On a new field theory formulation and a space-time adjustment that predict the same precession of Mercury and the same bending of light as general relativity

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Abstract: This article introduces a new field theory formulation. The new field theory formulation recognizes vector continuity as a general principle and begins with a field that satisfies vector continuity equations. Next, independent of the new formulation, this article introduces a new space-time adjustment. Then, we solve the one-body gravitational problem by applying the space-time adjustment to the new field theory formulation. With the space-time adjustment, the new formulation predicts precisely the same precession of Mercury and the same bending of light as general relativity. The reader will find the validating calculations to be simple. The equations of motion that govern the orbital equations are in terms of Cartesian coordinates and time. An undergraduate college student, with direction, can perform the validations. 2020 Physics Essays Publication.
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1 Introduction

One describes mathematically any space-time field that has flow lines that never begin, nor end, nor cross, as a fourdimensional vector function that satisfies vector continuity equations. The vector continuity equations are general equations that reduce to conservation laws, to wave equations, and to potential equations. Therefore, in retrospect, it was never a coincidence in Newtonian theory (NT) that the gravitational potential satisfies potential equations. It was never a coincidence in electromagnetic theory (EM) that Maxwell's equations describe fields that satisfy wave equations within a given frame of reference. Vector continuity appears throughout NT, EM, and special relativity (SR). One of the novelties of the new FT formulation is that it begins with vector continuity. NT, EM, SR, and general relativity (GR) claim different territories in the landscape of physics, and their territories overlap. The formulations differ by their metrics, by their frames of reference, and by their coordinate systems. Scientists have attempted to connect one theory to the other. For example, as it pertains to the connection between NT and GR, Atkinson1 examined GR in Euclidean terms and Montanus2 developed a formulation of GR in so-called absolute Euclidean space-time. Sideris asked fundamental questions about the connections between NT and GR, and Ziefle4 modified NT by the introduction of "gravitons" in an attempt to predict the precession of Mercury and the bending of light. These and other researchers strengthened the belief that important connections exist between NT, EM, SR, and GR. However, the connections continue to be confusing,

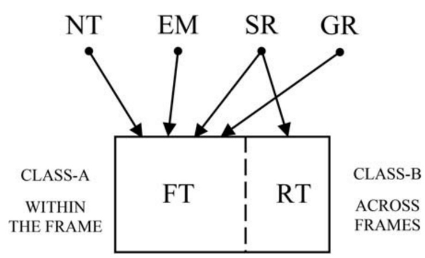

FIG. 1. The territories of analysis of FT and RT.

and the work is not complete.To address this confusion, let us now distinguish between two classes of physical theories: The class-A theory addresses physical behavior within a frame of reference, and the class-B theory addresses physical behavior across two or more frames of reference. This article focuses on the class-A theory, in particular, the new FT formulation and on a new space-time adjustment that we apply to gravitation in the new FT formulation. We will refer to the class-B theory as relativity theory (RT). To be clear, by frame of reference, we mean the frame in which one takes measurements and makes observations. This is quite different from what one means by the coordinate system. One can employ different coordinate systems within a frame of reference, and one can employ the same coordinate system across different frames of reference at the instant the frames are coincident. One employs the Galilean transformation between coordinate systems within a frame of reference and the Lorentz transformation across frames of reference regardless of the coordinate system .

2 Introduction to new FT formulation

Before proceeding to the validations, we briefly introduce the new FT formulation and compare it with the present-day formulation. The present day formulation starts with a relativistic correction in inertial space of the law of inertia in NT; the present-day field theory is a relativistic NT. It replaces the law $F_{\mathrm{r}} = m\frac{dv}{dt}v_{\mathrm{r}}$ (r = 1,2,3,4...) which describes the interaction force vector responsible for changing the state of a particle, with the relativistic law

$F_{\mathrm{r}} = m\frac{dv}{dt}(\frac{v_{\mathrm{r}}}{\sqrt{1-(\frac{v}{c})^2}})(r = 1, 2, 3, 4, ...)$

Notice in the law of inertia, with and without the relativistic correction, that one obtains the force vector by time differentiation. Furthermore, notice that the relativistic velocity components $(\frac{v_{\mathrm{r}}}{\sqrt{1-(\frac{v}{c})^2}})(r = 1, 2, 3)$ align with the first three components of a 4D unit vector that is tangent to the particle's space-time path. The authors characterize the presentday field theory as intending to accommodate the transition from the particle to the field and from the spatial domain to the space-time domain. We now contrast the present-day formulation with the new formulation.

3 Three Formulation

The fundamental problem of gravitation is a two-body problem. Whether employing FT, NT, or GR, one converts the two-body problem into a one-body problem (Appendix B). The following compares the treatments of the one-body problem in FT and NT with its treatment in GR. As will be seen below, the treatments require a space-time adjustment. Table I lists the fragment of energy, energy, action force, and interaction force for the one-body gravitational problem and more generally the governing equations (change equations and laws of inertia). For the one-body gravitational problem, the orbital mechanics takes place in the x_1,x_2 plane, the mass of the sun is M, and the mass of the orbiting body is m, where the orbiting body is either Mercury or a photon.

3.1 Gravitation in the new FT formulation with no space-time adjustment

In the one-body gravitational problem, the field consists of just one fragment of energy. TABLE Ia gives its components. The term A given there is the magnitude of the vector field with components A_s (s=1,2,3,4) Next, an action force is determined. Then, one determines 4D curvature vector components k_s(s=1,2,3,4) by substituting the action force vector into the change equation.

3.2 Gravitation in the new FT formulation with a space-time adjustment

Table Ib gives the components A_s (s=1,2,3,4) of the vector field of a stationary fragment using a space-time adjustment that we introduce for gravitation. We first apply it here to the new FT formulation and later to NT. The space-time adjustment adjusts the relationship between the speed of the source point of the orbiting fragment upon which the field of a stationary fragment acts, such as Mercury or a photon, and the orbiting fragment's corresponding angular momentum. Start by considering the circular motion of an orbiting fragment. In FT, the following expression is exact for circular motion: $\frac{1}{1-(\frac{v}{c})^2} = 1 + (\frac{h}{mc})^2 \frac{1}{r^2} (where, h = \frac{mrv}{\sqrt{1-(\frac{v}{c})^2}})$

3.3 Gravitation in NT with no space-time adjustment

NT with no space-time adjustment begins with a potential energy function V or with interaction force vector components F_s (s=1,2,3) A gradient vector relates the two by $F_s = -\frac{\partial v}{\partial x_s}(s = 1, 2, 3)$ Then, one determines 3D acceleration vector components a_s (s=1,2,3)) by substituting the interaction force vector into the governing law of inertia. Note that the potential energy function in NT with no space-time adjustment is not associated with a potential energy vector function. The potential energy function for gravitation will recognize that V is associated with a potential energy vector function.

3.4 Gravitation in NT with space-time adjustment

We begin with NT and now associate the potential energy V of a body with a potential energy vector function like in the new FT formulation. Next, we apply the space-time adjustment to the one-body gravitational problem in

NT. Again, the space-time adjustment considers the relationship between the speed of the mass center of the orbiting body and its corresponding angular momentum and, again, we start by considering the circular motion of the orbiting body. In NT, the following expression is exact for circular motion: $\frac{1}{1-(\frac{v}{c})^2} = 1 + (\frac{H}{mc})^2 \frac{1}{r^2} (where, H = rmv)$ where H is the angular momentum of the orbiting body. The space-time adjustment consists of first multiplying the gravitational potential $-GM\frac{1}{r}$ of the stationary body Again, in the one-body gravitational problem, the speed v of the orbiting body is not constant whereas its angular momentum is constant. Again, when one multiplies the gravitational potential $-GM\frac{1}{r}$by the right side of the first expression in above equation, one finds that the expression splits into two parts, with H being constant . Like in FT, the second step is to replace the left side of above equation with the right side of Eq. which eliminates the dependence on v and expresses V in terms of its independent spatial coordinates alone. We determine the interaction force by the sun from $F_{\mathrm{r}} = -\frac{\partial v}{\partial x_{\mathrm{r}}} (r = 1, 2, 3)$; holding H constant. Again, we used the resulting expression to determine the interaction force at any point along the trajectory wherein the motion is not circular .Again, we no longer guarantee vector continuity to be satisfied after making the adjustment. In this article, the reader will discover, had Newton added the previously mentioned second term in last eq. to the gravitational potential, that he would have predicted the same precession of Mercury as in GR. On the other hand, he would not have been inclined to pursue that because during the time of Newton scientists had not yet observed the precession of Mercury, they had not yet developed the concept of vector continuity, nor had scientists yet developed the apparatus of curved space-times .

4 Results

A body orbits the sun in the problem of the precession of Mercury and in the problem of the bending of light. In the bending of light problem, the body is a massless point traveling at the speed of light. One calls such a point a photon . each problem, we determined the trajectories by numerical integration of the accelerations of the orbiting body. We adopted a numerical approach instead of an analytical approach, because analytical results do not yet exist for all of the cases considered and because the numerical approach simplifies the verification of the results.

Table 1: Physical Constants

sun		
M	Mass of the sun	1.989×10^{39} Kg
r_s	Radius of Sun	696 000 000m

Mercury

m	Mass of the Mercury	3.3×10^{23}Kg
r_p	periphelion radius of Mercury	4.6×10^{10}m
r_b	Aphelion radius of Mercury	6.982×10^{10}m
A	Semimajor axis of Mercury	57.91×10^{9}m
e	Eccentricity of Mercury	0.20566
v_p	Perihilion Velocity	58.98×10^{3}m/s
T	Orbital Period	$87.969 EarthDays = 7600530$s

Other

G	Gravitational Constant	$6.674 \times 10^{-11} \frac{m^3}{kg-s^2}$
c	Speed of Light	2.99×10^{8}m/s

4.1 Precision of Mercury

GR predicted successfully the so-called anomalous precession of Mercury, over and above the precession caused by the other planets and solar oblateness. From GR, the analytically determined precession of Mercury is
$\delta\varphi = \frac{6\pi G(M+m)}{c^2 A(1-e^2)}$
$= 5.07 \times 10^{-7} rad/orbit$
$= 0.104093 arc - sec/orbit$
$= 43.2 arc - sec/century$
Again, the numerically integrated trajectories began at Mercury's perihelion with the initial conditions. In order to determine the precise location of the next perihelion, the time derivative of the orbit radius $\frac{dr}{dt} = \frac{(x_1 \frac{dx_1}{dt} + x_2 \frac{dx_2}{dt})}{r}$ was monitored, and the time when its value crossed zero was determined. At that instant, the predicted angle of precession was calculated numerically from $\delta\varphi = \frac{x_2}{r_p}$

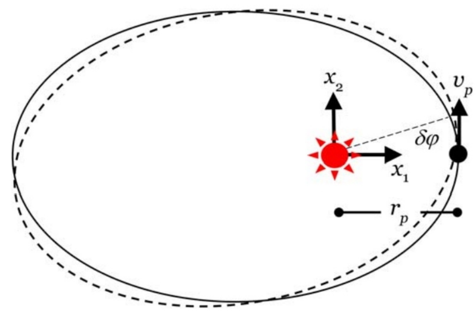

FIG. 2. (Color online) Trajectory of Mercury.

4.2 Bending of light

The classic problem of analytically determining the bending of light by GR predicts the angle of bending as $\delta_{\mathrm{N}} = \frac{4GM}{c^2 r_{\mathrm{p}}}$
$= 8.534 \times 10^{-6} rad$
$= 1.706 arc - sec$

where r_p is the "distance of closest approach" (the perihelion) and, for the purposes of simulation, has been set equal to the radius r_s of the sun . In order to predict the path of a photon orbiting the sun, we considered the model of a photon using the equations of motion . First, we set $\mu = \frac{mM}{m+M}$ Þ to m after which the m cancelled from the equations of motion. In FT with the adjustment, by setting the photon speed to the speed of light, one would get a divide by zero error . The divide by zero arises in the term $(\frac{h}{mc})^2 = (\frac{r_{\mathrm{S}} v_2}{c})^2 \frac{1}{1-(\frac{v}{c})^2}$

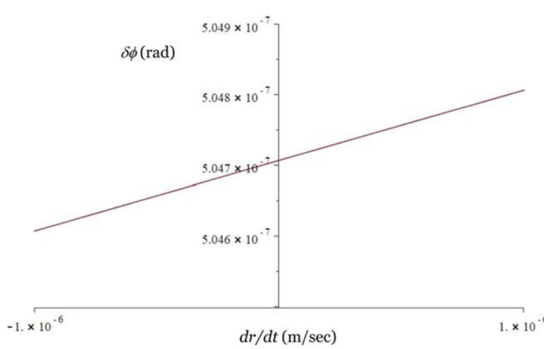

FIG. 3. (Color online) The precession angle in FT with the adjustment.

when v is set equal to c. The expressions for the acceleration components become indeterminate), so we take the limit as v approaches c instead of evaluating v at c. The bending angle of light numerically determined by FT with the adjustment for increasing initial photon speeds. For an initial speed equal greater than or equal to 0.9999c, the predicted numerical value agrees to three decimal places with the celebrated analytical result. FT without the

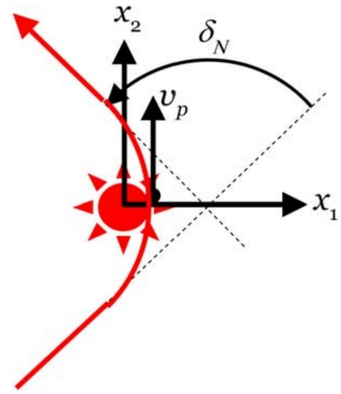

FIG. 4. (Color online) Bending of light.

adjustment predicts a bend angle of precisely zero. In contrast, NT without

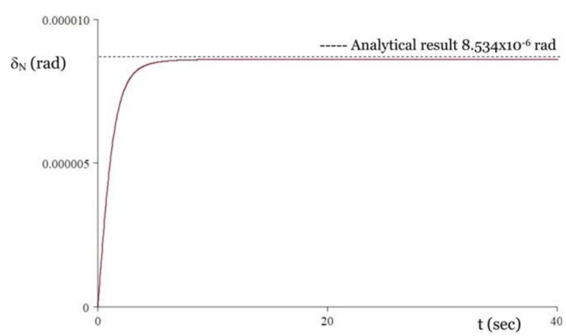

FIG. 5. (Color online) Determining the light bending angle in FT with the adjustment ($v = 0.99999c$).

the adjustment predicts a bend angle that is precisely 50% smaller than the bend angle that GR predicts. This result is well-known. Notably, with the space-time adjustment, FT predicts precisely the same bending of light that GR predicts in addition to precisely the same precession of Mercury that GR predicts ,respectively, predicts precisely 50% less and then precisely 50% more bending of light than GR predicts.

5 Summary

Think of energy as made up of lines that fill up a region of space and time, flowing into and out of that region, never beginning, never ending and never crossing one another. Even though, mathematically, there were lots of robust contenders, We can chose a concentration (or fragments) of energy as the building block. Such fragments have the properties of both particles and waves, with the highest concentration of energy at the centre, which dissipates as it moves further away.

While standard physics work perfectly fine in most cases, things often become much trickier when it comes to the very large and the very small scale.

Modelling the celestial bodies as fragments of energy, we can finf that the are identical to those predicted by the theory of general relativity.

6 Conslusion

The fragment could be a single potentially universal building block from which to model reality mathematically – and update the way people think about the building blocks of the Universe.

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