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SELECTED ESSAYS FOR 1962

- Bertotti, Bruno, TIME AND GRAVITATION. In the light of Mach's point of view it is pointed out that the theory of relativistic dynamics is relative to the method of time measurement one chooses and hence lacks a proper operational foundation. Thus an isotropic change in the time scales may produce an arbitrary Newtonian field, which can be distinguished from the real one only by the three classical tests of general relativity. A general dynamical theory invariant with respect to the choice of clock is hinted at.
- Boyer, R. H., ON THE ORIGIN OF INERTIA. Classically gravitational forces are seen as counterbalanced by inertial forces, inexplicably in the same ratio for all bodies. General relativity offers a solution in which both concepts become illusory but where, unfortunately, the origin of the inertia is obscured by conditions at infinity. However, the idea that the inertial property of infinity is due to the proximity of some stable mass there suggests the study of a hypothetical universe truly empty at infinity. More generally, a spacetime region having a singular metric might possess properties quite unlike those where the familiar inertial force constantly opposes gravitational attraction.
- Clemence, G. M., PLANETARY DISTANCES ACCORDING TO GENERAL RELATIVITY. The corrections to the radius vector of a planet, calculated according to the conventional Newtonian theory, that are required by general relativity are discussed. For Mercury the principal effect is one of anomalistic period and coefficient 2 km. If the effects smaller than this were detectable it would constitute a fourth observational test of general relativity.
- Dexling, L., EXPERIMENTAL PROOF OF A FIELD OF ROTARY MOTION GENERATED BY A SELF-CHANGING GRAVITATIONAL FIELD. The assumption behind the experiment is that in temporary changes of a gravitational field a field of rotary motion is created which causes a rotation of the attracted mass around the central mass. From my experiments I have deduced a law. My experiments have, however, been conducted primarily, using the simplest apparatus, but they really need more accurate examination with precision instruments, in order to reach an exact evaluation of the physical equation. And, moreover, from above developed laws a theory about the evolution of the solar system is obtained.

Dyson, F. J., GRAVITATIONAL MACHINES. A gravitational machine is designed as an arrangement of gravitating masses from which useful energy can be extracted. It is shown that may exist if the masses are of normal astronomical size. A simple example of a gravitational machine consisting of a double star with smaller masses orbiting around it, is described. It is shown that an efficient gravitational machine will also be a powerful emitter of gravitational radiation. The emitted radiation sets a limit on the possible performance of gravitational machines, and also provides us with a possible means for detecting such machines if they exist.

Fitzgerald, J. V., RESONANT ROTATIONAL GRAVIMETER. The resonant rotational gravimeter, of possible use in gravitational communication, certainly has promising applications in prospecting and as an accelerometer. When a mass capable of harmonic motion was rotated at gradually increasing speeds a resonant speed was reached where the restoring force was nearly neutralized. At this speed the gravitational field deflected the mass by small increments twice each revolution to a large circular amplitude directly proportional to the gravity component. The circular pattern was shown to be one of the solutions to the non-linear equation applicable to this system.

Forward, R. L., GUIDELINES TO ANTI-GRAVITY. This essay emphasizes some little-known aspects of Einstein's General Theory of Relativity. These features, although of minor theoretical importance, can lead us to the generation and control of gravitational forces. Four distinctly different non-Newtonian gravitational forces are described. Those research areas which will lead to control of gravitation are pointed out and guidelines for initial investigation into these areas are given.

Grebe, J. J., GRAVITY FROM ELECTRON POSITRON COUPLE. Gravity can be described as the cumulative interaction of nuclear masses with a postulated standing wave grid which pervades all space. This wave grid with  $0.7 \times 10^{-13}$  cm between nodes would be generated by positron-electron dipoles with the duality of a wave-producing oscillator particle (copel) spinning synchronously with the grid at  $2.2 \times 10^{23}$  cps. Interlocking flux forms clusters of copels into the cores of some thirty elemental particles and hundreds of isotopes. Close packed cubic copel clusters have been shown to correlate data on abundances geometry, electrostatics, nuclear properties, decay energies, quantum mechanics, and particularly the principle of equivalence. They provide the gridwork in space along which Einstein's curved space lines may be drawn. The contraction of this grid in the vicinity of matter allows other matter to interact with the grid to provide an energetically downhill force between the masses resulting in the force of gravity, gravitational red shift and short range nuclear forces.

- Gresky, A. T., A GYROMAGNETIC BASIS FOR GRAVITATION. Quantitative postulates are introduced to suggest that the forces of attraction between masses in free space may subtly involve the rotational, gyroscopic and magnetic properties of the interacting bodies. The mathematical equations expressing the details of these mechanisms are believed to hold possible answers to age-old questions such as those regarding terrestrial magnetism and the inter-relationships or gravitation and electromagnetism. They also contain hints regarding possible methods or principles for achieving levitation of an artificial Earth-satellite, e.g. by the production and control of its geometry, magnetization, rotation, and gyroscopic actions. (The postulates incidentally permit certain theoretic predictions which may be eventually tested in space programs, e.g. it is expected that the Moon will be found to have a very weak magnetic field strength of 0.00084 gauss, whereas the large planet Jupiter is expected to have a quite strong field of about 35 gauss.
- Halpern, L., ON THE RELATIONS BETWEEN GRAVITATION AND ELEMENTARY PARTICLE PHYSICS. The quantisation of the gravitational field by an elementary particle of spin 2 and vanishing rest mass is introduced. The results obtained from such a theory are discussed. The author's results on the limits of gravitational effects on elementary particle processes are presented and conclusions on the quantization of gravitational fields and the future directions of gravitational research are drawn. Special results of the author's investigations on the gravitational Bremsstrahlung of highly relativistic particles, the significance of the sun as a source of gravitons, the trisection of the photon in gravitational fields and others are discussed. Finally effects of the asymmetry of the metric tensor are considered.
- Hippard, J. A., ELECTROMAGNETIC EFFECTS UPON THE GRAVITATIONAL FIELD. A unified Field Theory is developed out of Einstein's General Theory of Relativity and it is found that electromagnetic potentials can influence the gravitational field. The fundamental principle of this theory is that space is five-dimensional with energy as the fifth dimension. The fifth dimensional scalar curvature  $R(5)$  is then seen to be divisible into the energy densities of the gravitational field, the electromagnetic field, matter, and additional terms involving the electromagnetic potentials. These terms suggest ways in which the gravitational field may be effected by the proper combinations of electromagnetic and mechanical techniques.
- Hunter, C., GRAVITATIONAL INSTABILITY AND STAR FORMATION. This essay is concerned with gravity on the cosmic scale. It discusses the role of gravity as a force which can cause a large diffuse cloud of gas to condense and to give rise to the formation of stars. This property of gravity was recognized by Newton. However, the way in which stars condense from diffuse matter is still a process about which a great deal remains to be discovered. This essay gives a brief survey of the mechanics of the condensation of a gas cloud under its own self-gravitation.

- Hurst, J. A., VECTORIAL DERIVATION OF THE EQUATIONS FOR PROPAGATION OF GRAVITY-WAVE ENERGY. Gravity-wave-energy propagation is predicted by general relativity theory field equation solutions. The travelling wave equation can also be derived using elementary vector methods. Relationships of electrostatic field theory are applicable to static gravitic fields with minor modifications. Applications of special relativity theory (Lorentz coordinate transformations) predicts the gravitational equivalent of magnetic "side-thrust" forces. Investigation of the nature of these forces leads to the gravitational equivalents of the Ampere Circuital Law, The Faraday Induction Law, and the "Displacement" mass currents. Applications of these laws, the equivalent of the Gaussian law and the expression of the solenoidal nature of "gravitokinetic" induction fields yields the familiar wave equations for single dimensional wave motion. The derivation can be made generally rigorous by application of microcosmic as opposed to macrocosmic concepts and methods.
- Just, K., QUANTIZATION PROBLEMS OF GRAVITY. The method of Gupta for quantizing Einstein's theory is corrected in its commutators, and extended by transformations which lead to gauges resembling those of Landau. Encouraged by this analogy to electrodynamics we ask for the relation corresponding to Takahashi's which could there be proved by the canonical formalism, and independently by the S-matrix. But we only find that here the connection between gauge transformations and Ward-Takahashi relation is certainly not as simple as there.
- Kirk, D. A., MEANS OF CREATING SIMULATED VARIABLE GRAVITY FIELDS FOR THE STUDY OF FREE CONNECTION HEAT TRANSFER. Theories concerning the transport of heat by free convection predict the effect of various physical parameters. All but gravity have been varied. Means of studying varying  $g$  are discussed. Because of time lag an e-m method appears feasible.
- Kraus, K., GRAVITY AS A LORENTZ INVARIANT INTERACTION. The field equations of Einstein with spatially isolated sources are interpreted as describing a Lorentz invariant interaction. This is possible by means of coordinates which are fixed uniquely up to Lorentz transformations. The existence of such reference frames was proved by Fock, they allow the separation of gravity and inertia. Using such coordinates we can solve many problems of gravitation theory; a consistent definition of energy and momentum and a quantization are now possible. In this interpretation gravity and electromagnetism are very similar, and moreover all field physics look much more uniform than in the usual description.

Maglic, B. C., SOME EXPERIMENTAL CONSEQUENCES OF THE GRAVITATIONAL SHIFT WITHOUT A PRINCIPLE OF EQUIVALENCE. An expression for the gravitational red shift derived without the equivalence principle, makes it possible to predict effects of anti-gravity on the energy exchange between matter and anti-matter. Should an antinucleus emit or absorb a photon, the antigravity would produce an anomalous frequency shift in magnitude or sign, or both, depending on the emitter-absorber configuration; whenever the antinucleus is used as an absorber, the shift will have a positive sign, (blue shift). If an antinucleus emitter and a nucleus absorber were placed next to each other in a terrestrial laboratory, a gravitational shift would be produced about  $10^6$  times as large as the one observed with nuclei. For example the frequency of Balmer series emitted by the antihydrogen atom (antiproton plus positron) in the gravitational field of the earth would be so shifted on the assumption of anti-gravity. As a consequence of such an anomalous gravitational shift in antinucleon-nucleon system an apparent energy unbalance of 2 ev (1 part in  $10^7$ ) would be observed in antiproton annihilations. The existence of these effects would not be in conflict with the actual experimental data, and establishing their absence, (presence) would provide direct and unambiguous arguments against (for) antigravity, not existent at the present.

Moore, F. L., Jr., ELECTROSTATIC ORIGIN OF GRAVITY. The hypothesis that gravitation is of electrostatic origin was developed by Weber and Zollner about 1882, and considered seriously by Lorentz in 1900. Swann expanded the theory in 1961. The theory requires that the proportionality factor in Coulomb's law vary by one part in  $10^{37}$ , an amount not directly observable by experiment. This paper develops a consequence of the theory; a predicted variation among the elements in the ratio of inertial mass to gravitational of nine parts in  $10^4$ . Because this variation is orders of magnitude greater than the limits of error in the Eotvos experiment, the long-standing theory is disproved.

Panders, D., Jr., A UNIFIED FIELD THEORY. When one uses the standard techniques of the calculus of variations to obtain equations of motion for fields from the action principle, one assumes implicitly that the fields must be single-valued. The basic idea of this paper is that although the Lagrangian density must be single-valued, when this does not require that the fields themselves be single-valued, the action principle must be allowed to choose from all the possibilities which remain. We show that this brings in all fields for which the particles described by the original fields are sources.

- Sarill, W. J., GRAVITATIONAL ELECTROMAGNETIC INTERACTIONS. Wheeler and Brills cross sectional estimate for graviton pair production by a neutrino pair is discussed and is found to be too small to produce significant results. Continuing the use of analogy, gravitational electromagnetic interactions are treated in a general fashion by comparing them with related electron-photon processes. An important model describing the virtual interaction of the gravitational field with the electromagnetic field is set up and evaluated. An experiment (now in progress) to determine its validity is described. The final conclusion reached is that gravitational fields are more fundamentally coupled to electromagnetic fields than to matter fields.
- Saxl, E. J., A NEW METHOD FOR THE DETERMINATION OF GRAVITATIONAL PHENOMENA AND SOME EFFECTS OBSERVED WITH IT. A new system for measuring gravitational and allied phenomena is presented that is sensitive to short-time gravitational changes, can interact with an electric field and resolve accelerations. Automatic, sequential, digital recording of gravitational, inertial and allied phenomena is made in motion under electromagnetically controlled conditions. Primary digital output simplifies input into electronic computer-logic and monitoring systems. Increased sensitivity and resolving power permits investigation of the possible interaction of electrical with gravitational phenomena. Electronic instrumentation seems to indicate new effects that may lead towards a more comprehensive theory and applications to engineering.
- Sciama, D. W., MACH'S PRINCIPLE AND THE GENERAL THEORY OF RELATIVITY. The aim of this essay is to propose a new formulation of Mach's principle in general relativity. The principle is regarded as a rule for choosing boundary conditions for Einstein's field equations, which ensures that the inertia of matter is entirely due to its interaction with the rest of the universe. Previous attempts to find such boundary conditions have failed. The new proposal is based on Papapetrou's formulation of Einstein's equations which shows explicitly that the gravitational field itself, as well as matter, is a source of gravitation and inertia. The required boundary conditions can then be stated directly. They lead to a non-linear integral equation which determines all those solutions of Einstein's equations which satisfy Mach's principle.
- Wang, Chi-Yuen, IMPLICATIONS OF GRAVITY DATA OBTAINED FROM ANALYZING THE MOTION OF ARTIFICIAL SATELLITES. The 3rd, 4th, and 5th zonal harmonics of the earth's external gravitational potential obtained by analyzing the motions of artificial satellites are considered to be caused by density variation with respect to latitude in the interior of the earth. This density variation may cause non-hydrostatic stress in the interior. The tangential and radial components are calculated on a surface at an arbitrarily chosen depth of 700 kilometers. The tangential component attains a maximum value of 14 bars at  $65^{\circ}$  N; the radial component 51 bars at the north pole.