EQUATIONS OF MOTION OF THE NEW GENERAL RELATIVITY

by

M .W. Evans and H. Eckardt,

Civil List, AIAS and UPITEC

(www.aias.us, www.webarchive.org.uk. , www.et3m.net, www.upitec.org,

www.atomicprecision.com)

ABSTRACT

Using the method of constraining the Minkowski metric with an observed orbit, the equation of motion of a new theory of general relativity is derived self consistently in two different ways. The observed orbit is shown to reduce the dimensionality of the metric as defined in general, thus simplifying the derivation of the equation of motion. The equation of the new general relativity is self consistent, while the Newtonian dynamics are not self consistent and the inverse square law is not unique. It is shown that the incorrectly named Schwarzschild metric does not reduce to Newtonian dynamics self consistently.

Keywords: General relativity based on the constrained Minkowski metric, equations of motion, ECE theory.

UFT 206

1. INTRODUCTION

Recently in this series of papers it has been shown that the Einsteinian general relativity (EGR) is incorrect in several ways. This has become very easy to demonstrate, it is sufficient to differentiate the equation of the precessing ellipse to show that EGR is incorrect fundamentally. The ECE series of papers {1 - 10} uses the completed geometry of Cartan to unify field theory covariantly and straightforwardly. However, the collapse of EGR means that there is a need for a fundamentally new equation of motion based on the infinitesimal line element defined from the metric. This is because the obsolete method was based on a metric that is now known not to be able to produce a precessing ellipse. In this paper the constrained Minkowski metric is used to give this equation of motion self consistently in two different ways. This method uses the observed orbit as a starting point, and to analyse the orbit in terms of Riemann torsion and curvature. In Section 2, some elements of differential algebra are given for convenience of reference and to emphasize that the orbit is a function of time as well as of the cylindrical polar coordinates in a plane (r, θ). Using these methods and those of UFT205 (www.aias.us) it is shown that the Evans identity is an exact identity. The metric is defined in general and it is shown that this definition is consistent with one based on basic differential algebra.

In Section 3 the equation of motion of the constrained Minkowski metric is developed self consistently using two different methods. It is reduced to the Newtonian limit, but it is shown that Newtonian dynamics is not uniquely defined, and conceptually self contradictory. Furthermore it is shown that the so called Schwarzschild metric does not reduce to Newtonian dynamics while maintaining the orbit intact. This analysis therefore shows that the constrained Minkowski metric is the only valid description of orbits based on an infinitesimal line element.

2. PROOF OF THE EVANS IDENTITY FOR ALL ORBITS

Some elements of differential algebra are reviewed for ease of reference as follows {11}. If f is a function of one independent variable u and u is a function of x, then:

$$\frac{df}{dx} = \frac{df}{du}\frac{du}{dx}, \quad f = f(u), \quad u = u(x). \quad -(1)$$

When f is a function of two or more variables:

$$f = f(u), \quad u = u(x, y), \quad -(2)$$

then:

$$\frac{\partial f}{\partial x} = \frac{df}{du}\frac{\partial u}{\partial x} \quad -(3)$$

$$\frac{\partial f}{\partial y} = \frac{df}{du}\frac{\partial u}{\partial y}. \quad -(4)$$

If:

$$f = f(x, y) \quad -(5)$$

then the total derivative is:

$$\frac{df}{dt} = \frac{\partial f}{\partial x}\frac{dx}{dt} + \frac{\partial f}{\partial y}\frac{dy}{dt} \quad -(6)$$

so:

$$\frac{df}{dx} = \frac{\partial f}{\partial x} + \frac{\partial f}{\partial y}\frac{dy}{dx}. \quad -(7)$$

These definitions are discussed in more detail in note 206(3) accompanying this paper on www.aias.us. Consider a function:

$$g = g(u(x, y)) \quad -(8)$$

then from Eq. (3):

$$\frac{\partial g}{\partial x} = \frac{dg}{du} \cdot \frac{\partial u}{\partial x}. \quad -(9)$$

Now let:

$$g = \frac{\partial f}{\partial u} \quad -(10)$$

then:

$$\frac{\partial}{\partial x}\left(\frac{\partial f}{\partial u}\right) = \frac{d^2 f}{du^2} \frac{\partial u}{\partial x} \quad -(11)$$

i.e.

$$\frac{d^2 f}{du^2} = \frac{\partial x}{\partial u} \frac{\partial^2 f}{\partial x \partial u}. \quad -(12)$$

Secondly let:

$$g = \frac{\partial f}{\partial x} \quad -(13)$$

then:

$$\frac{\partial}{\partial u}\left(\frac{\partial f}{\partial x}\right) = \frac{d^2 f}{dx^2} \frac{\partial x}{\partial u} \quad -(14)$$

i.e.

$$\frac{d^2 f}{dx^2} = \frac{\partial u}{\partial x} \frac{\partial^2 f}{\partial u \partial x}. \quad -(15)$$

As shown on page 139 of ref. (11):

$$\frac{\partial^2 f}{\partial u \partial x} = \frac{\partial^2 f}{\partial x \partial u} \quad -(16)$$

if both functions are continuous at (a, b). Dividing Eq. (12) by Eq. (15):

$$\frac{d^2 f}{du^2} = \left(\frac{\partial x}{\partial u}\right)^2 \frac{d^2 f}{dx^2} \quad -(17)$$

If:

$$u = t, \; x = \theta \quad -(18)$$

then

$$\frac{d^2 f}{dt^2} = \left(\frac{\partial \theta}{\partial t}\right)^2 \frac{d^2 f}{d\theta^2} \quad -(19)$$

which is the Evans identity derived in UFT205 (www.aias.us), Q.E.D.

Consider the orbital function:

$$f(x, y) = \theta(t, r) \quad -(20)$$

and apply the rule (6) for the total derivative. Define:

$$x = t, \; y = r \quad -(21)$$

then

$$\omega = \frac{d\theta}{dt} = \frac{\partial \theta}{\partial t} + \frac{\partial \theta}{\partial r}\frac{dr}{dt} \quad -(22)$$

where ω is the angular velocity, which is the total derivative of θ with respect to time t. There are contributions to the angular velocity from the partial derivative and a second term as shown in Eq. (22). In order to construct a self consistent theory of general relativity to replace the obsolete Einsteinian general relativity (EGR) it is necessary to define the constrained metric rigorously. In general {12} the infinitesimal line element is defined in terms of the metric as:

$$ds^2 = g_{\mu\nu}\, dx^\mu dx^\nu . \qquad (23)$$

Consider the plane cylindrical polar coordinates in the plane:

$$dZ^2 = 0 \qquad (24)$$

then the Minkowski line element is:

$$ds^2 = c^2 dt^2 - dr^2 - r^2 d\theta^2 \qquad (25)$$

and the Minkowski metric is:

$$g_{\mu\nu} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & -r^2 \end{bmatrix} . \qquad (26)$$

In this notation:

$$\left.\begin{aligned} g_{00} = 1,\ g_{11} = -1,\ g_{22} = -r^2, \\ dx^0 = c\,dt,\ dx^1 = dr,\ dx^2 = d\theta . \end{aligned}\right\} \qquad (27)$$

By defining the orbital function:

$$f\left(r(t), \theta(t)\right) = \frac{dr}{d\theta} \qquad (28)$$

it follows that:

$$ds^2 = c^2 dt^2 - \left(1 + \frac{r^2}{f^2}\right) dr^2 \qquad (29)$$

and:

$$g_{\mu\nu} = \begin{bmatrix} 1 & 0 \\ 0 & -\left(1 + \frac{r^2}{f^2}\right) \end{bmatrix} \qquad (30)$$

so that:

$$\left.\begin{array}{l} g_{00} = 1, \quad g_{11} = -\left(1 + \dfrac{r^2}{f^2}\right), \\ dx^0 = c\,dt, \quad dx^1 = dr. \end{array}\right] \quad -(31)$$

As shown in UFT205 the constrained metric (30) generates torsion and curvature elements, so it is no longer a metric of flat spacetime. This method is a rigorous development of special into general relativity. In curvilinear coordinates the diagonal metric in the plane:

$$dZ^2 = 0, \quad g_{ij} = \frac{\partial \underline{r}}{\partial u_i} \cdot \frac{\partial \underline{r}}{\partial u_j} \quad -(32)$$

is defined conventionally as:

$$ds^2 = d\underline{r} \cdot d\underline{r}. \quad -(33)$$

So in this plane:

$$g_{11} = g_{22} = 1 \quad -(34)$$

$$g_{12} = g_{21} = 0. \quad -(35)$$

By definition:

$$d\underline{r} = \frac{\partial \underline{r}}{\partial r} dr + \frac{\partial \underline{r}}{\partial \theta} d\theta \quad -(36)$$

using the chain rule (6). By using the orbital function:

$$f = \frac{dr}{d\theta} \quad -(37)$$

the metric matrix can be reduced using:

$$d\theta = \frac{dr}{f} \quad -(38)$$

so:

$$d\underline{r} = \left(\frac{\partial \underline{r}}{\partial r} + \frac{1}{f} \frac{\partial \underline{r}}{\partial \theta} \right) dr . \quad -(39)$$

The total derivative:

$$\frac{d\underline{r}}{dr} = \frac{\partial \underline{r}}{\partial r} + \frac{1}{f} \frac{\partial \underline{r}}{\partial \theta} \quad -(40)$$

may then be defined. Using the unit vectors:

$$\underline{e}_r = \cos\theta \, \underline{i} + \sin\theta \, \underline{j} \quad -(41)$$

$$\underline{e}_\theta = -\sin\theta \, \underline{i} + \cos\theta \, \underline{j} \quad -(42)$$

then:

$$\frac{d\underline{r}}{dr} = \underline{i} \left(\cos\theta - \frac{r}{f} \sin\theta \right) + \underline{j} \left(\sin\theta + \frac{r}{f} \cos\theta \right) . \quad -(43)$$

Finally define the metric:

$$g_{11} = \frac{d\underline{r}}{dr} \cdot \frac{d\underline{r}}{dr} \quad -(44)$$

using the total derivatives instead of the partial derivatives of Eq. (32). The complete spacetime metric is:

$$g_{\mu\nu} = \begin{bmatrix} 1 & 0 \\ 0 & -\left(1 + \frac{r^2}{f^2}\right) \end{bmatrix} \quad -(45)$$

which is the same as Eq. (30).

By defining the metric through the total derivative (44) the existence of the orbit is taken into account, so the metric (45) contains all the information needed to deduce the orbital equation as in the following section.

3. THE ORBITAL EQUATION

Consider the constrained line element:

$$ds^2 = c^2 d\tau^2 = c^2 dt^2 - (x^2 + r^2) d\theta^2 \quad - (46)$$

where:

$$x = \frac{dr}{d\theta} \quad - (47)$$

and $d\tau$ is the infinitesimal of proper time. Define the lagrangian {12, 13} using the methods of general relativity:

$$\mathcal{L} = \frac{1}{2} mc^2 \quad - (48)$$

where m is the mass of an object in orbit. Therefore:

$$mc^2 = mc^2 \left(\frac{dt}{d\tau} \right)^2 - m(x^2 + r^2) d\theta^2. \quad - (49).$$

The Euler Lagrange equation gives the total energy E and total angular momentum L as follows:

$$E = mc^2 \frac{dt}{d\tau}, \quad L = m(x^2 + r^2) \frac{d\theta}{d\tau}. \quad - (50)$$

It follows that:

$$mc^2 = \frac{E^2}{mc^2} - \frac{L^2}{m(x^2 + r^2)} \quad - (51)$$

giving the orbital equation:

$$\left(\frac{dr}{d\theta} \right)^2 = \frac{c^2 L^2}{E^2 - m^2 c^4} - r^2. \quad - (52)$$

In the limit of free particle motion:

$$\frac{dr}{d\theta} \rightarrow 0 \quad - (53)$$

and:

$$c^2 L^2 \rightarrow m r^2 \left(E^2 - m^2 c^4 \right). \quad -(54)$$

For a free particle in linear motion:

$$E^2 - m^2 c^4 \longrightarrow p^2 c^2 \quad -(55)$$

where p is the relativistic momentum:

$$p = \gamma m v = \gamma m \frac{d\underline{r}}{dt}. \quad -(56)$$

In this case:

$$L \rightarrow r p. \quad -(57)$$

In this limit the angular and linear momenta become non-relativistic so:

$$L \rightarrow m v r \quad -(58)$$

which is the non relativistic definition of angular momentum self consistently.

By definition:

$$c^2 d\tau^2 = c^2 dt^2 - d\underline{r} \cdot d\underline{r} \quad -(59)$$

where:

$$d\underline{r} \cdot d\underline{r} = v^2 dt^2 = \left(x^2 + r^2 \right) d\theta^2 \quad -(60)$$

so:

$$\frac{dt}{d\tau} = \left(1 - \frac{v^2}{c^2} \right)^{-1/2} \quad -(61)$$

where the velocity v is defined by:

$$v = (x^2 + r^2)^{1/2} \frac{d\theta}{dt}. \quad -(62)$$

In this theory the total angular momentum is defined by:

$$L = m(x^2 + r^2) \frac{d\theta}{d\tau} = m(x^2 + r^2) \frac{d\theta}{dt} \frac{dt}{d\tau}. \quad -(63)$$

From Eq. (62):

$$x^2 + r^2 = \left(\frac{v}{\omega}\right)^2 \quad -(64)$$

where:

$$\omega = \frac{d\theta}{dt} \quad -(65)$$

so the angular momentum is defined by:

$$L = \gamma m v^2 / \omega \quad -(66)$$

i.e.

$$\omega L = \gamma m v^2. \quad -(67)$$

In the limit:

$$v \ll c \quad -(68)$$

then

$$\omega L = m v^2 \quad -(69)$$

which is the non-relativistic result self consistently. From Eq. (63):

$$L = \gamma m \left(r^2 + \left(\frac{dr}{d\theta} \right)^2 \right) \omega. \quad -(70)$$

In the limit

$$\frac{dr}{d\theta} \rightarrow 0, \; \gamma \rightarrow 1 \quad -(71)$$

the non relativistic definition follows:

$$L = mr^2 \omega. \quad -(72)$$

Note carefully that the angular momentum defined by Eq. (70) is not a constant of motion because the only constant of motion is defined by the lagrangian (48). It becomes a constant of motion only in the non-relativistic limit (72).

The equation of motion can be derived self consistently in another way by considering the constrained metric:

$$ds^2 = c^2 dt^2 - \left(1 + \left(r \frac{d\theta}{dr} \right)^2 \right) dr^2 \quad -(73)$$

for which the lagrangian is:

$$\mathcal{L} = \frac{1}{2} mc^2 = \frac{1}{2} mc^2 \left(\frac{dt}{d\tau} \right)^2 - \frac{1}{2} m \left(1 + \left(r \frac{d\theta}{dr} \right)^2 \right) \left(\frac{dr}{d\tau} \right)^2. \quad -(74)$$

The Euler Lagrange equation gives the total energy:

$$E = mc^2 \left(\frac{dt}{d\tau} \right). \quad -(75)$$

Therefore:

$$mc^2 = \frac{E^2}{mc^2} - m\left(1 + \left(\frac{r\,d\theta}{dr}\right)^2\right)\left(\frac{dr}{d\tau}\right)^2 \quad -(76)$$

Now use:

$$\frac{dr}{d\tau} = \frac{dr}{d\theta}\frac{d\theta}{d\tau} \quad -(77)$$

so:

$$\frac{E^2}{mc^2} - mc^2 = m\left(1 + r^2\left(\frac{d\theta}{dr}\right)^2\right)\left(\frac{dr}{d\theta}\right)^2\left(\frac{d\theta}{d\tau}\right)^2 = \frac{L^2}{m(x^2 + r^2)} \quad -(78)$$

which is the same as eq. (51) Q.E.D.

The orbital equation (52) expresses any orbit in terms of the total energy:

$$E = \gamma mc^2 \quad -(79)$$

and the total angular momentum:

$$L = \gamma m\left(\left(\frac{dr}{d\theta}\right)^2 + r^2\right)\frac{d\theta}{dt} \quad -(80)$$

The total velocity v is defined as:

$$v = \left(\left(\frac{dr}{d\theta}\right)^2 + r^2\right)^{1/2}\omega. \quad -(81)$$

From Eqs. (81) and (52) it follows that:

$$\left(\frac{dr}{d\theta}\right)^2 = \left(\frac{v}{\omega}\right)^2 - r^2 \quad -(82)$$

so:

$$\left(\frac{v}{\omega}\right)^2 = \frac{c^2L^2}{E^2 - m^2c^4} \quad -(83)$$

In the limit:

$$\gamma \rightarrow 1 \quad -(84)$$

Eq. (83) reduces to:

$$E^2 - m^2 c^4 \rightarrow c^2 p^2 \quad -(85)$$

where:

$$p = \gamma m v \rightarrow m v . \quad -(86)$$

From Eq. (67):

$$\omega L \rightarrow m v^2 \quad -(87)$$

therefore:

$$\frac{c^2 L^2}{E^2 - m^2 c^4} \rightarrow \left(\frac{v}{\omega}\right)^2 \quad -(88)$$

which is a rigorously self consistent set of equations.

To exemplify the new orbital equation (52) consider orbits as follows. For a circle:

$$\frac{dr}{d\theta} = 0 \quad -(89)$$

so

$$v = \omega r \quad -(90)$$

self consistently. For the ellipse:

$$r = \frac{\alpha}{1 + \epsilon \sin\theta} \quad -(91)$$

then the orbital velocity is:

$$v = \left(\left(\frac{\epsilon}{\alpha} \right)^2 r^4 \sin^2\theta + r^2 \right)^{1/2} \omega. \quad -(92)$$

Note that Eq. (81) is:

$$v^2 = \omega^2 \left(\frac{dr}{d\theta} \right)^2 + r^2 \omega^2 = \left(\frac{d\theta}{dt} \right)^2 \left(\frac{dr}{d\theta} \right)^2 + r^2 \left(\frac{d\theta}{dt} \right)^2 = \left(\frac{dr}{dt} \right)^2 + r^2 \left(\frac{d\theta}{dt} \right)^2 \quad -(93)$$

which is the expression for v^2 obtained by differentiating:

$$\underline{v} = \frac{d\underline{r}}{dt} = \frac{d}{dt}(r\, \underline{e}_r) \quad -(94)$$

in cylindrical polar coordinates. Therefore Eq. (93) is obtained directly from the

constrained metric:

$$c^2 d\tau^2 = c^2 dt^2 - d\underline{r} \cdot d\underline{r} = v^2 dt^2 = \left(\left(\frac{dr}{d\theta} \right)^2 + r^2 \right) d\theta^2. \quad -(95)$$

In the Newtonian theory {14} the total Newtonian energy is the sum of the kinetic and potential energies:

$$E_N = \frac{1}{2} m v^2 - \frac{mMG}{r} \quad -(96)$$

where M is the attracting object, G is Newton's constant and r is the distance between m and M. Therefore the velocity is:

$$v = \left(\frac{2}{m} \left(E_N + \frac{mMG}{r} \right) \right)^{1/2}. \quad -(97)$$

The angular momentum of the Newtonian theory is the limit (72) and the kinetic energy of the Newtonian theory is the limit:

$$T = (\gamma - 1) mc^2 \rightarrow \frac{1}{2} mv^2 . \quad -(98)$$

The Newtonian limit is related to Eq. (52) by:

$$v^2 = \frac{2}{m}\left(E_N + \frac{mMG}{r}\right) \rightarrow \omega^2 \left(\frac{c^2L^2}{E^2 - m^2c^4}\right) \quad -(99)$$

which means that the concept of potential energy is replaced by the concept of constrained metric.

It is well known that the Newtonian theory gives an elliptical orbit:

$$r = \frac{\alpha}{1 + \epsilon \cos\theta} \quad -(100)$$

where α is the half right magnitude and where ϵ is the eccentricity. It follows that:

$$\left(\frac{dr}{d\theta}\right)^2 = \left(\frac{v}{\omega}\right)^2 - r^2 = \frac{2}{m\omega^2}\left(E_N + \frac{mMG}{r}\right)^2 - r^2$$
$$= \left(\frac{\epsilon}{\alpha}\right)^2 r^4 \sin^2\theta . \quad -(101)$$

In the constrained metric theory this expression is generalized to:

$$\left(\frac{dr}{d\theta}\right)^2 = \frac{c^2L^2}{E^2 - m^2c^4} - r^2 = \left(\frac{\epsilon}{\alpha}\right)^2 r^4 \sin^2\theta . \quad -(102)$$

It is claimed in the Newtonian theory that the ellipse (100) is given by the potential:

$$V = -\frac{k}{r} = -\frac{mMG}{r} . \quad -(103)$$

However, it may be shown as follows that this choice is not unique, so there is no universal law of gravitation. The Newtonian kinetic energy is:

$$T = \frac{1}{2} m \left(\frac{dr}{dt} \right)^2 + \frac{1}{2} m r^2 \left(\frac{d\theta}{dt} \right)^2 \quad -(104)$$

so the total Newtonian energy is:

$$E_N = \frac{1}{2} m \left(\frac{dr}{dt} \right)^2 + \frac{1}{2} m r^2 \left(\frac{d\theta}{dt} \right)^2 + V(r) \quad -(105)$$

Therefore:

$$\left(\frac{dr}{dt} \right)^2 = \frac{2}{m} \left(E_N - \frac{L^2}{2mr^2} - V(r) \right). \quad -(106)$$

Using:

$$\frac{dr}{dt} = \frac{dr}{d\theta} \frac{d\theta}{dt} = \omega \frac{dr}{d\theta} \quad -(107)$$

it is found that:

$$\left(\frac{dr}{d\theta} \right)^2 = \frac{2mr^4}{L^2} \left(E_N - V(r) \right) - r^2 \quad -(108)$$

which is the Newtonian orbital equation. By observation the orbit of a planet in the solar system is the ellipse (100). From this equation:

$$\left(\frac{dr}{d\theta} \right)^2 = \left(\frac{\epsilon}{\alpha} \right)^2 r^4 \left(1 - \frac{1}{\epsilon^2} \left(\frac{\alpha}{r} - 1 \right)^2 \right). \quad -(109)$$

Comparing Eqs. (108) and (109):

$$E_N - V(r) - \frac{L^2}{2mr^2} = \left(\frac{\epsilon}{\alpha} \right)^2 \frac{L^2}{2m} \left(1 - \frac{1}{\epsilon^2} \left(\frac{\alpha}{r} - 1 \right)^2 \right) \quad -(110)$$

from which:

$$V(r) = E_N - \frac{L^2}{2m}\left(\frac{2}{\alpha r} + \left(\frac{\epsilon^2 - 1}{\alpha^2}\right)\right) \quad -(111)$$

in which E_N, L, α and ϵ are constants, only two of which (α and ϵ) can be determined by observation. The potential (103) is obtained from the choice:

$$\alpha = \frac{L^2}{mk}, \quad \epsilon^2 = 1 + \frac{2E_N L^2}{mk^2}. \quad -(112)$$

From Eqs. (111) and (112):

$$V(r) = -\frac{k}{r}. \quad -(113)$$

However, this is a subjective choice. For an observed α and ϵ , the potential can be determined only up to E_N and L in Eq. (111).

The choice (112) is not unique, and there is no universal law of gravitation. For example V is no longer given by Eq. (113) for a precessing ellipse {1 - 10}.

The kinetic energy of the Newtonian theory is given from Eq. (111) as:

$$T = E_N - V(r) = \frac{L^2}{2m}\left(\frac{2}{\alpha r} + \left(\frac{\epsilon^2 - 1}{\alpha^2}\right)\right) = \frac{1}{2}mv^2 \quad -(114)$$

so the total linear velocity of m is:

$$v^2 = \left(\frac{L}{m}\right)^2\left(\frac{2}{\alpha r} + \left(\frac{\epsilon^2 - 1}{\alpha^2}\right)\right). \quad -(115)$$

The quantity that is determined experimentally is:

$$\left(\frac{mv}{L}\right)^2 = \frac{2}{\alpha r} + \left(\frac{\epsilon^2 - 1}{\alpha^2}\right). \quad -(116)$$

Now denote the Newtonian total energy by E_N and the Newtonian angular momentum by L_N for clarity. In the Newtonian theory these are defined as constants of motion. In the more general constrained metric theory:

$$\left(\frac{dr}{d\theta}\right)^2 = \frac{c^2 L^2}{E^2 - m^2 c^4} - r^2 \quad -(117)$$

in which the only constant of motion is the lagrangian:

$$\mathcal{L} = \frac{1}{2} mc^2 . \quad -(118)$$

In the general theory (117) there is no potential energy, a property of general relativity. The reduction to Newtonian theory occurs through a choice:

$$\left(\frac{v}{\omega}\right)^2 = \frac{c^2 L^2}{E^2 - m^2 c^4} \longrightarrow \frac{2mr^4}{L_N^2}\left(E_N - V(r)\right) \quad -(119)$$

but the Newtonian theory is only one out of an infinite number of possibilities. It is therefore entirely wrong to claim that the Newtonian theory predicts an elliptical orbit.

The only thing that can be said is that any observed orbit can be analysed by the orbital equation:

$$\left(\frac{dr}{d\theta}\right)^2 = \left(\frac{v}{\omega}\right)^2 - r^2 \quad -(120)$$

Finally consider the orbital equation of EGR, which is:

$$\left(\frac{dr}{d\theta}\right)^2 = r^4\left(\frac{1}{b^2} - \left(1 - \frac{r_0}{r}\right)\frac{1}{a^2}\right) - \left(1 - \frac{r_0}{r}\right) r^2 \quad -(121)$$

where:

$$a = \frac{mc}{L}, \quad b = \frac{Lc}{E} \quad -(122)$$

and where the so called Schwarzschild radius is:

$$r_0 = \frac{2MG}{c^2} \quad -(123)$$

The EGR equation (121) can reduce to the more general Eq. (52) if and only if:

$$r \to \infty \quad -(124)$$

in which case:

$$\frac{1}{b^2} - \frac{1}{a^2} + \frac{r_0}{a^2 r} \to \frac{2m}{L^2}\left(E_N - V(r)\right). \quad -(125)$$

$$= 2mT / L^2.$$

Therefore:

$$\frac{1}{b^2} - \frac{1}{a^2} + \frac{r_0}{r a^2} \longrightarrow \left(\frac{mv}{L}\right)^2 \quad -(126)$$

i.e.

$$\frac{E^2 - m^2 c^4}{c^2 L^2} + \frac{r_0}{r a^2} \to \left(\frac{mv}{L}\right)^2. \quad -(127)$$

This is true if and only if:

$$E^2 - m^2 c^4 \to c^2 p^2, \quad -(128)$$

$$p = \gamma m v \to mv,$$

i.e.

$$v \ll c \quad -(129)$$

and

$$r \to \infty. \quad -(130)$$

In this case however there is no orbit. Therefore the EGR theory never reduces correctly to the Newtonian theory, contrary to the claims of the twentieth century literature.

ACKNOWLEDGMENTS

The British Government is acknowledged for a Civil List Pension and the staff of AIAS and others for many interesting discussions. Dave Burleigh is thanked for posting and Alex Hill, Robert Cheshire and Simon Clifford for translation and broadcasting. The AIAS is established under the aegis of the Newlands Family Trust.

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