GRAVITY RESEARCH FOUNDATION
New Boston, New Hampshire

SELECTED ESSAYS FOR 1964

Bergmann, Otto   MACH'S PRINCIPLE AND THE COSMOLOGICAL CONSTANT.

If the universe is oscillating in time, Mach's principle could be satisfied by a subsidiary condition to Einstein's action principle which ensures that the total energy in the universe is proportional to the space-time extension of the universe. The cosmological constant has then the character of a Lagrange multiplier. A specific analysis of these thoughts is unfortunately too speculative to be of any use to present day cosmology, but it may become useful as guiding principle for fundamental theory.

Brans, Carl H.   A STUDY OF THE LOCAL, ANALYTIC SOLUTIONS TO THE EINSTEIN EMPTY SPACE EQUATIONS.

This essay consists of a study of the structure of the local, analytic solutions to the Einstein empty space equations. Such solutions are divided into discrete types, refining the Petrov classification. Within each type it is shown that a certain set of functions, which can be assigned arbitrarily, can be placed in one-to-one correspondence with the set of metric solutions of that type. Further, different choices for these functions yield essentially different metrics, i.e. not just different coordinate representations of the same metric. In addition, an analytic expression for the metric can be obtained from these functions by differentiation and algebraic operations. Hence, these types and functions provide a complete classification and representation of the local, analytical solutions to the Einstein empty space equations.

Fiala, Harvey E.   DESIGN AND USE OF A GRAVITATIONAL FUNCTION GENERATOR.

This essay goes through the basic steps involved in designing a gravitational function generator. The function generator utilizes the Newtonian fields associated with rotating masses to produce sine waves, square waves, and even pulses that actively attract or repel matter. Experiments are proposed that would result in gravitational shielding if refraction of dynamic fields exists.

Forward, Robert L.   DETECTION OF NON-NEWTONIAN GRAVITATIONAL EFFECTS WITH QUANTUM FLUIDS.

Quantum fluids, such as the superficial components of liquid helium and the superconductive electronics in a superconductor, have the property that once a flow is generated, it will not decay. These fluids therefore have the capability of integrating small continuous forces acting on the superfluid component. It is found that superconductive devices may be able to measure the non-Newtonian gravitational drag effect of a rotating mass.

Halpern, Leopold and Laurent, Bertel   EMISSION, ABSORPTION, AND STIMULATED EMISSION OF GRAVITATIONAL RADIATION OF HIGH FREQUENCY.

It is demonstrated that in the hitherto unaccessible high frequency domain gravitational radiation exists in abundance. Various production mechanisms and their significance in nature are discussed. Methods for absorption and experimental detection of this radiation are described. It is shown that gravitational fields of, in principle, arbitrarily high strength can be produced with the help of stimulated emission by a device which is the gravitational analog of the optical laser. A brief historical survey on the questions of the double nature and propagation of the gravitational field is given.

Harvey, A. L.   ROTATING OBJECTS IN A GRAVITATIONAL FIELD.

The principle of equivalence may be given in two alternative forms following a distinction made by Dicke (1959). The weak form states no more than that which an Eötvös type experiment is presumed to check, i.e. the equivalence of inertial and gravitational mass. The strong form is much more restrictive in that it requires of a theory that there be the possibility of transforming away the field in a suitably small region. It can be shown that Lorentz-covariant theories of gravitation cannot satisfy the strong form but only the weak form. Admitting such theories is tantamount to admitting behavior normally prohibited by the strong principle. Among the phenomena so admitted is that the gravitational acceleration of all objects need not be identical.

Hoffmann, Banesh   NEGATIVE MASS AS A GRAVITATIONAL SOURCE OF ENERGY IN THE QUASI-STELLAR RADIO SOURCES.

Based on the asymmetry of gravitational radiation with respect to positive and negative mass, a physical process is proposed whereby negative mass could be generated inside certain celestial objects. This process could then account for the prodigious amounts of energy radiated by the recently-discovered quasi-stellar radio sources, and could provide an alternative to the synchrotron theory of the continuous spectrum of their emitted radiation. It could also account for the existence of cosmic ray showers of extremely high energy.

Hsu, Lee   GRAVITATION THEORY AND THE FUNDAMENTAL STRUCTURES, AND THE MULTI-FOLD HYPOTHESIS.

An extended gravitation theory, geometrodynamics together with quantum laws in their geometrical interpretations, may be used to describe the fundamental structure of matter. We suggest a quasi-static model for elementary processes. Energy is relative to curvature. By quasi-staticness we mean the use of covarient amplitudes for events in space-time. A "Multi-fold Hypothesis" is suggested. According to it one views the world as a multi-fold space-time composite. The compositions being defined by quantum laws.

Hunt, Hiram Morris   AN HYPOTHESIS ON THE ORIGIN OF GRAVITY.

The gravitational field about a body is postulated to be a
function of the gravitational permeability of the body and the gravi-
tational induction field in which the body lies. The gravitational
induction field is produced by the separation of all of the bodies in
the expanding universe. The limiting factors in the production of the
gravitational induction field include the velocity of the field, the
mass and velocity of the bodies producing the field, and the Doppler
effect. The Einstein relativity theory is compatible with the hypo-
thesis and the relation of inertial mass to gravitational mass is ex-
plained.

Johansen, P. M.   A GRAVITATIONAL ANALOGUE TO THE MAGNETIC FIELD AND
THE CONSEQUENCES OF ITS EXISTENCE.

The striking similarity between Coulomb's Law for the forces
between electrical charges and Newton's Law of Universal Gravitation,
both in the spatial dependence and the products of the charges and the
masses, naturally leads one to investigate the possibility of extending
that similarity to the prediction of a gravitational analogue to the
magnetic field. At the same time, one must identify the dimensions
and numerical values of the constants involved, and also explore the
possibility of other analogues to the accepted relationships of elec-
tromagnetic theory, such as Ampere's Circuit Law.

Just, Kurt   THE SPIN OF GRAVITONS.

It is often stated that quantized gravity employs gravitons
of two spin states (helicity = + 2). While this holds for a "free"
field related to particles of vanishing mass, a more important aspect
of gravity is its quantized interaction with matter, for which six
field components are needed.

Kalmus, H. P.   A NEW GRAVITY METER.

A new system for the measurement of gravity is described in
which g is compared with centripetal acceleration. An AC-null method
is employed so that the measurement becomes independent of the trans-
ducer characteristic. The value of g is finally measured by the de-
termination of a frequency. The instrument should make it possible
to obtain measurements in a much shorter time than with pendulum
methods. Integration methods for the elimination of the effects of
periodic accelerations on a moving platform can easily be applied.

Kantor, Frederick W.   AN EXAMINATION OF THE EXPERIMENTAL AND
THEORETICAL STATUS IN GENERAL RELATIVITY OF THE ASSUMPTION THAT
GRAVITATIONAL EFFECTS TRANSFER ENERGY.

Often, parts of a theory are accepted without stronger support
than that they are customary and esthetically pleasing: conservation
of parity is an example. These can hinder further work. A careful

examination of both the theory of general relativity and the avail-
able experimental evidence indicates that that part of the theory
which is directly supported by experiment is completely independent
of the assumption that the gravitational field can either store and
release energy or serve for energy exchange. Removing this assumption
from the rest of the theory has important, possibly testable, con-
sequences for gravitational radiation.

Kennedy, J. J.   GRAVITATIONAL ANALYSIS OF A MODEL UNIVERSE.

        The model universe analysis is a classical mechanical, non
relativistic treatment of the nature of spatial extension and gravita-
tional fields. The method of approach employs the dynamics of mass
particles in a hypothetical model gravitational field. ...It is
postulated in this paper that gravitational fields are matter waves
which make material particles correspond to them. This, in effect,
is a reverse of the de Broglie hypothesis. ...The model universe is
assumed to be finite and to have positive curvature at infinity.

Kiehn, R. M.   GRAVITATION, RADIATION PRESSURE, AND ELECTRODYNAMICS

        A mechanism of electromagnetic pressure is used as the common
link between gravitational and electrodynamic phenomena. An attempt
is made to derive an equation of state for a distributed charge density
which implies that electromagnetic pressure prevents the elementary
electron from exploding, in essentially the same way that radiation
pressure prevents the gravitational collapse of stars.

Luther, Robert N.   AN APPROACH TO GRAVITY THROUGH RELATIVITY.

        It is the author's belief that gravitation is best approached
through the theory of General Relativity. Mach's Principle and the
Theory of General Relativity, along with D. W. Sciama's observations
and interpretations are used to present a very brief, logical, and
theoretical summation of what gravity is and how it works. A time-
varying constant of gravitation is introduced and a theoretical sub-
stantiation provided. Some of the consequences of a time-varying
constant are suggested.

Mannheimer, Manfred   FIELD ENERGY OF GRAVITATION.

        The mass loss corresponding to potential energy in masses
brought close together as against these identical masses remote from
each other is localized in the gravitational field as a negative mass
of a density $-f^2/8\,r\,k\,c^2$, wherein k is the gravitational constant,
f is the gravitational field strength and c is the velocity of light.
This can explain the advance of the Mercury perihelion. Extrapolation
to atomic and subatomic dimensions has not been made, only to cosmic
dimensions, where gravity controls attraction and repulsion as well.

Mead, C. Alden   POSSIBLE CONNECTION BETWEEN GRAVITATION AND FUNDA-
MENTAL LENGTH.

 An analysis of the effect of gravitation on hypothetical experi-
ments indicates that it is impossible to measure the position of a
body with an error less than $\sqrt{}$ 1.6 x 10^{-33} cm, where G
is the gravitational constant in natural units. A similar limitation
applies to the precise synchronization of clocks. An equivalence is
established between the postulate of a fundamental length and a
postulate about gravitational field fluctuations, and it is concluded
that any fundamental length theory must involve gravitational effects
in an important way.

Melosh, H. Jay IV   A METHOD OF GENERATING LARGE NON-NEWTONIAN
GRAVITATIONAL FORCES.

 This essay employs the isomorphism between electromagnetism
and gravitation to calculate the output of a device which generates
detectable gravitational forces. This device is treated practically,
and the method of driving it is explained in detail. An approximate
solution for the values of the forces generated is made, assuming
feasible values for each quantity. The conclusion is reached that the
device generates readily detectable gravitational forces, and is
feasible.

Melvin, M.A.   A MAGNETO-GRAVITATIONAL STRUCTURE ILLUSTRATING THE
NATURE, ACTION, AND CONTROL OF GRAVITY.

 Underlying the modern theory of gravity is the double physico-
geometrical aspect of energy-stress density in "matter" (including
electromagnetic fields) and spacetime curvature. There follow two
mutually connected sets of gravity and energy-stress field equations.
A recently discovered exact solution for a parallel bundle of magnetic
flux held together by its own gravitational pull is used to illustrate
these equations. A Newtonian model shows many of the features of the
exact theory provided it is supplimented by the idea that stress as
well as energy density can contribute to the gravitating mass of a
system.

Newman, Ezra T.   THE NATURE OF SOURCES OF A GRAVITATIONAL FIELD.

 In most field theories, it is possible to obtain solutions of
the equations in a source free region of space in terms of a distant
source distribution. When one attempts to do the same to Einstein's
theory of gravitation great difficulties are encountered. Due to the
extreme non-linearity of the equations it has so far proven impossible
to determine solutions directly in terms of the sources other than by
approximation techniques. We propose here a means of obtaining asymp-
totically exact solutions at large distances from the source and in
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addition a means of identifying the moments of the source.

Peebles, P.J.E.   THE EQUIVALENCE OF ACTIVE AND PASSIVE GRAVITATIONAL
MASS.

We do not yet have a very accurate observation of equivalence
of active and passive gravitational mass, and it is interesting there-
fore to consider this question in terms of available gravity theories.
There is a general, widely accepted basis, and a very accurate exper-
imental support, for the assumption that gravity may be described by
a classical generally covariant field theory, with a tensor, and per-
haps a scalar gravitational field interaction. Assuming also an active
principle, in this important class of theories active and passive
gravitational mass are equivalent in any laboratory experiment, and
there is the usual conservation law for the energy and momentum of
gravitational field, plus electromagnetic field, plus particles.

Peters, Philip C.   THE DECAY OF A BINARY STAR BY GRAVITATIONAL RADIA-
TION.

The equations of Einstein's general theory of relativity are
found to predict the emission of gravitational waves by a binary star
system. This causes a collapse of the system in a finite time. The
lifetimes, decay rates, and decay characteristics of the major axis
and eccentricity are given. It is found that there can be close binary
stars for which the effects of gravitational radiation can be appre-
ciable, but which have not yet been observed. This would be a further
test of the general theory of relativity.

Rosen, Gerald   A POSSIBLE CONNECTION BETWEEN QUANTIZED GRAVITATIONAL
THEORY AND THE SPACE-TIME PROPERTIES OF ELECTRONS AND PROTONS.

New theoretical conclusions, allowing for a way to control
and use gravitational forces, may actually follow from the theory of
gravity in the small-scale atomic world, namely the quantum theory
of general relativity. As suggested by the analysis in this essay,
there may be a quantum state associated with a certain kind of gravi-
tational disturbance having a radius $r_o - 2.5 \times 10^{-13}$ cm and a life-
time $\tau \simeq 10^{16}$ sec, a quantum state manifesting the space-time pro-
perties of an electron or a proton. If gravity does indeed play an
important role in the quantum domain, then considerable and perhaps
useful gravitational energy is likely to be latent in elementary
particle structure.

Rosen, Leonard C.   SET THEORY FORMULATION OF GRAVITY.

A universal law of gravitation is derived from a formulation
based upon the interaction of sets associated with mass points. A
closed set representation leads to a derivation of Newton's law of
gravitation whereas an open set representation can introduce an addi-
tional $1/r^2$ term in the potential. Utilizing the gravitational po-
tential by defining the sets as open, leads to a predicted rate of
precession of the perihelion of planetary orbits given by:

$$E_p = \frac{constant}{T^{1/3} (1 - E^2) R^2}$$

Rossberg, Klaus   WARD RELATIONS FOR GRAVITY.

      In addition to some well known similarities of the gravitational and electromagnetic fields a Ward-identity also exists for the gravitational field formally similar to that of the electromagnetic field.

Rottenberg, John A.   ORBITAL DYNAMICS IN A GRAVITATIONAL FIELD - A GENERAL SOLUTION.

      After the energy and angular momentum integrals have been extracted, the equations of motion fall into two groupings, here dealt with under the headings, (a) the key equation and its solution, and (b) the osculating conic. As a test of the formula derived in (a), the contributions which would be made by the small relativistic corrections to the dynamical terms are computed. As a test of (b), it is shown that one can now prove the classical conjecture that there is no secular increases in the semi-major axis of the orbit in a gravitational field.

Roxburgh, Ian W.   GRAVITATIONAL THEORIES IN FLAT SPACE-TIME AND THE ONE BODY PROBLEM.

      Arguments are presented in favour of gravitational theories in flat space-time over theories in curved space-time such as the general theory of relativity. It is concluded that flat space-time theories are to be preferred since they only use concepts that can be easily understood whereas curved space-time theories introduce concepts beyond our range of comprehension. Scalar, vector, and tensor theories in flat space-time are presented and the one-body problem is considered in detail. The relation between the tensor theory and general relativity is discussed and it is shown that both the vector and tensor theory are capable of predicting the observed value of the "tests" of gravitational theories.

Rush, Joseph H.   THE ROLE OF INERTIA IN CLASSICAL GRAVITATIONAL THEORY.

      Certain fundamental similarities between gravitation and electromagnetism suggest that the adequacy of classical Newtonian theory may be improved by the hypotehsis of an inertial field, related to a moving mass as the electromagnetic field is related to a moving charge. Ordinary matter and antimatter are considered polar opposites analogous to positive and negative electric charge, and certain dissimilarities between the mechanical and electromagnetic models are attributed to the incompatibility of matter and antimatter. Though the magnitudes of inertial field interactions must be very small, some situations are noted in which such effects may be significant.

Sachs, Mendel   A UNIFIED THEORY OF ELEMENTARY INTERACTIONS.

A new approach to the theory of fundamental processes is discussed that is based on a premise that replaces the "free particle" with the "interaction" as an elementary entity from which the theory is to be constructed. The resulting field equations, in terms of basic spinor and quarternian variables, unify in a dynamically complete description, the matter, electromagnetic, and gravitational manifestations of elementary interactions. The correspondence between the mass spectrum of interacting particles and the geometry of the underlying space-time, according to the solutions of the field equations, implies a uniqueness of the space-time manifold, which in turn has physical implications in regard to astronomical phenomena.

Utiyama, Ryoyu   QUANTUM THEORY AND GRAVITY.

A new kind of approach to the unification of quantum theory with general relativity is proposed. For this purpose a local Lorentz-frame (or Vierbein system) together with a local Hilbert-space is attached to each world point in order to establish a Lorentz-covarient quantum theory at the neighborhood of each world point. The connection between state vectors at different world points is derived from the connection of the corresponding Vierbeins at these points. This connection enables one to derive covarient equations in the macroscopic world from q-number equations in the microscopic world.

Wilkensen, Erik A.   AN INTERPRETATION OF THE RELATIVISTIC GRAVITATIONAL EFFECTS.

The space dragging concept of general relativity theory is traced back to the Thomas effect, occurring when two velocity vectors at an angle are added. Taking the second vector as the change of the first one by time, the change is identified with the gravitational acceleration. Combining Thomas rotation and central gravity acceleration gives formulas which conform with the general relativistic ones, resulting eventually in the famous perihelion advance and light deviation effects. Flat space with constant rate of time is used. The approach opens possibilities to interpret the local relativistic field theories in an external description.

Wirsching, Paul H.   A POSSIBLE USE OF THE GRAVITATIONAL FORCE TO DETERMINE THE PHYSICAL PROPERTIES OF THE EARTH.

A knowledge of gravity, or the force of gravitational attraction from point to point over the surface of the earth may be used to determine the geometry and mass distribution of the earth. It is possible to establish a series expression for the gravitational potential which may be better approximation of the potential than the presently popular but slowly converging spherical harmonic series, and at the same time uncover information on the physical properties

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presently popular but slowly converging spherical harmonic series,
and at the same time uncover information on the physical properties

of the earth. The gravitational potential may be expressed as a finite series, each term having an undetermined coefficient representing either the mass distribution or geometry of the earth. Subsequent data on the gravitational force may be used to evaluate these coefficients.

Zaromb, Solomon   EQUILIBRIUM MODEL OF A GRAVITATIONALLY BOTTLED UNIVERSE.

In the absence of heretofore unknown effects, a gravitationally bottled universe in a state of maximum entropy would exhibit:

(a) a fixed matter-energy content within an approximately constant volume;

(b) radial temperature, matter-energy density, and gravitational gradients;

(c) marked local density and temperature fluctuations; and

(d) a continuous gravitational inflow of matter into its central high-density region counterbalanced by violent ejection or escape of masses of ultra-high kinetic energy.

These features are shown to be consistent with density distribution estimates. Hubble's red shift, galactic shapes and rotations, cosmic particles, quasi-stellar sources, and violent events in galactic nuclei.