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THE NUCLEAR ORIGIN OF GRAVITY

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A brief historical account of our present understanding of gravity serves to set the scene for a re-evaluation of the problem. It is kept in mind that successful applications of gravity hinge upon an adequate theory. A new approach toward a more fundamental understanding of the origin of gravity, which is of some experimental as well as theoretical interest, is brought forward.

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Throughout his history man has sought an understanding of nature and a knowledge of the physical universe. This quest has led him to the many great discoveries which make our present civilization technologically possible; but even the marshalled forces of modern science have not wrested from nature all her innermost secrets. Gravity has long been one of the most intriguing of these enigmas, both from the practical as well as the purely intellectual point of view; and since it has puzzled man and scholar for so long, it is of considerable historical interest as well.

It is an obvious fact that man cannot do without gravity, but the record of what he has done with gravity is a short one. Besides its use as part of the cycle in the hydroelectrical process, which actually gets its energy from the sun, very little has been done to harness gravity, for schemes, such as the extraction of energy from gravitationally produced tides, are impractical because of the small amount of energy involved. To answer the problem of gravity's practical application, man first sought an understanding of what gravity really is.

In Sir Isaac Newton's masterpiece, The Principia Mathematica (a work almost as immutable as the force it describes), the first precise description of the gravitational force was given in the famous universal law of gravitational attraction. Unfortunately, this law, which purportedly gives the force of attraction between every massive body in the universe, only remained universal from 1686 to 1915. With the advent of the general theory of relativity it became necessary to delete such words as "universal" and "absolute" in favor of "waves" and "transformations." In this new theory of Einstein's, gravity is viewed as a necessary consequence of the inertial properties of matter and the inertia (or resistance to acceleration) of a body is held to be "equivalent" to a property called mass.[1] In relativity, Newton's mechanical concept of one body acting on another at a distance is replaced by the Maxwellian concept of the interaction between fields. In 1929 Einstein published further work on a field theory of gravity, and subsequent efforts were aimed at a unified field theory. The first of these essentially did for gravity what Maxwell had already done for electricity. It was hoped to ultimately bring both field theories into complete harmony with each other. This task has, unfortunately, not been accomplished.

However, the new theory allows one to speak of gravity waves as well as electromagnetic waves, both of which propagate at the speed of light _in vacuo_. These waves represent an energy density which, by virtue of the famous $E = mc^2$ relation, create their own gravitational field. Here there is a certain harmony with the wave mechanics of Schrödinger and Dirac. But, in general, we must always make three subdivisions of physics: classical, relativistic, and quantum.

This brings us to a necessary re-evaluation of the problem at hand. Is gravity to be treated classically, relativistically, or quantum

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[1] This latter quantity is the familiar m_1 and m_2 in Newton's law,

$$F = \frac{G\, m_1\, m_2}{r^2}$$

mechanically? One of the weaknesses of classical theory is its inability to distinguish between what we may call the macro- and the microcosm.[2] Relativity is designed for the macrocosm, and it is here that gravity becomes important, for in the microcosm of the quantum theory gravitational forces become negligible.[3] Does this say, however, that gravity should not be treated as a microcosmic phenomenon? The proper answer to this question seems obvious in light of the fact that virtually all of the mass in the known universe is contained within the nucleus. Furthermore, these minuscule "centers of gravity" have a density of over one hundred million million grams per cubic centimeter. Despite the fact that the magnitude of the gravitational force in the vicinity of a nucleus is relatively small, the convergence of the lines of force is phenomenally large.

This poses the question of what can be done to create a new theory of gravity based on the hypothesis of nuclear origin. The answer to this question lies hidden within the nucleus itself, for it is there that an entirely new kind of force is making itself known. Despite the concentrated experimental and theoretical attack which is being made on this new problem of nuclear forces, it still remains unsolved. This much

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[2]That the distinction between a macro- and a microcosm can be made and how to make such a distinction is profoundly important, both to the philosopher and the scientist. The existence of the distinction is implied by the existence of the universal constants of nature, such as the speed of light, Planck's constant, the constant of universal gravitation, etc.

[3]The gravitational attraction between a neutron and proton with minimum separation of 2.8×10^{-13} cm is

$$F = \frac{G\, m_p\, m_n}{(2.8 \times 10^{-13})^2} = \frac{(6.67 \times 10^{-8})(1.67 \times 10^{-24})^2}{(2.8 \times 10^{-13})^2} = \underline{2.38 \times 10^{-30} \text{ dynes}}$$

we do know--both gravitational and electrical lines of force converge rapidly towards a nuclear surface, inside of which quite different and exceedingly powerful forces come suddenly into being. Furthermore, there is good evidence that the electrical field extends within the nucleus; it seems plausible that the gravitational field must do likewise. We can be certain that the multitude of microcosmic fields combine and interact to give a total macrocosmic field of the familiar kind. This field has the appearance of converging to one geometric point within the body. This point is called the center of mass. (More properly it should be called the center of gravitation.)

What happens to the gravitational field when it penetrates the nucleus, or rather, what happens to the field equations inside the nucleus? Also, what is the effect of nuclear motion (vibrational, rotational, and pulsating) in regard to gravitational wave phenomena? The nucleus should set up waves in the gravitational field. These questions and a multitude of others of a similar nature are difficult to answer experimentally; but they necessarily must be answered before we can give a complete picture of gravity on both the macro- and microcosmic levels.

At present, we must appreciate the magnitude of the difficulties involved in attempting to measure the gravitational field of an individual nucleus.[4] But we must constantly keep in mind the new techniques which

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[4]The weight of the heaviest naturally occurring nucleus, U^{238}, at the earth's surface, which is the force of gravitational attraction between the nucleus and the earth, is only

$$F = \frac{G M_E m_U}{R^2} = m_U g = (3.88 \times 10^{-22})(980) = \underline{3.80 \times 10^{-19} \text{ dynes}}$$

have been recently developed to study the nucleus. The Nobel prize winning work of Professors Block, Purcell, and Rabi has made possible extremely accurate experiments involving nuclear magnetic moments; and more recently work is being done in nuclear alignment.

As these and other techniques develop, it will eventually become possible to attack the gravity problem on the nuclear level. It is then, and only then, that we can hope to gain an understanding of the origin of gravity. As the answers to these questions are found, one may look forward to the time when gravity will be as well understood as electricity and, consequently, as useful to mankind as electricity.