Impact of Propagation of Light on the General Theory of Relativity influencing Einstein's Researches on Gravitation

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Abstract:

A closer analysis of the mathematical expressions for the description of linear and revolutionary motions reveals that the characteristics of these two motions are interconvertible under appropriate condition. Here, it is proposed that revolutionary motion is the only type of motion that exists in the universe and rectilinear motion is a special case of it. In case of propagation of light, this proposal fails in the terrestrial experiments but at astronomical distances the revolutionary motion of light was reported as experimental observations. Einstein considered the propagation of light rays in straight lines and in his general theory of relativity he proposed the bending of light rays as the effect of gravitational field of the Sun. According to him, force of gravity arises from the curvature of space-time. He tried to place gravitational force in line with electrical and magnetic interactions obeying Newton's description of universal gravitation. This might be the leading cause that Einstein was not successful in interpreting the gravitation as well as the unified field theory.

Key words: *Linear vs. revolutionary motion, Bending of light rays, Impact of bending of light on GTR, Inconsistency on curvature of space-time, Einstein's research on gravitation.*

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Introduction:

Kinematics is a branch of mechanics which involves mathematical methods for describing motion. The motion of a particle is considered to be of two types, revolutionary (including rotation) and translational i.e. motion in a straight line. Characteristics of these two types of motion are formulated mathematically in any elementary text book of Physics. These are shown in the following Table with generally accepted symbols.

Table I:

CONCEPT	**TRANSLATION**	**ROTATION/ REVOLUTION**
Displacement	s	ϑ
Velocity	$v = ds/dt$	$\omega = d\vartheta/dt$
Acceleration	$f = dv/dt$	$\alpha = d\omega/dt$
Force, moment	F	Γ
Equilibrium	$\Sigma F = 0$	$\Sigma \Gamma = 0$
Constant acceleration	$v = u + f t$ $s = u t + ½ f t^2$ $v^2 = u^2 + 2 f s$	$\omega = \omega_0 + \alpha t$ $\vartheta = \omega_0 t + ½ \alpha t^2$ $\omega_t^2 = \omega_0^2 + 2 \alpha \vartheta$
Mass, moment of inertia	m	I
Newton's second law	$\Sigma F = m f$	$\Sigma \Gamma = I \alpha$
Work	$W = \int F ds$	$W = \int \Gamma d\vartheta$
Power	$P = F v$	$P = \Gamma \omega$
Kinetic energy	$K = ½ mv^2$	$K = ½ I \omega^2$
Impulse	$\int F dt$	$\int \Gamma dt$
Momentum	mv	$L = I\omega$

The similarity of the expressions for the two types of motion is striking. There is a complete parallelism between the two classes of motion which could be shown in the following way.

Let us consider a particle moving along a circle of radius ‘r’ with initial velocity ‘u’. After time ‘t’, its final velocity is ‘v’ and it moves a distance ‘s’ and subtends an angle ϑ at the centre (Fig. I).

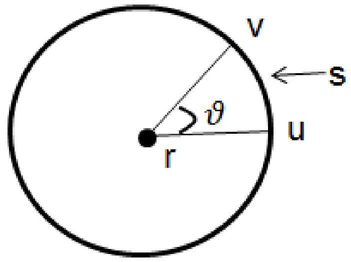

Fig. I: Interrelation between linear and rotational motion

Then $s = r\,\vartheta$ and the angular velocity $\omega = \vartheta/t$, the final velocity $v = s/t = r\,\vartheta/t = r\,\omega$. The linear acceleration $f = r\,\alpha$ where α = angular acceleration. The transformation relation from linear to rotational motion and vice versa is $u = r\,\omega_0$, $v = r\,\omega_t$, $f = r\,\alpha$ and $s = r\,\vartheta$.

By applying these relations to translational equation, $s = u\,t + ½\,f\,t^2$

We get $r\,\vartheta = r\,\omega_0\,t + ½\,r\,\alpha\,t^2$, thus $\vartheta = \omega_0\,t + ½\,\alpha\,t^2$ (from translation to revolution)

And from revolution to translation, $\omega_t^2 = \omega_0^2 + 2\alpha\,\vartheta$

$$v^2/r^2 = u^2/r^2 + 2\ f/r \times s/r$$

then $$v^2 = u^2 + 2\,f\,s$$

Thus, it is evident that the two sets of equation for rotational and translational motions are inter-convertible. This is due to the fact that the arc subtended by the angle ϑ can be considered as a straight line if the angle ϑ tends to zero and the radius ‘r’ tends to infinity. It is, therefore, apparent that linear motion is a special case of revolutionary motion. If we consider the astronomical description of the universe, we find that all the planets comprising the universe are in revolutionary motion among themselves. Not a single instance is there that a planet is moving in a straight line. Any mass ejected as a meteorite from an asteroid moves some distance in a straight line and exhaust itself as being converted to energy ($E = mc^2$) as velocity approaches speed of light. In case, the energy is not exhausted the meteorite will move in a straight line to reach a planet (say earth).

It can therefore be assumed that *in the universe only rotational motion prevails and the translational motion is a special case of rotational motion.*

Propagation of light:

It is desirable to test this proposition with light rays. In about 300 BC, Euclid studied the properties of light and postulated that light travels in straight lines [1]. But till now no unambiguous proof for the rectilinear motion has been put forward. This is mainly due to the very high speed, indeed highest possible ($c = 3 \times 10^8$ m/s) of light. It is not possible to show if light rays deviate from linearity by any terrestrial experiment. In fact, reflection, refraction, dispersion, interference, Compton effect, photoelectric effect, to name a few, are all indicative of the vast studies on the nature of light but none provided any acceptable evidence as to establish the rectilinear propagation of light. In all of these experiments the rectilinear propagation of light was accepted as an axiomatic truth and no question arose as to the bending of rays of light or revolutionary motion of light rays.

It appears that if the propagation of light is to be tested, this should be done through experiments which involve astronomical distances and terrestrial measurements are of no use considering the high velocity of light. A suggestion was made by Poincaré [2,3] for bending of light from a remote celestial body. He retained the notion of Euclidian space and the bending of light rays was attributed to some disturbing force from planets. On the other hand, in his general theory of relativity, Einstein [4] considered the movement of light rays along the geodesic lines in a curved space without the influence of any force. Thus, the light rays were considered to propagate in straight (straightest) line.

In his famous Gedanken experiment, Einstein considered the motion of a ray of light in a space ship. He assumed that the propagation of light was rectilinear and the effect of gravitational field was thought to cause the motion of the ray in a parabolic path. Although the photon with m = 0 is not expected to be affected by the gravitational field.

According to general theory of relativity, light rays propagating through any gravitational field producing acceleration should be directed to the active force. Experimental observations were made on the island of Principe on the African coast and at Sobral in Brazil on May 29, 1919 during a solar eclipse [5] . A similar observation was made at another solar eclipse in 1922 at Wallal in Western Australia [6]. These results show that the expected bending of light rays occurred in the gravitational field of the Sun. The deflection of light was however very small. A few observations can be made on these experiments.

1. Since the mass of photon is zero, whatever be the value of 'g' for Sun, m x g = 0 so that, the photon will not at all be attracted by Sun's gravity. On the other hand, if the photon moves with the velocity of light 'c', then according to Einstein's theory its mass will be $m = m_0/(1-v^2/c^2)^{1/2}$. If v = c, m = 0/0 i.e., indeterminate implying any value of mass is possible. Then if the mass of photon is high, it will be completely captured by the black holes of the Sun. While the mass of photon can have any possible value, uncertainty will be reflected in its intensity. However, no such thing is reported.
2. Since the Sun is emitting light rays (photons) for billions of years without affecting their emission process, it indicates that gravity of Sun has little effect on light rays.
3. If light rays are affected by the gravity of a planet, then in course of its movement through astronomical distances, the light rays would be affected by more than one planet. This will result in multiple distortion in the course of light rays. The

positioning of the planets by astronomical observation would then be of no accuracy. This will turn the science of astronomy to insignificance.

4. The slight shift in the spectral lines in a solar spectrum (10^{-10} cm) might be due to the bending of the light rays. The shift in the spectrum of the dwarf companion of Sirius might be due to the same effect.

It therefore appears that while the bending of light ray i.e., its revolutionary motion is quite possible, the effect of gravity of a planet on light rays is doubtful.

Impact on General Theory of Relativity:

The famous general theory of relativity rests on three experimental facts. 1) Mercury's perihelion precision, 2) Shifting of a ray of light near a gravitational mass and 3) The gravitational red shift.

1) The major axis of the elliptical orbit of Mercury precesses around the Sun approximately 575 sec of arc per hundred years. Applying Newtonian mechanics involving attraction from all other planets 43 sec per hundred years remains unaccounted for. Einstein's calculation [7] shows 43 sec per hundred years without the pull of any other planet. But it has also been shown that if the Sun is not perfectly spherical, it may affect the precision of Mercury to a similar extent.
2) Light rays from distant stars are supposed to be attracted by the gravitational field of the Sun to produce a small deviation but as described above it may trace a curved path even in the absence of a gravitational field.
3) The red shift effect as revealed in a spectral line of extra galactic nebulae shifted towards the red end of the spectrum which means that the frequency of electromagnetic radiation received on the earth decreases. The explanation provided is that this is a consequence of the radiation source moving away according to Doppler's principle. This shows that the red shift is not geocentric in character. The red shift

does not indicate the runaway of galaxies but could also be the result of expansion of space itself.

It is, therefore, seen that the evidences on which Einstein formulated his general theory of relativity is not conclusively proved and other explanations for the evidences could be provided with equal effect.

Gravitation as curvature of space-time

As the motion of light deviates from rectilinear path, the notion of gravitation as arising from curvature of space-time becomes questionable and requires a serious reconsideration. Einstein inferred that gravitation is nothing but a depression (curvature) of space-time. Just like a rubber sheet is depressed by a mass, the space is also curved depending on the difference of masses. The tendency of the smaller mass to move towards the greater depression is the gravitational force.

From general theory of relativity, Einstein concluded that space in which there is gravitational field is not flat. Gravitation is manifested in space-time curvature and this distinguishes the gravitational field from all other known fields like nuclear and electromagnetic fields. To account for the curvature in space-time, Einstein applied tensorial metric to find the length and distances of geodesic lines but such mathematical manipulation did not help much to explain the nature and properties of gravitation.

After toiling hard for about eight years in his later life, Einstein arrived at gravitational field equations in the form of

$R_{\mu\nu} - \frac{1}{2} g_{\mu\nu} R = \frac{8\pi k}{c^4} T_{\mu\nu}$ where $R_{\mu\nu}$ is the R_{icci} tensor containing gravitational field energy expressing space-time curvature. Scalar curvature $R = g^{\mu\nu} R_{\mu\nu}$ and $T_{\mu\nu} =$ Energy-momentum tensor containing all other kinds of energy excepting gravitation.

Of the many solutions of Einstein's equations, most well-known are the solution of Schwarzschild and Friedmann [8]. The Schwarzschild metric describes the results of general theory of relativity very well and describes the geometrization of physics in an elegant way although ultimately gives rise to unsurmountable difficulties for gravitational field energy momentum.

It may be inferred that 1) Einstein was influenced by the notion of infallibility of Newton's laws of gravitation which assured 'attractive interaction' between masses, 2) There is no convincing proof that the space can actually be curved by a mass, 3) The rubber sheet analogy of curvature of space by means of different sizes of the mass only applies if 'attractive force' is present. But this does not explain how to account for the permeability of G and 'g' being indifferent to any intervening medium. For that matter, Newton's theory of gravitation also required a radical review of concept, details of which has been reported in an earlier communication [9].

Concluding Remarks:

Einstein was the pioneer to recognize the most important distinguishing feature of gravitational field that it imparts identical acceleration to all particles regardless of its mass. This is distinct from all other fields viz., nuclear, electric and magnetic fields. For example, under the influence of one and the same electric field, particles are differently accelerated depending on the value of their charge/mass ratio.

This clearly indicates that while the nuclear and electromagnetic fields are characterized by mutually attractive forces resulting from exchange of the π-meson (nuclear), positive and negative charges (electric), north and south poles (magnetic), the gravitational force is completely different (opposite) as there is no attractive force between masses. But instead of searching for the cause of this difference, Einstein under the notion of infallibility of Newton's gravitational force of attraction, tried to match gravitation with magnetic and electric forces as if to fit a square peg in a round hole which ultimately failed.

In this connection it may be noted that acceleration may be produced on a body either by pushing or pulling force. While the push produces a uniform acceleration, the pull gives rise to non-uniform (increasing) acceleration. The uniform acceleration shows a parabolic form (Fig. II) which is the characteristics of the gravitational force. The non-uniform acceleration force also produces a flatter parabolic form which does not correspond to the gravitational force.

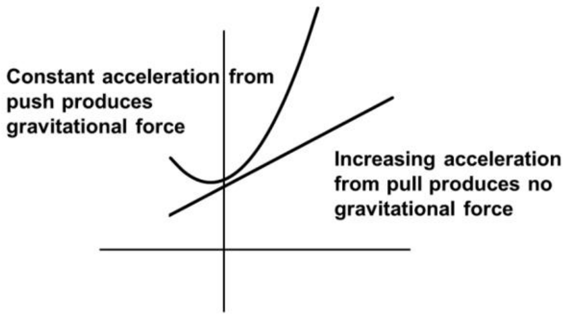

Fig. II: Identification of push and pull forces by generation of gravitational force (not to scale)

Unified fields

Philosophers of antiquity proposed to reduce everything to a single cause and effect chain of phenomena. It led to the idea that a single substance was the basis of everything. Ancient Indian philosophers characterized *Panchbhutani* (five elements) viz., *kshiti* (earth), *Aup* (water), *Tej* (fire), *Marut* (air) and *Baum* (space). Aristotle later recognized first four of these elements as the basis of forces operating in a nuclear and electromagnetic origin (this was later recognized as π-meson and photon as field quanta). Space (field) was considered by Einstein to be the source from which matter was produced and vice versa.

Gravitation is a macroscopic property of a force for which the proposed quanta “graviton” (micro or macroscopic) cannot properly be placed in the same class as “photons” or “π-meson” which are proper quantum mechanical field quanta. For this, unification of fields appears to be a wild goose chase which perhaps would never be realized. The idea also goes against the formulation of quantum theory of the gravitational field.

Hopefully, the followers of Einstein who are still working on his unfinished works on unified field, under proper course correction, may arrive at an acceptable description. This would then be a proper tribute to Albert Einstein, the greatest genius of all-times.

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