

Effect of Gravity Expressed as a Fluid Dynamic Phenomenon on Space Curve

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ABSTRACT: The alteration of the curvature of space time has been determined by directly linking gravity significantly to the Einstein Field Equations, with respect to coordinates in space and frame of reference. A similarity between gravitational field and the flow of fluids has been determined, by equating the like terms of the Einstein Field Equation and the Bernoulli's equation. Further calculations have focussed on finding the expression of space curve by knowing its direct dependence on time and vice versa. The calculations take into account the effects of (i) huge masses on space curve (ii) flow ability of gravitational field (iii) Newton's gravitational constant and the speed of light in vacuum. The applicability of the above calculations in more effective, fuel-efficient manoeuvring in space travel has been discussed.

KEYWORDS: Gravitation, Space Curve, Einstein Field Equation, Bernoulli principle

<https://doi.org/10.29294/IJASE.6.S1.2019.10-12>

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1. INTRODUCTION

Curved space is described best by Riemannian geometry as the spatial geometry which is not flat. It plays a significant role in general relativity describing gravity as curved space. General relativity depicts gravity as a geometric property of space and time thereby providing a unified interpretation of special relativity and Newton's law of universal gravitation. General relativity states that the behavior of an object in a gravitational field is same as that of accelerating enclosure. For example, an observer will observe an object under free fall in same way in a rocket as it does on Earth, provided the acceleration of rocket is equal to the acceleration due to gravity on Earth ($\approx 9.8 \text{ m/s}^2$). The Einstein Field Equation (EFE) through its system of partial differential equations illustrates the relationship between curvature of space and time as directly dependent on the energy and momentum of matter and radiation in that space [1,2].

The Einstein field equations comprise the set of ten equations in Albert Einstein's general theory of relativity (GTR), that describe the fundamental interaction of gravitation as a result of space-time being curved by mass and energy. It can be represented by the equation ^[1]:

$$R_{\mu\nu} - \frac{1}{2}Rg_{\mu\nu} + \Lambda g_{\mu\nu} = \left(\frac{8\pi G}{c^4}\right) T_{\mu\nu} \quad (1)$$

where,

- $R_{\mu\nu}$ is the Ricci tensor (the part of the curvature of space-time that determines the degree to which matter will tend to converge or diverge in time.)
- Λ is the cosmological constant (the energy density of space.)

- G is Newton's gravitational constant
- $T_{\mu\nu}$ is the stress-energy tensor (describes the density and flux of energy and momentum in space-time.)

Gravity is most accurately described by the general theory of relativity which describes gravity not as a force but as a consequence of the curvature of space time caused by the uneven distribution of mass. In practical physics, the 3D distribution of the point in a space and the single dimension of time into a four dimension continuum is a space time model. Without application of any net external force on an object a body will continue its straight line motion through a space time at a constant velocity along a straight path [3-5].

When gravity is taken into consideration, it is seen that the movement of an object is deflected from its straight space time path. It changes to a curve and its motion becomes accelerated as it is subjected to attraction from any other body present in its vicinity [1, 2]. In Einstein's geometric theory of gravity, the situation is described in a completely different way. A mass that we place in a region of space will lead to a distortion of space-time [1]. Empty space-time is flat; it looks exactly like the space-time of special relativity [9]. Space-time is the presence of masses is curved [1, 2, 4, 5]. Now, the gravitational field can be expressed as a fluid dynamic phenomenon in general relativistic space. Mathematically, gravity is just creating a potential field, the gradient of which produces acceleration. Gravitational field around a particle (spherical in shape); can be compared to a pond having a constant height and depth, such that, water is constantly being pumped in the center [2]. The water flows radially outward which is similar to that of the gravitational

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Received: 05.04.2019

Accepted: 18.05.2019

Published on: 20.07.2019

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field around a spherical object [2]. Hence, it can be easily compared to the flow of fluids as described by Bernoulli's principle. In fluid dynamics, Bernoulli's principle states that an increase in the speed of a fluid occurs simultaneously with a decrease in pressure or a decrease in the fluid's potential energy. According to the Bernoulli's equation,

$$P + \frac{1}{2}\rho V^2 + \rho gh = \text{constant} \quad (2)$$

The purpose of the present calculations is to obtain a similarity between the gravitational field and the flow of fluids, by establishing the similarity of expression of the EFE and the Bernoulli's equation [5]. The expression of the Einstein Field Equation has been modified and the terms have been re-arranged so that it seems to match the Bernoulli's equation. The final equation has been brought down to the form of the Bernoulli's Equation. The similarity between the expressions of the two equations leads to the conclusion that the effect of gravitational field on space curve can be related to the flow of fluid/water into a pond of constant depth. The water flows radially outwards which is similar to that of the gravitational field around a spherical object. An attempt to obtain the expression of the scalar curvature from expression of the radius of curvature has been made. The calculations have been carried out with the assumption that gravitational field is laminar and not intersecting, so that while plotting the relation between gravitational wave and time, the similarity of the Bernoulli's principle can be considered [4].

2. DEVELOPMENT

Bernoulli's principle, being conservative in nature, follows the paradox of the gravitational wave. Comparing the equation of relativity with respect to Bernoulli's equation, it can be shown that gravitational wave and space-time curve is same if the motion of fluids can be described in the *n*th dimension space with respect to time. Being associated with laminar flow only, thus, this equation is a key concept when linked with gravitational wave. The motion of a secondary body around a centralized body can be achieved by gravitational wave and space curve concept just by changing its radius after one lap [2, 3, 7].

Now, according to the EFE, we have

$$R_{\mu\nu} - \frac{1}{2}Rg_{\mu\nu} + \Lambda g_{\mu\nu} = \left(\frac{8\pi G}{c^4}\right)T_{\mu\nu} \quad (3)$$

Also, according to the Bernoulli's Equation, we have

$$P + \frac{1}{2}\rho V^2 + \rho gh = \text{constant} \quad (4)$$

Transforming equation (3) by dividing both sides by $T_{\mu\nu}$ (stress-energy tensor), we get,

$$\left(\frac{R}{T_{\mu\nu}}\right) - \frac{1}{2}R\left(\frac{g_{\mu\nu}}{T_{\mu\nu}}\right) + \Lambda\left(\frac{g_{\mu\nu}}{T_{\mu\nu}}\right) = \left(\frac{8\pi G}{c^4}\right) \quad (5)$$

Now, comparing the similarity of terms in equations (4) and (5), regarding the conservation of energy, we get,

- (i) $\left(\frac{R}{T_{\mu\nu}}\right)$, or, the ratio of the Ricci curvature tensor to the stress-energy tensor in equation (5) is similar to pressure (P) in equation (4).
- (ii) R, or, the scalar curvature in equation (5) is similar to minus of Volume squared ($-V^2$) in equation (4).
- (iii) $\left(\frac{g_{\mu\nu}}{T_{\mu\nu}}\right)$, or, the ratio of the metric tensor to the stress-energy tensor in equation (5) is similar to density of fluid (ρ) in equation (4).
- (iv) Λ , or, the cosmological constant in equation (5) is similar to the product 'gh' in equation (4).
- (v) $\left(\frac{8\pi G}{c^4}\right)$ on the right hand side of equation (5) has a constant value, and hence, is similar to the right hand side of equation (4).

3. RESULTS AND DISCUSSION

Upon the comparison of the two expressions, it may be concluded that, Bernoulli's theorem is a way forward in energy conservation in which the turbulence and laminar flow are being decided by its Reynold's number. Thus the curve of the gravitational field can also be decided (that whether it will be continuous laminar or distorted turbulent) on the particular constant value. The above comparison is an aid in determining the gravitational wave features, based on the theory of the Bernoulli's principle. Based on this principle, the following results can be said to be possible:

1. In space time curvature, when in the presence of a bigger mass, a smaller mass is made to move in a straight line, it will always get deflected and revolve around the bigger mass.
2. The trajectory of the orbit is a spiral, as it starts losing energy and eventually falls into the bigger mass. However, this trajectory is not observed in the solar system, since the other revolving planets cancel out the losing of energy. Hence the trajectory in that case is slightly elliptical.
3. The equation of the scalar curvature in the Einstein Field Equation can be found by finding the inverse of the radius of curvature of the spiral trajectory as mentioned in the previous point.
4. The expression for scalar curvature :

$$\rho = k [\exp \{-\alpha (\cot b)\}]$$

where, $k = 1/a$

a, b and k are constants

ρ is the scalar curvature

α is the angle of rotation as the curve spirals.

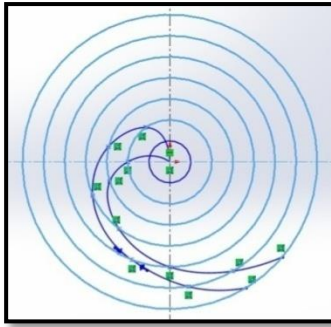


Figure 1 Shows the possible diagram of the spiral trajectory of the smaller mass when it is made to move in a straight line in the space time curvature. The radius of each turn of this spiral varies exponentially with the angle of rotation, thus giving us the expression for scalar curvature.

- In accordance with point 2 in results, the concept of the spiral trajectory comes from the already observed ripple phenomenon in gravitational field. This ripple phenomenon proves that gravitational field is, actually, closely related to the motion related characteristics of fluids.

4. CONCLUSION

Scopes for application and improvement in the future:

In future, gravitational field can be used as a medium for propagation of mass under a given equation by changing the scalar curvature. The conservative nature of the gravitation also makes the work done in a spiral path least and thus, least energy is lost in work. Hence, since work done and energy loss are reduced, the above mentioned comparison might

thus, provide a method to discover safer, cheaper and faster methods of manoeuvring in space travel.

ACKNOWLEDGEMENT

The authors are thankful to Mr. Samarpan Deb Majumder, Department of Mechanical Engineering, Institute of Engineering & Management, Kolkata, India, for his help in constructing the diagram of the spiral trajectory.

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Selection and/or Peer-review under the responsibility of 2nd International Students' Conference on Innovations in Science and Technology (Spectrum - 2019), Kolkata

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