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The object of this paper is to show that our current conception of space is not adequate to explain gravitational attraction; to substitute Riemannian space therefor; to expose weakness where it exists in the Euclidean system.

<u>The Title is</u>

<u>GRAVITY</u>

It would be singular if the law of gravity as given by Newton centuries ago exhausted completely the subject; yet no worth-while advances in it have been made until of late years; these advances, although they supported the great Cambridge scholar, yet differed from him widely in ultimate results. Based on unimpeachable demonstration, Newton gave the "how" of gravity; said nothing, however, on the "why". Taken by and large the mere statement of the law of the inverse square left us standing in our tracks, and so it continued, until Einstein flashed "Sit Lux" across our line of vision.

In fact, so little lucid knowledge of gravity made its appearance that we began to suspicion that all was not right; that perhaps even the entire body of fundamentals were not all they should be; and among these "space" was losing all credibility in steady manner. From debatesin quasi - scientific societies to learned bodies, it was sought to pin some identifying badge on this elusive myth or phantom reality, and whatever clarity was gained in the end was usually lost in the semi-darkness that surrounded the whole subject. That, however, it is a vital matter to all, is evidenced by it's ever-present reflection on our sense-perceptions; it's there, it's here, it's everywhere.

This is perhaps a favorable point to turn our attention to Euclid, formerly reputed to be an authority in matters pertaining to space. In small scale he indeed was, but went astray in his conception regarding parallels, a vexed question not settled for centuries. But either he or some unknown predecessor was first to enunciate that unique quality of the geodesic:- "the shortest distance between two given points is a straight line". Had he also been much of a natural philosopher as well, probably he would have observed that freely falling bodies move also in geodesics; that geodesics are favored in natural phenomena; his era, however, had no inkling of what might occur if plane surfaces were replaced by curved ones.

Illustrative of the advance made since Newton, we no longer see such mathematical hybrids as many of us saw in our early texts on Analytic Dynamics, such as:- "If a body is situated in a homogenous sphere free to move, and is acted on by an attractive force in its line of motion which varies directly as the distance of the particle from the center of force, it will describe vibrations, whose amplitude is the diameter of the sphere".(a)

This theorem was assumed to cover the performance of a body that could pass through the earth's center from perimeter to perimeter, and the time of a single vibration, t, was given as $1/\mu^{1/2} \cos^{-1} \frac{x}{a}$ The constant μ is the unit gravitational force; a, radius of sphere; x the position of the particle as measured from the center. Under such conditions, <u>t = 21 minutes + 6 seconds</u>.

1 If we now turn to the diagram facing Sheet I, we see a representation of the coordinate axis, Cartesian style, and a mass situated at P on the Z axis; vertically below is O, it's projection on the XY plane; for a freely falling body of P, the line PO represents the path followed, a geodesic. This is valid for an observer in the ZX plane. But to a space observer, situated say to the right of Z somewhere in the first quadrant, it is not; owing to the earth's diurnal and orbital motions the end of descent is at Q, in the XY plane. Both observers are right in their conclusions, ~~tht~~ but these in turn are functions of their positions;

in one case the path travelled is rectilinear, in the other curvilinear, yet both are geodesics. The physicist says the terminal momenta are the same, and times of descent identical. Thus one of the commonest of phenomena, a falling body, is capable of diametrically opposite interpretations. The facts themselves, as always, are incontrovertible, invariant; but factors appear in the interpretation which are in their essence transient, without fixation.

The mathematical expressions for these paths of a falling body are as diverse as the lines themselves: viz, for PO, $S = \frac{1}{2} g t^2$, the simple time-distance formula, g -the acceleration due to gravity; PQ, however, is a second order differential containing fundamental tensors and a Christoffel symbol of the first kind. As the second covers all phases of the action when a body falls under the influence of gravitative action, then the first must have been incomplete in its description of the phenomenon. This was established firmly after Einstein's corps of Relativists moved in. This type of demonstration was similar to others in the classical method and, as Riemann (b) showed in 1857, the whole structure of classic mathematics, especially geometry, shared this shortcoming.

For the reasons set out (Page 2) we cannot accept the idea of Euclidean space (V_3) as a veracious and trustworthy picture of space, generally spoken of as the cosmos. We will consider as a substitute <u>Riemannian space</u>, , whose metric $S =$

$$\sqrt{\frac{g_{ij} \, X \, dx_i \, dx_j}{dt \; dt}}$$

$$S^2 = X^2 + y^2 + z^2$$

replaces the familiar. The i, j's are here functions of the X 's; all other terms have their usual meanings. In addition we postulate a spherically symmetric field of gravitation, and static. This leads us to a metric of the form given as:

$$ds^2 = \int_1 r\,dt^2 - \int_2 r\,dr^2 - r^2(d\theta)^2 - r^2 \sin^2\theta\, d\phi^2$$

where the velocity of light is taken as 1, for simplicity, instead of the usual c; $\int_1$ and $\int_2$ are functions of r, radius; they will be denoted by e^{μ} and e^{λ} respectively and will so keep the signature = -2. These substitutions made, the above equation becomes

$$ds^2 = -e^{\lambda}(dr)^2 - r^2(d\theta)^2 - r^2\sin^2\theta(d\phi)^2 + e^{\mu}(dt)^2$$

Taking this equation as starting point instead of the deceptively simple equation of Einstein $R_{ij} = 0$, Schwarzschild (c) deduced a complete solution (gamma) $y = e^{\mu} = 1 - \frac{2m}{r}$, where m can be identified with the mass of the sun; r any radius of the gravitational field, sun at the origin. We see that as $r \to \infty$ both λ and μ tend to 0, hence $y = 1$. Substituting this value for y, we will have

$$ds^2 = -(dr)^2 - r^2(d\theta)^2 - r^2\sin^2\theta(d\phi)^2 + (dt)^2$$

for a gravitative field in the Riemannian manifold, N_A. This is Schwarzschild's (c) equation, representing a geodesic. It will be seen here that time holds a position practically establishing the geodesic as a part of Gravity, on an equal footing with other variables, which is unquestionably as it should be, and this advance we owe directly to Relativity. As we are now dealing with geodesics, their defining form is called for; in generalized form it is:

It is needless to solve this equation here, as it is given in appropriate texts (for instance see Barry Spain, Trinity College, Dublin, 1953). But if we choose the super script, our case, $i = 4$, the solution becomes easy and yields

$$\frac{d^2 t}{ds^2} + \frac{1}{\gamma}\frac{d\gamma}{dr}\frac{dt}{ds}\frac{dr}{ds} = 0$$

$$\frac{d^2 t}{ds^2} + \underset{\text{gamma}}{\frac{1}{\gamma}}\frac{d\gamma}{ds}\frac{dt}{ds} = 0, \text{ or } \frac{d}{ds}\left(\gamma\frac{dt}{ds}\right) = 0$$

, where γ, (gamma) has the original value $= e^{\mu}$, and all other symbols have their customary meanings, and the braces indicate the Christoffel symbol of the second kind.

We are now in a position to evaluate some of the questions asked as to the possibility of insulating or absorbing gravity by any means, but employing only gravity itself to accomplish such objective.

Let us suppose that we have to investigate the question whether gravitative action alone upon some given substance or alloy can produce heat. We do not specify its texture, density nor atomic structure; we assume simply the flux of gravitative action followed by an increase of heat in the alloy.

If we assume a small circular surface on the alloy, then the gratitative flux on it may be expressed by Guass' theorem and it is $4\pi M$, where M represents mass of all sub-surface particles; the question is, can this expression be transformed into heat. We will assume it can be. Now recalling the relativity law connecting mass and energy the law is $M = m_0 + \frac{T}{C^2}$ { by A. Einstein

where T = Kinetic energy
m_o = Initial mass
c = Velocity of Light
M = resultant mass

we set

$$4\pi M = m_0 + \frac{T}{C^2} = m_0 + \frac{m_0 v^2}{2c^2}$$

But $\frac{V^2}{C^2}$ is a proper fraction, , hence

$$M = m_0 + \frac{1}{2K} m_0$$

In the boundary case where $v = c$, $M = m_0 (1 + \frac{1}{K})$; for all other cases $4\pi M = m_0 (\frac{K+1}{K})$, $K \neq 0$. Strictly, M should be preceded by a conversion factor $\propto \frac{1}{K}$, but if inserted, it does not alter results. Thus if gravity could produce heat, the effect is limited to a narrow range, as this result shows.

It merits stress that in a gravitational field the flow lines - lines of descent - are Geodesics.

REFERENCES

(a) See Bowser's Dynamics, passim, 19th ed. 1907.

(b) Riemann; Dissertation, Prague, 1857.

(c) Schwartzchild; Berlin ~~Sitzvergsverichte~~, 1916, p. 189.
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