The Theoretical Basis of Gravity Research

1951

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It has been said that the purpose of a general theory is not only to tell us what to look for in the way of scientific observation but also to show us what not to look for. A theory should help us to understand and correlate isolated phenomena, predict new avenues of research, and point out which lines are sterile and impossible of fruition. Sometimes extremely subtle changes in the fundamental postulates of theories which alter the predictions of common experience only in the seventh or eighth decimal place have had tremendous effect on man's aspirations. Thus, special relativity which only immeasurably affects common observations of velocities has put an absolute ceiling on the actual speed attainable in the universe. There are now those who would halt the long hunt for an insulator or absorber for gravity because of the conclusions of Einstein's General Theory of Relativity.

Many commentaries have shown fairly exhaustively that the existence of any reflector, insulator, or absorber of gravity is completely precluded or at least rendered extremely doubtful by the General Theory of Relativity. This can be shown as follows:

We first note that the vanishing of the Rieman Cristoffel tensor is both a necessary and a sufficient condition for flat space-time (for proof see any standard text on general relativity such as Tolman, Relativity, Thermodynamics, and Cosmology). If $B^{\epsilon}_{\mu\nu\sigma}=0$ we can adopt Galilean coordinates at the point; if not, we can adopt coordinates which agree with the Galilean at a given point in the value of $g_{\mu\nu}$ and first derivatives, though in general not in the second derivatives.

Let the contracted Rieman Cristoffel tensor, formed by setting $\epsilon=\sigma$ in $B^{\epsilon}_{\mu\nu\sigma}$ be represented by $G_{\mu\nu}$

$$B^{\varepsilon}_{\mu\nu\sigma} = \{\mu\sigma,\alpha\}\{\alpha\nu,\varepsilon\} - \{\mu\nu,\alpha\}\{\alpha\sigma,\varepsilon\} + \frac{\partial}{\partial x_\nu}\{\mu\sigma,\varepsilon\} - \frac{\partial}{\partial x_\sigma}\{\mu\nu,\varepsilon\}$$

$$G_{\mu\nu} = \{\mu\sigma,\alpha\}\{\alpha\nu,\sigma\} - \{\mu\nu,\alpha\}\{\alpha\sigma,\sigma\} + \frac{\partial}{\partial x_\sigma}\{\mu\nu,\sigma\}$$

Since $\{\mu\sigma,\sigma\} = \frac{\partial}{\partial x_\mu} \log\sqrt{-g}$

$$G_{\mu\nu} = \frac{\partial}{\partial x_\alpha}\{\mu\nu,\alpha\} + \{\mu\alpha,\beta\}\{\nu\beta,\alpha\} + \frac{\partial^2}{\partial x_\mu \partial x_\nu}\log\sqrt{-g} - \{\mu\nu,\alpha\}\frac{\partial}{\partial x_\alpha}\log\sqrt{g}$$

Further contraction by setting $\varepsilon = \mu$ does not give another tensor for

$$B^{\mu}_{\mu\nu\sigma} = g^{\mu\rho} B_{\mu\nu\sigma\rho} = 0$$

Einstein hence took $G_{\mu\nu} = 0$ as his law of gravitation assuming, as a postulate, the exact proportionality between inertial and gravitational mass. Since a field of force is described by the difference between the natural coordinate geometry and the abstract Galilean geometry attributed to it, Einstein's law is now seen as a restriction on the possible natural geometry of the world. As Eddington says, "The inverse square law which is a plausible weakening of a supposed absolute force becomes quite unintelligible (and indeed impossible) when expressed as a restriction on the intrinsic geometry of space time; we have to substitute some law obeyed by the tensors which describe the world-conditions determining the natural geometry.

Quite simply this means that mass is merely a manifestation of curvature of space-time or Rieman space, and that even though the law of gravitation will in the limit of earthly conditions reduce to something of the form of Newton's Law, the theoretical background would be far different. There would be little hope of changing the gravitational constant or of finding something with a different value analogous to μ of magnetic permeability.

Despite this deduction from General Relativity, hope of actually discovering an insulator for gravity with all its attendant blessings for humanity is nowhere near gone. Einstein's greatness would be well assured by his work on photoelectric effect, Brownian motion, specific heats, or special relativity. The General Theory of Relativity, however, is on by no means so firm a footing as might be expected.

First of all its main experimental verification has come under serious question. The bending of light rays predicted and observed in the eclipses of May, 1919 and September, 1922 was not nearly observed as predicted in the eclipse of May, 1929, and a re-examination of the data of the 1922 eclipse has raised further doubts. The eclipses of 1954 and 1955 may settle this question. Also the red shift in light originating in strong gravitational fields has apparently been disproved by some of M. G. Adams work on solar spectra.

General relativity arose mainly because of the assumed impossibility of bringing gravitation within the range of the Lorentz formulae of the Special Theory of Relativity. Einstein allowed his element of space-time "length" to represent non-Eiclidean metrics and set as a condition that the laws of nature should be describable in equivalent forms in <u>all</u> sets of coordinates. Gravitation then was merely the restriction defining the nature of space-time in the neighborhood of "mass".

E.A. Milne quite logivally objects to this making all observers equivalent. He assumes in his Kinematic Relativity that only those observers similarly situated with respect to the distribution of matter and motion (such as those at the centers of the various receding galaxies) would be equivalent. He also generalizes Einstein's approach by making the choice of space (Euclidean or non-Euclidean) arbitrary for the observer and denies Einstein's conception of natural time, using instead the time graduated by observers in relative motion, or kinematic time.

Lack of space prevents any mathematiwal discussion of Milne's theory. His gravitation originates from statistical considerations and has its most simple expression in terms of the proper time (or time since the formation of the universe). The proportionality between inertial and gravitational mass is not postulated and the law of attraction between two particles in its most general form, taking into account the rate of expansion of the galaxy, is:

$$\chi = -\frac{m_1 m_2 c^2}{M_0} \times \frac{\cosh\frac{h_1}{ct_0}\cosh\frac{h_2}{ct_0} - \sin\frac{h_1}{ct_0}\sin\frac{h_2}{ct_0}(\mathbf{1}_1\cdot\mathbf{1}_2)}{\left\{\cosh\frac{h_1}{ct_0}\sinh\frac{h_2}{ct_0}\mathbf{1}_2 - \cosh\frac{h_2}{ct_0}\sinh\frac{h_1}{ct_0}\mathbf{1}_1\right\} - \sinh^2\frac{h_1}{ct_0}\sinh^2\frac{h_2}{ct_0}(\mathbf{1}_1\cdot\mathbf{1}_2)}$$

Unnecessarily complex as this appears, it has found wide acceptance in superseding Einstein's Gravitation, even though in form it is far closer to Newton's conception.

This, it is important to note, is by no means the only alternative theory to Einstein's.

S. M. Sulaiman bases his theory on the assumption that gravitational waves are propagated outward from a massive body with a finite velocity. This, combined with the fairly reasonable postulate that the planets move in a resisting medium, is sufficient to explain an entire cosmology as well as charted astronomical observations.

Hely's Synthetic Relativity predicts a correction term in Newton's inverse square law of $\frac{-6\mu^2}{c^2 r^3}$ which adequately accounts for the perihelion of Mercury though its theoretical background is still in dispute.

A great number of modern physicists have come to the conclusion that no method of representing space-time by a set of continuous differential equations in no matter how many dimensions can be successful. Thus a comparatively large number of Quantum-type theories have recently been evolved.

One of the most fruitful of these has been that of J. Solomon in which he effects a tie-up between electrodynamics, which has yielded so well to theoretical investigation, and gravitation by means of a quantum field theory.

It is interesting to note that in none of the above theories is the finding of an insulator or absorber of gravity or even a negative mass precluded (though Solomon's theory seems to render the finding of the latter, at least in quantities greater than the subatomic, extremely unlikely).

It seems that we are now in a position, with respect to gravitation, similar to that occupied by scientists of the 1830's with respect to Ohm's law. On first investigation it appeared that the proportionality between the electromative force applied to a conductor and the current transmitted by it was exact and dependent only on various characteristics, viz. length, material, cross sectional area and temperature, of the conductor. This "observation", somewhat similar though far less complex than the supposedly invariant proportionality between gravitational and inertial mass, brought forth many theories explaining many attributes of the electric current and showing certainly that all electricity must obey Ohm's law. Experiment on a large number and range of conductors appeared to confirm this until Kirchoff and others noted non-linear conductors. Now, of course, we know even of materials on which an increase of potential difference will result in a decrease of current and appreciate that what had previously been thought to be a basic and fundamental property of electricity was in reality only a property of the material carrying it, and a restricted one at that.

So, similarly, though the search for an insulator or absorber of gravity has covered a wide range of materials and been carried out to extreme accuracy, there is still hope of someday finding an answer. Not only is there seen to be no theoretical objection but both Milne's theory, or at least the Bourgin modification, and Solomon's Quantum Theory appear to predict its existence.

The answer may be found at any moment by mere trial and error. It may be in an undiscovered mineral or alloy or only a common material as yet untested. The principle is clear; the search should go on.