxwell theory. It is the purpose of the present note to state that this is wrong and to describe ten recently discovered absolutely conserved quantities in the Einstein theory and six conserved quantities in the Einstein-Maxwell theory. These quantities, though they have a trivial meaning in the linear theory of gravity, appear to play a fundamental role in the dynamics of the non-linear gravitational field.

Ne'eman, Yuval and Tauber, Gerald E.     ENERGY GENERATION FROM OSCILLATING CORES IN AN EXPANDING UNIVERSE

In order to account for the energy released and irregular fluctuations present in quasi-stellar sources Nivikov and Ne'eman have suggested that the central part represents a massive core in an expansion stage, perhaps a lagging part of the original cosmological expansion.

For a homogeneous distribution of density and pressure the time-dependent spherically symmetric field equations reduce to those describing an expanding universe. For an equation of state of the form  $P/C^2 = \rho$  corresponding to a maximum concentration of matter they admit oscillating solutions, with periods in agreement with the observed variational periods of the quasi-stellar sources and masses necessary to account for the required energy generation.

Phillips, Peter R.     IS THE GRAVITON A GOLDSSTONE BOSON?

The Nambu theory of elementary particles is examined. We encounter grave difficulties if we insist upon Lorentz invariance. But the model provides an ether, which can violate Lorentz invariance. By taking this idea completely seriously, we can show how the photon and the graviton arise as collective oscillations, and can estimate their coupling constants. These fields travel with velocity  $c$  in spite of being collective oscillations, so that classical experiments seem to have no bearing on the existence of an ether. A new experiment to look for the ether is described in the final section.

Rosen, Gerald     THEORETICAL CONNECTION BETWEEN QUANTIZED GRAVITATIONAL THEORY AND THE SIZE OF ELEMENTARY PARTICLES

For the quantum theory of general relativity in the real physical universe of radius about  $10^{28}$  cm, the order of magnitude analysis in this essay leads to a fundamental and characteristic metrical disturbance with a size of about  $10^{-12}$  cm. It is possible that such a characteristic metrical disturbance (and the considerable amount of associated gravitational energy) may play an important role in elementary particle structure.

Roxburgh, Ian W.     THE STRUCTURE AND STABILITY OF ROTATING MASSIVE STARS IN GENERAL RELATIVITY

The structure equations for a rotating massive star in the general theory of relativity are presented and solved. The dynamical equations

are then considered and the fundamental radial mode of oscillation is calculated from a variational principle. This is found to be zero, implying transition from stability to instability when

$$\frac{2 \frac{GM}{R^2}}{2} = 1.3 \left( \frac{M_\odot}{M} \right)^{\frac{1}{2}} + 0.015 \frac{\Omega^2 R^3}{GM}$$

where  $\Omega$  is the angular velocity and  $R$  the radius of a star of mass  $M$ . This implies that stars less than  $2 \times 10^7 M_\odot$  can reach the temperatures required to burn hydrogen and that more massive stars live for some  $2 \times 10^4$  years before becoming unstable.

Sinsky, Joel A. GRAVITATIONAL INDUCTION FIELD COMMUNICATIONS AT 1660 CYCLES PER SECOND

This reports observations of the dynamical gravitational interaction at the frequency of 1660 cycles per second. The induction fields are employed. The generator consists of the volume integrated acoustic stresses in an aluminum cylinder. The detector is a larger cylinder, instrumented with piezoelectric crystals and cryogenic electronics to detect the dynamical strains. The difficulty of carrying out Cavendish experiments increases with frequency and the work reported here represents a substantial advance in the technology of gravitation.

Weber, Joseph GRAVITATIONAL SHIELDING AND ABSORPTION

The General Theory of Relativity enables us to calculate gravitational shielding and absorption. These effects are analogous to the shielding of electromagnetic fields with the exception that in lowest order quadrupoles rather than dipoles are involved. Quasistatic shielding effects occur in the tides and for some models the shielding effect is several per cent of the applied field. The dynamic shielding is much too small to observe at this time.

Wormell, R. L. GRAVITATION AND THE EXPANDING UNIVERSE

Gravitation is a relatively slight force; in character it is similar to surface tension, but one dimension more complex. Whereas the latter acts across a line, the former acts across an area. Whereas surface tension is equivalent to surface energy, gravitation may be equated with bulk energy. These considerations, together with the expansion of the universe, as shown by the recession of the extra-galactic nebulae, allow a logical deduction of the gravitational constant. The calculated value is found to be in good agreement with that determined by actual laboratory investigation.