1953

THE RELATIONSHIP OF GRAVITATION TO RADIATION

by Phyllis Gregg
Department of Civil Engineering
632 West 125th Street
New York 27, New York

The fundamental property of all forces to be found in nature is their dual existence; whether action and reaction, tension and compression, or electro-magnetic forces of attraction and repulsion, they exhibit this phenomenon. In the case of gravitation, our analogy seems to be false, since we encounter only attraction obeying the Newtonian inverse-square law. It is the purpose of this paper to present an argument for accepting gravitation as the counterforce of radiation. If this is found to be true, it is of the utmost importance since it would give us a vital clue towards solving the riddle of anti-gravity.

Our investigation begins with the two quantities most closely related to gravitation, i.e., the inertial mass m of a material body and the value of the gravitational constant, $k = 6.67 \times 10^{-8}$ in the centimeter-gram-second system of units.

According to Einstein, all energy exhibits identical inertial characteristics as matter, possessing masses of the magnitude $m = E/c^2$. All matter contains the so-called "energy of constitution" of the value mc^2. This concentrated matter-energy has been interpreted as being potential energy and in the case of radiation manifests itself in its kinetic radiational aspect.

We find ourselves faced with the following situation: We have the mass m and the gravitational constant k as the expression of the gravitational attraction directed toward the center of the mass. In addition, the same matter represents a given concentrated potential energy as predicted by the Einstein formula which is latent. Proceeding from this, let us present the hypothesis that the force of gravitation is the exact counter-force of the outwardly directed radiational force of matter-energy, a supposition which shall now be verified.

According to modern theory, a material body appears as the phenomenological expression of an electromagnetic concentrated energy of the magnitude mc^2, hence, of a potential character. Our original basic conjecture, that it is gravitation which corresponds to this potential and forms the bond preventing radiation, has to be verified by the existence of equilibrium between the radiational and gravitational forces; hence, the potential energy of matter, $E = mc^2$, must become an extreme value and its time-variation must be put equal to zero:

$$\delta E/\delta t = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

If we should assume, in accordance with the relativity theory, that the velocity of light c is a constant, we should obtain:

$$\delta(mc^2)/\delta t = c^2(\delta m/\delta t) = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

stating simply that the radiational (kinetic) energy must remain continuously equal to zero in order to preserve matter and its energy in the original potential, undivided state, a rather trivial result.

However, we have to realize the full implication of our hypothetical basic assumption as to the existence of equilibrium between the radiational and gravitational forces. We know that energy of any kind, including that of an electromagnetic nature, manifests inertia, mass, hence is subject to the action of gravitation. In line with our basic conjecture, radiation is now also affected by gravitation; its velocity c must therefore become retarded and can no longer be considered as constant. We must then discard - in the presence of gravitational fields - the conception of the constancy of c, which bars the way to a fruitful application of the extremal principle as the supreme equilibrium law. Both terms, m and c, now have to be considered as variable, and we form the total time-derivative of the given potential matter-energy and put it equal to zero, as follows:

$$d(mc^2)/dt = 2mc(dc/dt) + c^2(dm/dt) = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Let us now get at the interpretation and understanding of this basic relation. We have here two unknown quantities, the two derivatives dc/dt and dm/dt; first we have to find some general relation connecting these quantities with the given values of m and c. Dividing by 2, (the end results would not be changed if we did not divide by 2) Equation (3) now reads:

$$mc(dc/dt) + 1/2(dm/dt)c^2 = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

The time-rate mass flow, 1/2(dm/dt), radiating from the main mass m represents a certain, still unknown small fraction α of this main mass m, and the process of radiation, conceived as a continuous process, requires this flow to be constant. Thus we may write:

$$1/2(dm/dt) = \alpha m \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Substituting (5) in (4), we obtain:

$$mc(dc/dt) + \alpha\, mc^2 = 0, \text{ or } dc/dt = -\alpha c \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

appears as a retardation factor. Equation (4) then reads:

$$mc(-\alpha c) + 1/2(dm/dt)c^2 = 0$$

$$-\alpha mc + 1/2(dm/dt)c^2 = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

actually representing the extremal condition of equilibrium for the existing energy potential of matter, mc^2. Let us now look for the correct interpretation of this all-important relation (7).

The term $1/2(dm/dt)c^2$ stands for the time-rate flow of the radiating <u>kinetic</u> energy, outwardly directed, whereas the term $-$ mc^2 obviously denotes the time-rate decrease of the existing <u>potential</u> matter-energy of an equal amount, a simple and self-evident result - the law of conservation of energy - valid for the <u>actual</u> state of radiation.

But we are in a position to give a second, different interpretation to Equation (7) in its true sense as an extremal condition for the <u>statical equilibrium</u>.

The concentrated potential energy represents a stress-condition in equilibrium, there always exists an outwardly directed force, which must be kept in equilibrium by some other opposite and equal force. All this expresses the state where no radiation takes place, a state that is the common case for material bodies. The interpretation of Equation (7) then reads : The outwardly directed energy $1/2(dm/dt)c^2$ is counteracted by a <u>retarding energy</u> $-\alpha mc^2$; both fields of energy are always present and co-existent, and their continuous interplay as action and reaction manifests itself as that physical phenomenon which is matter. The existence of the (inwardly directed) energy term $-\alpha mc^2$ thus appears as the indispensable condition to preventing radiation and preserving matter in its undivided, non-radiating state. And this retarding energy $-\alpha mc^2$, as derived above and here interpretated, is actually present in nature:

<u>IT IS THE GRAVITATIONAL FIELD OF MATTER</u>

WHOSE existence thus follows from the energy-aspect of matter: By holding in bond the outwardly directed, radiating force, it turns out to be the necessary condition for the preservation of matter.

We have succeeded in deriving, theoretically, from the law of conservation of matter-energy, the existence of a retarding field, which, with respect to its physical quality and nature, appears to be a gravitational field; the all-important quantitative determination of this field will show whether or not all of our hypothetical conjectures are true.

Our next decisive step entails a closer study of the radiational aspect of matter. First let us consider more closely Equation (5):

$$1/2(dm/dt) = \alpha m,$$

taken per cubic unit. Here m denotes a certain given mass-density, and 1/2(dm/dt) the time-rate of mass radiation or the appropriate density of radiating matter, which latter we consider as constant, the process of radiation being visualized as a continuous, uniform process. In the preceding discussion we found or formed the conception of the radiating mass-density, derived from the given units of mass, length, time, and the radiating velocity c. Thus we obtain for 1/2(dm/dt) a very definite value, viz., the radiating matter-density μ,

$$1/2(dm/dt) = \mu$$

Equation (5) now reads:

$$\alpha\, m = \mu = \underline{\text{constant}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(8)$$

The retardation factor, as well as the mass density m, is not yet determined; their product being constant, the given function may be represented by a hyperbola. The factor μ determining the (retarding) gravitational field is obviously dependent upon the magnitude of m, the mass-density; the assumption of the correct value for m appears thus of paramount importance.

In order to arrive at this value, let us turn our attention to the physical process of radiation, which we find occurring as disintegration of atoms, the smallest building stones of matter in a non-radiating state. It thus appears justified to take for the mass-density m precisely this minimum value, represented by the hydrogen nucleus, the proton:

$$m = m_p = (5/3)10^{-24} \text{ in the c.g.s. system of units}$$

as the critical boundary value of matter-density between the radiating and non-radiating states.

We are now in a position - after substituting the value for m in Equation (8) - to obtain the corresponding factor α :

$$\alpha_\rho \; m_p = \mu = \underline{\text{constant}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(9)$$

From this equation we may calculate the exact numerical value of α_ρ . We have to bear in mind that this factor determines the value of the previously derived <u>retarding</u> energy, recognized according to Equation (7) as being qualitatively of a <u>gravitational</u> nature. Substituting now the numerical values in Equation (9), we obtain:

$$\alpha_\rho (5/3) 10^{-24} = (1/9) 10^{-30}$$

$$\alpha_\rho - 6.67 \cdot 10^{-8} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(10)$$

for the <u>retardation</u> factor.

But this is precisely the value of the gravitational constant k as manifested in nature:

Gravitational constant $k = 6.67 \cdot 10^{-8}$ in the c.g.s. system.

Thus all our conjectures on the nature of gravitation seem to have found their verification in the above result, namely, in the value for the <u>retardation factor which turns out to be the gravitational constant</u>.

Let us now draw the full conclusion from this noteworthy result of our investigations.

Since radiation manifests itself as an atomic disintegration process and since, according to the above results, gravitation is related to it, it appears quite logical to treat the whole problem only in connection with the proton mass, the <u>smallest unit of undivided matter</u>. Equations (6), (7), (8) then read:

$$dc/dt = -kc \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(11)$$

as the retardation of the radiating velocity. And the gravitational, retarding energy preventing radiation, according to Equation (7), gives the following relation:

$$-km_\rho c^2 + \mu c^2 = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(12)$$

Dividing by c we obtain, according to (7):

$$km_\rho = \mu \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(13)$$

The above derivation is not radically new, since it has been expounded by physicists prior to this date. It does, however, present a challenging picture of the universal forces of gravitation and radiation. Much work, of course, still remains to be done in this field, but there will come a time when these investigations will be directly utilized by man to harness the force of gravity for the benefit of mankind.