FORWARD AND RETROGRADE PRECESSION FROM THE ECE2 LAGRANGIAN.

by

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ABSTRACT

It is shown that the ECE2 covariant lagrangian gives both forward and retrograde precessions, whereas Einsteinian general relativity (EGR) produces only forward precessions. The relevant force equation is the relativistic Newton force equation. This is combined with the ECE2 covariant gravitational field equations for gravitostatics to give a precisely self consistent theory and to define the relevant spin connections.

Keywords: ECE2 unified field theory, forward and retrograde precessions, spin connections.

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1. INTRODUCTION

In recent papers of this series {1 - 12}, the theory of precession has been developed with various force equations and lagrangians. In this paper it is shown that the ECE2 covariant lagrangian can give both forward and retrograde precession, depending on how it is solved. The retrograde precession is given by the ECE2 lagrangian corresponding to the relativistic Newton force law and a vector Euler Lagrange equation,. and the forward precession by the use of the same lagrangian and two scalar Euler Lagrange equations. The solution is combined with the ECE2 field equations to calculate the relativistic spin connections uniquely. The spin connections are determined completely by the orbit.

This paper is a short synopsis of detailed calculations in the background notes posted with UFT377 on combined sites www.aias.us and www.upitec.org. In note 377(1), the orbital equation is defined using the relativistic Newton law. In Note 377(2) the spin connection vector is introduced and retrograde precession discussed. Note 377(3) gives a summary of calculations. Notes 377(4) to 377(7) show that the forward and retrograde precessions can be the same if and only if the orbit is the Newtonian ellipse and if and only if the precessions vanish. Note 377(8) uses the gravitostatic limit of the field equations of ECE2 together with the force equation to define the relevant spin connections uniquely.

2. FORWARD AND RETROGRADE PRECESSION FROM THE SAME LAGRANGIAN

Consider the ECE2 lagrangian in the Cartesian format {1 - 12}:

$$\mathcal{L} = -mc^2\left(1 - \frac{\dot{x}^2 + \dot{y}^2}{c^2}\right)^{1/2} + \frac{mMG}{(x^2+y^2)^{1/2}} \cdot \quad -(1)$$

The Lorentz factor is:

$$\gamma = \left(1 - \frac{\dot{X}^2 + \dot{Y}^2}{c^2}\right)^{-1/2} \quad -(2)$$

in which:

$$v^2 = \dot{X}^2 + \dot{Y}^2 \quad -(3)$$

The potential energy is:

$$U = \frac{-mMG}{(X^2 + Y^2)^{1/2}}. \quad -(4)$$

This lagrangian is a description of a mass m orbiting a mass M in a plane, a distance r apart.

The proper Lagrange variables are X and Y, and there are two Euler Lagrange equations:

$$\frac{\partial \mathcal{L}}{\partial X} = \frac{d}{dt}\frac{\partial \mathcal{L}}{\partial \dot{X}} \quad -(5)$$

and

$$\frac{\partial \mathcal{L}}{\partial Y} = \frac{d}{dt}\frac{\partial \mathcal{L}}{\partial \dot{Y}}. \quad -(6)$$

They are developed with computer algebra as in Section 3 to give:

$$\ddot{X} = \frac{MG}{\gamma (X^2 + Y^2)^{3/2}} \left(\frac{\dot{X}\dot{Y}Y + X\dot{X}^2}{c^2} - X\right) -(7)$$

and

$$\ddot{Y} = \frac{MG}{\gamma (X^2 + Y^2)^{3/2}} \left(\frac{\dot{Y}\dot{X}X + Y\dot{Y}^2}{c^2} - Y\right). -(8)$$

These equations are integrated by computer algebra as discussed in Section 3. They give an orbit in which forward precession occurs in a plane. This is precession in the same direction as the motion of m around M. For an initial condition of:

$$v(0) = 7.7529 \times 10^{6}\ ms^{-1} \quad -(9)$$

the precession is

$$\Delta\phi = 5.903 \times 10^{-4}\ \text{rad.} \quad -(10)$$

Now consider the same lagrangian (1) written as:

$$\mathcal{L} = -mc^2 \left(1 - \frac{\underline{\dot{r}} \cdot \underline{\dot{r}}}{c^2}\right)^{1/2} + \frac{mMG}{|\underline{r}|} \quad -(11)$$

where

$$\underline{r} = X\underline{i} + Y\underline{j}. \quad -(12)$$

The proper Lagrange variable is $\underline{r}$ and the Euler Lagrange equation is:

$$\frac{\partial \mathcal{L}}{\partial \underline{r}} = \frac{d}{dt}\frac{\partial \mathcal{L}}{\partial \underline{\dot{r}}} \quad -(13)$$

in which the relativistic momentum is:

$$\underline{p} = \frac{d\underline{r}}{d\tau} = \gamma \frac{d\underline{r}}{dt} = \gamma m \underline{v}_0 = \frac{\partial \mathcal{L}}{\partial \underline{\dot{r}}} \quad -(14)$$

where $\underline{v}_0$ is the Newtonian or non-relativistic velocity:

$$\underline{v}_0 = \underline{\dot{r}} = \frac{d\underline{r}}{dt}. \quad -(15)$$

It can be shown as in Note 377(1) that:

$$\frac{d\underline{p}}{dt} = \frac{d}{dt}\frac{\partial \mathcal{L}}{\partial \underline{\dot{r}}} = \gamma^3 m \underline{\ddot{r}} \quad -(16)$$

Furthermore:

$$\frac{\partial \mathcal{L}}{\partial \underline{r}} = -mMG\frac{\underline{r}}{r^3} \quad -(17)$$

so the Euler Lagrange equation (13) becomes:

$$\underline{F} = \gamma^3 m \ddot{\underline{r}} = -mMG\frac{\underline{r}}{r^3}. \quad -(18)$$

This is the orbital equation with the relativistic Newtonian force:

$$\underline{F} = \gamma^3 m \ddot{\underline{r}}. \quad -(19)$$

As shown in Note 377(1) this force is consistent with the Einstein energy equation:

$$E = \gamma m c^2. \quad -(20)$$

The Cartesian component equations of Eq. (18) are:

$$\ddot{X} = -\frac{MG}{\gamma^3 (X^2+Y^2)^{3/2}} X \quad -(21)$$

and

$$\ddot{Y} = -\frac{MG}{\gamma^3 (X^2+Y^2)^{3/2}} Y \quad -(22)$$

These are integrated by computer algebra in Section 3 and give a negative or retrograde precession of:

$$\Delta\phi = -1.7697 \times 10^{-3} \text{ radians} \quad -(23)$$

for an initial condition of the S2 star system {1 - 12} of:

$$v(0) = 7.7529 \times 10^{6} \text{ m s}^{-1} \quad -(24)$$

The experimentally observed precession for the S2 star system is between

-0.017 and 0.035 radians. The theoretical results are:

$$\Delta\phi = 5.903 \times 10^{-4} \text{ rad}, \quad -(25)$$

$$\Delta\phi = -1.7697 \times 10^{-3} \text{ rad} \quad -(26)$$

from Eqs. (7) and (8), and from Eq. (13) respectively. Therefore the theoretical results are in the middle of the experimental range. Einsteinian general relativity (EGR) can give only forward precession, so ECE2 relativity is preferred to EGR in yet another way. During the course of development of ECE2, the EGR has been refuted in at least eighty three ways ("Eighty Three Refutations of EGR" on www.aias.us).

In the non relativistic limit:

$$\gamma \rightarrow 1 \quad -(27)$$

the lagrangian (1) becomes:

$$\mathcal{L} = \frac{1}{2} m \left(\dot{x}^2 + \dot{y}^2 \right) + \frac{mMG}{(x^2+y^2)^{1/2}} \quad -(28)$$

and the Euler Lagrange equations (5) and (6) give an elliptical orbit via the equations:

$$\ddot{x} = -MG \frac{x}{(x^2+y^2)^{3/2}} \quad -(29)$$

and

$$\ddot{y} = -MG \frac{y}{(x^2+y^2)^{3/2}} \quad -(30)$$

In the same non relativistic limit, the non relativistic lagrangian can be written as:

$$\mathcal{L} = \frac{1}{2} m \underline{\dot{r}} \cdot \underline{\dot{r}} + \frac{mMG}{|\underline{r}|} \quad -(31)$$

and the Euler Lagrange equation (13):

$$\frac{\partial \mathcal{L}}{\partial \underline{r}} = \frac{d}{dt} \frac{\partial \mathcal{L}}{\partial \dot{\underline{r}}} \quad -(32)$$

gives an elliptical orbit via:

$$\ddot{\underline{r}} = - \frac{MG\underline{r}}{r^3} \quad -(33)$$

which is the vector form of Eqs. (29) and (30).

The vector lagrangian is the same as the scalar lagrangian because:

$$\dot{\underline{r}} \cdot \dot{\underline{r}} = \dot{x}^2 + \dot{y}^2 \quad -(34)$$

and:

$$\frac{1}{|\underline{r}|} = \frac{1}{r} = \frac{1}{(x^2+y^2)^{1/2}}. \quad -(35)$$

However, the vector Euler Lagrange equation is:

$$\frac{\partial \mathcal{L}}{\partial (x\underline{i}+y\underline{j})} = \frac{d}{dt} \frac{\partial \mathcal{L}}{\partial (\dot{x}\underline{i}+\dot{y}\underline{j})}. \quad -(36)$$

Now note that:

$$\frac{\partial \mathcal{L}}{\partial (x\underline{i}+y\underline{j})} = \frac{\partial \mathcal{L}}{\partial x} \frac{\partial x}{\partial (x\underline{i}+y\underline{j})} = \frac{1}{\underline{i}} \frac{\partial \mathcal{L}}{\partial x}, \quad -(37)$$

so:

$$\frac{\partial \mathcal{L}}{\partial x} = \underline{i} \cdot \frac{\partial \mathcal{L}}{\partial (x\underline{i}+y\underline{j})}. \quad -(38)$$

Similarly:

$$\frac{\partial \mathcal{L}}{\partial y} = \underline{j} \cdot \frac{\partial \mathcal{L}}{\partial (x\underline{i}+y\underline{j})} \quad -(39)$$

Also:

$$\frac{\partial \mathcal{L}}{\partial \dot{X}} = \mathbf{i} \cdot \frac{\partial \mathcal{L}}{\partial (\dot{X}\mathbf{i} + \dot{Y}\mathbf{j})} \quad -(40)$$

and:

$$\frac{\partial \mathcal{L}}{\partial \dot{Y}} = \mathbf{j} \cdot \frac{\partial \mathcal{L}}{\partial (\dot{X}\mathbf{i} + \dot{Y}\mathbf{j})} . \quad -(41)$$

Therefore:

$$\mathbf{i} \cdot \frac{\partial \mathcal{L}}{\partial \mathbf{r}} = \mathbf{i} \cdot \frac{d}{dt} \frac{\partial \mathcal{L}}{\partial \dot{\mathbf{r}}} \quad -(42)$$

gives:

$$\frac{\partial \mathcal{L}}{\partial X} = \frac{d}{dt} \frac{\partial \mathcal{L}}{\partial \dot{X}} \quad -(43)$$

and:

$$\mathbf{j} \cdot \frac{\partial \mathcal{L}}{\partial \mathbf{r}} = \mathbf{j} \cdot \frac{d}{dt} \frac{\partial \mathcal{L}}{\partial \dot{\mathbf{r}}} \quad -(44)$$

gives:

$$\frac{\partial \mathcal{L}}{\partial Y} = \frac{d}{dt} \frac{\partial \mathcal{L}}{\partial \dot{Y}} . \quad -(45)$$

The scalar Euler Lagrange equations are the two components of the vector Euler Lagrange equation. The remarkable conclusion is reached that the same lagrangian can give forward and retrograde precession, depending on the method of solution.

As described in Notes 377(4) to 377(7), if it is assumed that:

$$\ddot{X} = \frac{mG}{\gamma (X^2+Y^2)^{3/2}} \left(\frac{\dot{X}\dot{Y}Y + X\dot{X}^2}{c^2} - X \right) = -\frac{mGX}{\gamma^3 (X^2+Y^2)^{3/2}} \quad -(46)$$

and:

$$\ddot{Y} = \frac{mG}{\gamma\,(X^2+Y^2)^{3/2}}\left(\frac{\dot{Y}\dot{X}X+Y\dot{Y}^2}{c^2}-Y\right) = \frac{-mG\,Y}{\gamma^3(X^2+Y^2)^{3/2}} \quad -(47)$$

it follows that:

$$\dot{X}Y = X\dot{Y}. \quad -(48)$$

This result is given by the equation of an ellipse:

$$\frac{X^2}{a^2}+\frac{Y^2}{b^2} = 1 \quad -(49)$$

where a and b are the semi major and semi minor axes. So the forward and retrograde precessions are the same if an only if they are both identically zero, when there is no precession and when the orbit is an ellipse. In general, two entirely different precession phenomena are given by the same ECE2 lagrangian. The correct method and correct sign of the precession must be found by comparison with experimental data. For example in the S2 system the precession is negative or retrograde. This cannot be described by EGR.

The spin connections for retrograde precession are found from the the force equation (33) and two ECE2 gravitational field equations {1 - 12}:

$$\underline{\nabla}\cdot\underline{g} = \underline{\kappa}\cdot\underline{g} = 4\pi G\rho_M \quad -(50)$$

and

$$\underline{\nabla}\times\underline{g} = \underline{\kappa}\times\underline{g} = \underline{0} \quad -(51)$$

in which $\underline{\kappa}$ is related to the spin connection as described in UFT318 and in which ρ_M is the mass density of the source of mass M. It follows from the gravitational Coulomb law (50) that:

$$X\kappa_X + Y\kappa_Y = -1 \quad -(52)$$

(Note 377(8)). In the gravitostatic limit, the ECE2 Faraday law of induction becomes:

$$\underline{\nabla} \times \underline{g} = \underline{\kappa} \times \underline{g} = \underline{0} \quad -(53)$$

so:

$$\underline{\kappa} \parallel \underline{g}. \quad -(54)$$

It follows that:

$$\kappa_X = -\frac{mG\,X}{v_0^2 (X^2+Y^2)^{3/2}} \quad -(55)$$

and:

$$\kappa_Y = -\frac{mG\,Y}{v_0^2 (X^2+Y^2)^{3/2}} \quad -(56)$$

where v_0 is a velocity to be defined. Using Eq. (52), the velocity is deduced to be:

$$v_0^2 = \frac{mG}{(X^2+Y^2)^{1/2}} = \frac{mG}{r} \quad -(57)$$

and as shown in Note 377(8):

$$\kappa_X = -\frac{X}{X^2+Y^2} \quad -(58)$$

and

$$\kappa_Y = -\frac{Y}{X^2+Y^2} \quad -(59)$$

for the retrograde precession, and can be found from the numerical solution that gives X and Y. These vector components of $\underline{\kappa}$ are plotted in Section 3.

3. DISCUSSION OF NUMERICAL RESULTS AND GRAPHICS.

Section by Dr. Horst Eckardt.

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