

The Gravitomagnetic and Field Magnetic Centrifugal Force Using Force and Four-Dimensional Potential Concepts

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ABSTRACT

Unification of fundamental forces is the dream of physics. Nevertheless, unfortunately gravitational force operators to be isolated in its geometrical content from other forces. This encourages some researchers to propose the so-called gravimagnetic field to unify gravity with other forces and to explain some cosmological problems at the early universe. This motivates to construct a new model to confirm the existence of gravitomagnetic and a corresponding magnetic field associated with any field. Using the formal Newton definition of force and considering the magnetic force to be related to the time varying mass, the magnetic force is shown to be equal to the centrifugal force. This equality is typical when treating a particle as string. Using also the definition of force in terms of potential and electric force only, energy is shown to be conserved. The Newton force can be defined also in terms of four-dimensional potential with the time varying part related to the magnetic potential. When the particle is treated as a string, energy conservation holds, while for ordinary particle, the Lagrangian is conserved. The energy conservation holds for special relativity also for energy per unit mass. The definition of acceleration for forces that obeys inverse square law shows also the magnetic force is equal to the centrifugal force.

1. INTRODUCTION

Observing the sky at night, shows that, it is filled with small glittering objects. Some of them are called planets, while others are called stars. In addition, a large godly attractive object called the moon can also be observed [1].

One then asks a question, what are the forces, which causes these astronomical objects to be fixed firmly on the sky without escaping to the free space and without falling down towards the earth surface. The answer of these questions is possible within the framework of Newton's laws of motion and gravitation. According to his gravitational law, massive objects attract each other, with force proportional to the masses and inversely proportional to the square of the distance between the masses [2]. This explains the force of attraction between astronomical objects. This force is counter balanced by the so-called centrifugal force, which is an inertial force [3].

The gravitational field is well known as that force which is responsible for the interaction of astronomical objects with each other [4]. Recently, the behavior of the cosmos as a whole is described by general relativity, which was proposed by Einstein [5].

General relativity (gr) describes gravity using geometrical language. In his gr theory, Einstein considers gravity as space deformation caused by massive particles. He utilized Riemann geometry for a curved space to describe gravitational phenomena [6]. This geometrical structure of gravity makes it isolated from the main stream of physics.

This causes the gravitational phenomena to be not amenable to quantization [7]. This causes some difficulties in describing the early universe, where elementary particles and fields are generated. This needs a quantum gravity theory, since elementary particle cannot be described by classical laws [8, 9]. Until now, no theory that ultimately unifies all forces exists. Strictly speaking attempts made to unify gravity with other forces is accompanied with failure [10]. However, some attempts were made to quantize gravity field by M. Dirar and others [11, 12]. Another approach was initiated by Arbab to abandon the geometrical language of general relativity (gr) and replace it by suggesting the existence of the so-called gravitomagnetic field associated with the ordinary gravitational field. His theory, fortunately, successively describes a number of astronomical observations [13, 14]. These successes of Arbab model motivate construction of this model which has been done in Section 2. Sections 3 & 4 are devoted for discussion and conclusion.

2. THE MAGNETIC TIME DEPENDENT POTENTIAL FIELD USING THE FORCE DEFINITION

The force of a particle having mass m and velocity v is defined according to Newton second law of motion, where the gravitational force is given by [1]

$$F = \frac{dmv}{dt} = \frac{mdv}{dt} + v \frac{dm}{dt} = F_{eg} + F_{mg} \quad (1)$$

One can assume here the two terms in Equation (1) consists of electric (e) part and magnetic (m) part given by

$$F_e = \frac{mdv}{dt} \quad (2)$$

$$F_m = v \frac{dm}{dt} \quad (3)$$

For spherical body of mass density and radius r , the mass is given by [2]

$$m = \frac{4\pi}{3} \rho r^3 \quad (4)$$

$$m = \frac{[(2\pi r) \rho r^2] 2}{3} = \frac{2L}{3} \rho r^2$$

where L is the length of a circle on the sphere surface. Thus

$$F_m = v \frac{dm}{dt} = \frac{2}{3} \rho v r^2 \frac{dL}{dt} = \frac{2}{3} \rho v r^2 \frac{dL}{dt}$$

$$F_m = \frac{2}{3} \rho v^2 r^2 = \left(\frac{4\pi}{3} \rho r^3 \right) \left(\frac{1}{2\pi r} \right) v^2 = \frac{mv^2}{2\pi r} \quad (5)$$

This conforms with the definition of energy in Newtonian mechanics, where the magnetic part resembles the centrifugal force and proportional to it [2].

This view can help in understanding the notion of energy as resulting from the work done by the electric part only. This requires recalling the definition of force in terms of the potential V in the form:

$$F = -\nabla V = -\left(\frac{\partial V}{\partial x} \hat{i} + \frac{\partial V}{\partial y} \hat{j} + \frac{\partial V}{\partial z} \hat{k} \right) \quad (6)$$

where

$$d\mathbf{r} = dx \hat{i} + dy \hat{j} + dz \hat{k} \quad (7)$$

Thus the work done due to the potential is given by:

$$\int F \cdot d\mathbf{r} = -\int \nabla V \cdot d\mathbf{r} = -\int \left(\frac{\partial V}{\partial x} dx + \frac{\partial V}{\partial y} dy + \frac{\partial V}{\partial z} dz \right) = -\int dV = -V + c_1 \quad (8)$$

The work done by magnetic and electric part is given by:

$$\begin{aligned} \int F \cdot d\mathbf{r} &= \int \frac{dmv}{dt} d\mathbf{r} \\ \int \frac{d\mathbf{r}}{dt} dm v &= \int v dm v = \int v m dv + \int v^2 dm \end{aligned} \quad (9)$$

But when considering gravity force without gravito magnetic or more generally when considering electric force part and figuring the magnetic part one gets

$$\int m \frac{dv}{dt} d\mathbf{r} = \int F \cdot d\mathbf{r} = \int m v dv = \frac{1}{2} m v^2 + C_2 \quad (10)$$

Thus from (8) and (10) one gets

$$\begin{aligned} \frac{1}{2} m v^2 + C_2 &= -V + C_1 \\ C_1 - C_2 &= \frac{1}{2} m v^2 + V = K + V = \frac{p^2}{2m} + V \end{aligned} \quad (11)$$

This constant of motion is called the total energy E , which is a sum of kinetic and potential energy. This new definition removes the conflict of mass variation which is observed in fluids and sr particle mass [3, 4].

The expression of the magnetic force is not exactly equal to the centrifugal force. This discrepancy can be removed if one considers the particle as a string of length and density per unit length [5], thus

$$L = 2\pi r = \text{circumference} \quad (12)$$

Using the definition of magnetic force, it takes the form

$$F_m = v \frac{dm}{dt} = v \rho \frac{dL}{dt} \rho v^2 = \frac{2\pi r \rho v^2}{2\pi r} = \frac{mv^2}{2\pi r} \quad (13)$$

Thus using Equation (12), yields

$$F_m = \frac{mv^2}{2\pi r} \quad (14)$$

This resembles that of the centrifugal repulsive force, which results from the trial of a particle of con-

stant speed to change its direction.

This force is called reaction or interial force. Physics thought that this force is a fictitious force. However, one may also propose, according to Equation (14) that this force is a real gravito magnetic force.

The conventional definition of force per unit mass introduces spatial change of scalar function only. The definition of force for all fields per uni mass E_f can be extended to a four dimensional space to include time in the form

$$E = -\nabla\phi = -\nabla\varphi_e - \frac{1}{c} \frac{\partial\phi_m}{\partial t} \quad (15)$$

where φ_e is the electric equivalent part, while φ_m stands for the magnetic time part. According to this definition, the force is defined by:

$$F = mE_f = -\nabla\varphi_e - \frac{1}{c} \frac{\partial\phi_m}{\partial t} = -\nabla\varphi_e - \frac{m}{c} \frac{\partial\phi_m}{\partial t} \quad (16)$$

Here m stands for

The mass of the particle, where sr and gsr states that the mass is velocity and potential dependent.

$$m = m(v, \phi)$$

Thus according to the partial differentiation law:

$$dm = \frac{\partial m}{\partial v} dv + \frac{\partial m}{\partial \phi} d\phi \quad (17)$$

But, usually, v, ϕ are assumed as independent variables. This means that

$$\frac{\partial m}{\partial v} = 0, \quad \frac{\partial m}{\partial \phi} = 0 \quad (18)$$

However:

$$\begin{aligned} \frac{dm}{d\kappa} &= \frac{\partial m}{\partial v} \frac{dv}{d\kappa} + \frac{\partial m}{\partial \phi} \frac{d\phi}{d\kappa} \neq 0 \\ \frac{dm}{dt} &= \frac{\partial m}{\partial v} \frac{dv}{dt} + \frac{\partial m}{\partial \phi} \frac{d\phi}{dt} \neq 0 \end{aligned} \quad (19)$$

This is since

$$\frac{d\phi}{d\kappa} \neq 0, \quad \frac{dv}{dt} = a \neq 0 \quad (20)$$

Using Newton second law the force is defined as

$$\begin{aligned} F &= d(mv)/dt \\ F &= m \frac{dv}{dt} + v \frac{dm}{dt} \end{aligned} \quad (21)$$

According to string theory

$$ma = F = -k\kappa$$

This means that a is negative, thus, one can define the magnetic force per unit mass to be

$$E_m = -\frac{\partial v}{\partial t} = -\frac{1}{C} \frac{\partial\phi_m}{\partial t} \quad (22)$$

Thus comparing both sides of Equation (22) means that

$$v = \frac{\phi_m}{C} \quad (23)$$

But using the definition of force in Equation (16), one gets

$$F = -m\nabla\phi_e - \frac{m}{C} \frac{\partial\phi_m}{\partial t} = -\nabla m\phi_e - \frac{m}{C} \frac{\partial\phi_m}{\partial t} = -\nabla V - m \frac{\partial v}{\partial t} \quad (24)$$

Thus the total work done is given by

$$\begin{aligned} \int_1^2 F \cdot dr &= -\int_1^2 \nabla V \cdot dr - \int_1^2 m \frac{dv}{dt} \cdot dr \\ &= -V \int_1^2 - \int_1^2 m \frac{dv}{dr} \frac{dr}{dt} dr \\ &= -V \int_1^2 - m \int_1^2 v dv \\ &= -V_1 - \frac{1}{2} m v_1^2 + V_2 + \frac{1}{2} m v_2^2 \\ &= E_2 - E_1 \end{aligned} \quad (25)$$

Thus this integration is independent of the path followed. Thus one can define F to be

$$F = \frac{dE}{dr} \quad (26)$$

Such that

$$E = V + \frac{1}{2} m v^2 \quad (27)$$

But E_1 and E_2 are constants, which have constant values thus

$$\int_1^2 F \cdot dr = E_2 - E_1 = \text{constant} = C_0 \quad (28)$$

Hence

$$E_2 = E_1 + C_0 \quad (29)$$

Choosing

$$C_0 = 0 \quad (30)$$

The energy is thus conserved.

In view of Equations (2) and (3), one can use another alternative, to define the magnetic force per unit mass to be

$$E_m = \frac{\partial v}{\partial t} = \frac{dv}{dt} \quad (31)$$

Thus according to this definition the total force is given by

$$F = -m\nabla\phi_e + m \frac{mv}{dt} \quad (32)$$

Integrating both sides with respect to r gives

$$\begin{aligned} \int_1^2 F \cdot dr &= -m \int_1^2 \nabla\phi_e + m \int_1^2 \frac{dv}{dr} \frac{dr}{dt} dr = -\int_1^2 \nabla m\phi_e + m \int_1^2 v dv \\ &= -\int_1^2 \nabla V + \frac{1}{2} m v^2 \int_1^2 = [-v]_1^2 + \frac{1}{2} m [v^2]_1^2 \\ &= \left[\frac{1}{2} m v_2^2 - V_2 \right] - \left[\frac{1}{2} m v_1^2 - V_1 \right] = L_2 - L_1 \end{aligned} \quad (33)$$

Since L_2 and L_1 are constants it follows that

$$L_2 - L_1 = C_0 \quad (34)$$

where L represents the lagrangian defined by

$$L = \frac{1}{2}mv^2 - V = T - V \quad (35)$$

Thus

$$L_2 = L_1 + C_0 \quad (36)$$

Thus for the lagrangian to be conserved:

$$C_0 = 0 \quad (37)$$

$$L_2 = L_1 \quad (38)$$

This definition needs to be compatible with the fact that in special relativity (sr), where the mass is speed dependent, *i.e.*

$$m = m(v) \quad (39)$$

In this case, one cannot take amount of integration, thus:

$$\int m \frac{dv}{dt} dr = \int mvdv \quad (40)$$

This conflict can be removed by defining the force per unit mass in the form (see equation)

$$E_f = -\nabla \phi_e = \nabla \phi_m - \nabla \phi_e = \frac{dv}{dt} \quad (41)$$

$$\int E_f \cdot dr = -\int \nabla \phi \cdot dr = \int \frac{dv}{dt} \cdot dr = \int vdv$$

$$-\phi + C_1 = \frac{1}{2}v^2 + C_2 \quad (42)$$

$$\frac{1}{2}v^2 + \phi = C_1 - C_2 = C_0 = \text{constant} \quad (43)$$

Thus this quantity is conserved within the framework of Newton's laws and sr. this conserved quantity, one call it the energy per unit mass E_u which is given by

$$E_u = \frac{1}{2}v^2 + \phi \quad (44)$$

This expression secures the conservation of energy per unit mass in both Newtonian mechanics and sr.

The inverse square law forces magnetic forces can be shown to be equal to the centrifugal force.

According to the formal definition of acceleration

$$a = \frac{\partial v}{\partial t} = \frac{dv}{dt} = \frac{dv}{dr} \frac{dr}{dt} = \frac{F}{m} = \frac{C_0}{r^2} = C_0 r^{-2} \quad (45)$$

where C_0 is a constant parameter. Thus

$$\int a \cdot dr = \int vdv = C_0 \int r^{-2} dr = -\frac{C_0}{r} \quad (46)$$

$$\frac{1}{2}v^2 = \frac{C_0}{r} r = -ar \quad (47)$$

Considering the wave nature of particles as proposed by De Broglie the maximum speed v_m is related to the effective one v_e according to the relation

$$v_e = \frac{1}{\sqrt{2}} v_m$$

Thus

$$v_e^2 = \frac{1}{2} v_m^2 = \frac{1}{2} v^2 \quad (48)$$

Thus Equation (7) gives

$$v_e^2 = -ar \quad (49)$$

$$a = -\frac{v_e^2}{r} \quad (50)$$

Thus according to Equation (31)

$$E_m = -\frac{dv}{dt} = -a = \frac{v_e^2}{r} \quad (51)$$

3. DISCUSSION

It is very interesting to note that using the conventional definition of Newtonian force, one can prove that the centrifugal inertial force observed, may be itself the gravito magnetic field or in general the magnetic field corresponding to any field in nature.

According to Newton's laws, the force has two time variables, the velocity and the mass. The first approach associates the velocity time differential part with the well-known conventional force of moving solid bodies known as the electric force (see Equation (2)). The mass time differential part is related to the magnetic force as shown by Equation (3). Using the later definition (3), besides defining the mass in terms of its radius for spherical body (see Equation (4)), it has been shown that the magnetic force is proportional to the centrifugal force as Equation (5) shows. Defining the work done as to be results from potential field and electric force only the ordinary Newtonian energy conservation has been derived as shown by Equation (11).

Treating particles as one-dimensional string, the expression of mass in Equation (12), the magnetic force is typical to that of centrifugal repulsive force. This expression (14) enables to explain the origin of repulsive centrifugal force to be of magnetic origin instead of being resulting from inertia.

Another magnetic version of energy can be suggested also. This version extends the energy and force definition to four-dimensional spaces. Such that the spatial part is related to conventional potential, while the time differential part is a magnetic part, in which the magnetic potential is related to the velocity as shown by Equations (15) & (23). Using this force depending on four-dimensional potential, the work done gives lagrangian conservation (see Equations (33)-(38)). This may explain why lagrangian is the main tool used in formulating physical laws for all fields and elementary particles.

Unfortunately, these conservation laws require velocity in dependent mass. For velocity dependent mass as that in sr, the energy conservation holds for unit mass. This is done by equating the conventional potential per unit mass (the electric part) and the velocity dependent one (the magnetic part) which gives the energy conservation for unit mass for Newtonian mechanics as well as sr. Using the formal definition of acceleration with the forces that obeys inverse square law, one can easily again prove that the magnetic force is the centrifugal force itself (see Equation (45), Equation (51)).

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The authors declare no conflicts of interest regarding the publication of this paper.

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