FIELD, POTENTIAL AND FORCE EQUATIONS OF ORBITS IN ECE2

by

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ABSTRACT

A general theory of orbits is developed by using a combination of the orbital, or force equation, and the field and potential equations of ECE2 gravitation. The lagrangian and hamiltonian formulations are implemented to produce both forward and retrograde precessions, a property unique to ECE2 relativity. The initial conditions for the computation of the orbit are introduced through the kappa vector of ECE2 relativity, and the theory of zero and counter gravitation (UFT318 and UFT319) merged with orbital theory.

Keywords: ECE2, field, potential and force equations, initial conditions, counter gravitation.

UFT378

1. INTRODUCTION

In immediately preceding papers of this series {1 - 12} it has been shown that the ECE2 lagrangian produces both forward and retrograde precessions, a property unique to ECE2 relativity. Retrograde precessions do not occur in Einsteinian general relativity (EGR) but are thought to be observable in S2 star systems. In Section 2 the force or orbital equation is used together with the field and potential equations (UFT318 and UFT319) relevant to gravitostatics, in which there is no gravitomagnetic field. The result is a general theory of orbits which can be merged with the theory of zero and counter gravitation.

This paper is a short synopsis of notes accompanying UFT378 on www.aias.us and www.upitec.org (referred to as "combined sites"). Note 378(1) is a derivation of a general relation between the kappa vector and the acceleration due to gravity using two relevant field equations. Note 378(2) develops the field equations in Cartesian components, Note 378(3) introduces the concept of initial conditions being determined by the kappa vector, which models the background spacetime or aether. Note 387(4) introduces the hamiltonian into the theory, and Note 378(5) introduces the field potential equations of ECE2 gravitation first developed in UFT318 and UFT319.

2. THEORETICAL DEVELOPMENT

In immediately preceding papers it has been shown that the ECE2 lagrangian produces both forward and retrograde precessions, and so is preferred experimentally to EGR. The acceleration due to gravity in the forward precession is:

$$\underline{g} = \ddot{\underline{r}} = \frac{mG}{\gamma r^3}\left(\frac{\dot{\underline{r}}\,(\dot{\underline{r}}\cdot\underline{r})}{c^2} - \underline{r}\right) \quad -(1)$$

where γ is the Lorentz factor and $\underline{r}$ the position vector joining a mass m orbiting a mass M. Here G is the Newton constant. The acceleration due to gravity in the retrograde precession is:

$$\underline{g} = \ddot{\underline{r}} = -\frac{MG}{\gamma^3}\frac{\underline{r}}{r^3}. \quad -(2)$$

Both Eqs. (1) and (2) are derivable from the same ECE2 lagrangian:

$$\mathcal{L} = -\frac{mc^2}{\gamma} + \frac{mMG}{r} \quad -(3)$$

in a space with finite torsion and curvature {1 - 12}.

The relevant gravitostatic field equations are:

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

and

$$\underline{\nabla} \times \underline{\kappa} = \underline{\kappa} \times \underline{g} = \underline{0}, \quad -(5)$$

where $\underline{\kappa}$ is the kappa vector of the ECE2 field equations of gravitation (UFT318 and UFT319). Eq. (5) means that $\underline{\kappa}$ is parallel to $\underline{g}$ and:

$$\underline{g} = v_0^2 \underline{\kappa} \quad -(6)$$

where v_0 has the units of linear velocity. It follows that:

$$\underline{\nabla} \cdot \underline{g} = v_0^2 \kappa^2. \quad -(7)$$

From Eqs. (6) and (7):

$$\underline{\kappa} = \frac{\kappa^2 \underline{g}}{\underline{\nabla} \cdot \underline{g}}. \quad -(8)$$

For example, for a planar orbit in the non relativistic limit:

$$\underline{g} = g_x \underline{i} + g_y \underline{j} \quad -(9)$$

where

$$g_x = -\frac{mGX}{(X^2+Y^2)^{3/2}}, \quad g_Y = -\frac{mGY}{(X^2+Y^2)^{3/2}}. \quad -(10)$$

Therefore:

$$\underline{\nabla} \cdot \underline{g} = \frac{\partial g_x}{\partial X} + \frac{\partial g_Y}{\partial Y} = \frac{mG}{(X^2+Y^2)^{3/2}} \quad -(11)$$

and

$$X = -\frac{\kappa_x}{\kappa_x^2+\kappa_Y^2}, \quad Y = -\frac{\kappa_Y}{\kappa_x^2+\kappa_Y^2}, \quad -(12)$$

which is the result fond in UFT377 by another method.

Note 378(2) gives more examples of this method using Cartesian components for forward and retrograde precessions using the structure of the kappa vector:

$$\underline{\kappa} = 2\left(\frac{\underline{q}}{r^{(0)}} - \underline{\omega}\right) \quad -(13)$$

where $\underline{q}$ is the tetrad vector and $\underline{\omega}$ the spin connection vector.

In general, the field equations show that:

$$\frac{\ddot{X}}{\ddot{Y}} = \frac{\kappa_x}{\kappa_Y} \quad -(14)$$

an equation which can be used as an initial condition for the numerical solution of Eqs. (1) and (2). The final orbit will depend on $\kappa_x(0)$ and $\kappa_Y(0)$ and can be "aether engineered" by choice of initial conditions. For retrograde precession and for the non relativistic orbit:

$$\frac{x(0)}{y(0)} = \frac{\ddot{x}(0)}{\ddot{y}(0)} = \frac{\kappa_x(0)}{\kappa_y(0)} \quad -(15)$$

For forward precession:

$$\frac{\kappa_x(0)}{\kappa_y(0)} = \frac{\ddot{x}(0)}{\ddot{y}(0)} = \left(\frac{\dot{x}(0)\dot{y}(0)y(0)+x(0)\dot{x}^2(0)}{c^2} - x(0)\right)\left(\frac{\dot{x}(0)\dot{y}(0)x(0)+y(0)\dot{y}^2(0)}{c^2} - y(0)\right)^{-1} \quad -(16)$$

as described further in Note 378(3).

Note 378(4) introduces a constant of motion, the hamiltonian, which gives further information about the orbit. The non relativistic hamiltonian is:

$$H = \frac{1}{2}m\left(\dot{x}^2+\dot{y}^2\right) - \frac{mMG}{(x^2+y^2)^{1/2}}, \quad -(17)$$

a result that can be used to check that the numerical solution gives a constant H self consistently. Using the results:

$$x^2+y^2 = \frac{1}{\kappa_x^2+\kappa_y^2} \quad -(18)$$

and

$$v^2 = \dot{x}^2+\dot{y}^2 \quad -(19)$$

it follows that:

$$H = \frac{1}{2} m v^2 - mMG \left(\kappa_x^2 + \kappa_y^2 \right)^{1/2} \quad - (20)$$

so the initial velocity can be expressed as:

$$v^2(0) = x^2(0) + y^2(0) = \frac{2}{m} \left(H + mMG \left(\kappa_x^2(0) + \kappa_y^2(0) \right) \right) \quad - (21)$$

and is defined by H, $\kappa_x(0)$ and $\kappa_y(0)$, initial conditions which define the Newtonian orbit a conic section, notably the ellipse.defined by the force equations:

$$\ddot{x} = -MG \frac{x}{(x^2+y^2)^{3/2}} \quad - (22)$$

and

$$\ddot{y} = -MG \frac{y}{(x^2+y^2)^{3/2}} . \quad - (23)$$

Retrograde precession is defined by:

$$\ddot{x} = -\frac{MG}{\gamma^3} \frac{x}{(x^2+y^2)^{3/2}} \quad - (24)$$

and

$$\ddot{y} = -\frac{MG}{\gamma^3} \frac{x}{(x^2+y^2)^{3/2}} \quad - (25)$$

and the hamiltonian:

$$H = \gamma m c^2 - \frac{mMG}{(x^2+y^2)^{1/2}} . \quad - (26)$$

The Lorentz factor is defined by:

$$\gamma = \left(1 - \frac{v_0^2}{c^2} \right)^{-1/2} \quad - (27)$$

where v_0 is the Newtonian velocity {1 - 12}. From Eq. (26) the Lorentz factor is:

$$\gamma = \frac{H}{mc^2} + \frac{MG}{c^2 (X^2 + Y^2)^{1/2}} \quad -(28)$$

and retrograde precession becomes more and more pronounced as:

$$\gamma \rightarrow \infty \quad -(29)$$

i. e. as:

$$\left(1 - \frac{v_0^2}{c^2}\right)^{3/2} \rightarrow 0. \quad -(30)$$

Note carefully that the ECE2 theory of light deflection due to gravitation {1 - 12} imposes an upper bound:

$$v_0^2 \rightarrow \frac{c^2}{2}. \quad -(31)$$

In the non Newtonian limit the initial velocity is maximized with:

$$\kappa_X^2(0) + \kappa_Y^2(0) \rightarrow \infty \quad -(32)$$

under which condition very large precessions can be aether engineered.

The ECE2 field potential equations of gravitation were first given in UFT318 and UFT319:

$$\underline{g} = -\underline{\nabla}\Phi - \frac{\partial \underline{Q}}{\partial t} + 2\left(c\omega_0 \underline{Q} - \Phi \underline{\omega}\right) \quad -(33)$$

and

$$\underline{\Omega} = \underline{\nabla} \times \underline{Q} + 2\underline{\omega} \times \underline{Q} \quad -(34)$$

where Φ and $\underline{Q}$ are the gravitational scalar and vector potentials respectively. Here:

$$U = m\Phi \quad -(35)$$

is the gravitational potential energy in joules. The spin connection four vector is:

$$\omega^\mu = (\omega_0, \underline{\omega}) \quad -(36)$$

and

$$\underline{p} = m\underline{Q} \quad -(37)$$

is a momentum vector. The force equation is therefore:

$$\underline{F} = m\underline{g} = -\underline{\nabla} U - \frac{\partial \underline{p}}{\partial t} - 2U\underline{\omega} + 2c\omega_0\underline{p}. \quad -(38)$$

By the ECE antisymmetry law:

$$-\underline{\nabla} U - \frac{\partial \underline{p}}{\partial t} = -2U\underline{\omega} + 2c\omega_0\underline{p} \quad -(39)$$

so:

$$\underline{F} = m\underline{g} = 2\left(-\underline{\nabla} U - \frac{\partial \underline{p}}{\partial t}\right) = 4\left(c\omega_0\underline{p} - U\underline{\omega}\right). \quad -(40)$$

In the Newtonian theory there is no gravitational vector potential:

$$\underline{p} = m\underline{Q} = \underline{0} \quad -(41)$$

so the force equation is:

$$\underline{F} = m\underline{g} = -2\underline{\nabla} U = -4U\underline{\omega}. \quad -(42)$$

Here:

$$U_0 = 2U = -\frac{mG}{r} \quad -(43)$$

where:
$$U_0 = -\frac{mG}{r} \quad -(44)$$

is the Newtonian gravitational potential. As in Note 378(5) the spin connection is:

$$\underline{\omega} = -\frac{1}{2}\frac{\underline{r}}{r^2} \quad -(45)$$

with Cartesian components:

$$\omega_X = -\frac{X}{2(X^2+Y^2)}, \quad \omega_Y = -\frac{Y}{2(X^2+Y^2)}. \quad -(46)$$

Using the Cartesian components of the kappa vector:

$$\kappa_X = -\frac{X}{X^2+Y^2}, \quad \kappa_Y = -\frac{Y}{X^2+Y^2} \quad -(47)$$

the tetrad vector components can be found:

$$\frac{q_X}{r^{(0)}} = \kappa_X = -\frac{X}{X^2+Y^2}, \quad \frac{q_Y}{r^{(0)}} = \kappa_Y = -\frac{Y}{X^2+Y^2} \quad -(48)$$

for a Newtonian orbit.

For a non Newtonian orbit, for example a precessing orbit:

$$\underline{F} = m\underline{g} = -\underline{\nabla} U - \frac{\partial \underline{p}}{\partial t} \quad -(49)$$

where $\underline{p}$ can be interpreted as an aether momentum. So the orbital equations become:

$$\ddot{X} = -mG\frac{X}{(X^2+Y^2)^{3/2}} - \ddot{X}_{\text{aether}} \quad -(50)$$

and

$$\ddot{Y} = -\frac{mGY}{(X^2+Y^2)^{3/2}} - Y_{aether} \quad -(51)$$

By assuming a particular solution of Eq. (39):

$$\frac{\partial \underline{p}}{\partial t} = -2c\omega_0 \underline{p} \quad -(52)$$

and Eq. (52) gives:

$$\ddot{X}_{aether} = -2c\omega_0 \dot{X}_{aether} \quad -(53)$$

$$\ddot{Y}_{aether} = -2c\omega_0 \dot{Y}_{aether} . \quad -(54)$$

Eqs. (50), (51), (53) and (54) are four equations in four unknowns: X, Y, X_{aether} and Y_{aether} , and any non Newtonian orbit can be found for a given ω_0 .

The condition for zero gravitation is:

$$\underline{\nabla U} + \frac{\partial \underline{p}}{\partial t} = \underline{0} \quad -(55)$$

and counter gravitation occurs when $\underline{p}$ in Eq. (49) is negative, so the force $\underline{F}$ can be aether engineered to be positive. In this case two gravitating masses m and M repel.

<u>Section 3 by Dr. Horst Eckardt</u>

Field, potential and force equations of orbits in ECE2

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3 Computational results and graphics

We start this section with deriving expressions for $\boldsymbol{\nabla}\cdot\mathbf{g}$. The equations of motion are for the non-relativistic case:

$$\ddot{\mathbf{r}} = -\frac{M\,G}{r^3}\mathbf{r}, \tag{56}$$

for forward precession (Euler-Lagrange equation):

$$\ddot{\mathbf{r}} = \frac{M\,G}{\gamma\,r^3}\left(\frac{\dot{\mathbf{r}}\,(\dot{\mathbf{r}}\cdot\mathbf{r})}{c^2} - \mathbf{r}\right), \tag{57}$$

and for retrograde precession:

$$\ddot{\mathbf{r}} = -\frac{M\,G}{\gamma^3\,r^3}\mathbf{r}, \tag{58}$$

each with

$$r = \left(X^2+Y^2\right)^{1/2}. \tag{59}$$

By computer algebra we obtain for the non-relativistic case:

$$\boldsymbol{\nabla}\cdot\mathbf{g} = \frac{M\,G}{r^3}, \tag{60}$$

for forward precession:

$$\boldsymbol{\nabla}\cdot\mathbf{g} = \frac{M\,G}{\gamma r^3}\left(\frac{\dot{X}^2Y^2+X^2\,\dot{Y}^2-2\left(Y^2\,\dot{Y}^2+X^2\,\dot{X}^2\right)-6XY\,\dot{X}\dot{Y}}{c^2\,r^2}+1\right), \tag{61}$$

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and for retrograde precession:

$$\boldsymbol{\nabla} \cdot \mathbf{g} = \frac{M\,G}{\gamma^3 r^3}. \tag{62}$$

According to Eq. (4), these terms correspond to the charge density ρ_M. Obviously the structure of the equations of motion (56-58) is reflected in the charge density. The case for retrograde precession differs from the non-relativistic case only by a factor of $1/\gamma^3$, while more terms of order $1/c^2$ appear in the case of forward precession.

As a second point we have investigated the orbits resulting from different initial conditions defined by the $\boldsymbol{\kappa}$ vector of ECE2 relativity. In two-dimensional calculations we have to define four initial values, ordinarily $X(0), Y(0), \dot{X}(0), \dot{Y}(0)$. Alternatively, when using the κ values, these are $\kappa_X(0), \kappa_Y(0), \dot{\kappa}_X(0), \dot{\kappa}_Y(0)$. These values have to be transformed to the ordinary initial values to start the calculation. Instead of using the derivatives of κ, we prefer using the constants of motion H (total energy) and L (angular momentum). Therefore we have to derive the ordinary values from $\kappa_X(0), \kappa_Y(0), H, L$. Using the non-relativistic versions, we have

$$H = \frac{m\,v^2}{2} - \frac{mMG}{\sqrt{X^2+Y^2}} \tag{63}$$

and

$$L = m\,(X v_Y - Y v_X)\,. \tag{64}$$

These equations are transformed to their κ-dependent forms by:

$$X = -\frac{\kappa_X}{\kappa_X^2 + \kappa_Y^2}, \tag{65}$$

$$Y = -\frac{\kappa_Y}{\kappa_X^2 + \kappa_Y^2}. \tag{66}$$

However we have also to transform the velocity components. Therefore we proceed as follows. From (64) we obtain

$$v_X = \frac{m\,X\,v_Y - L}{m\,Y} \tag{67}$$

and from (63)

$$v_X^2 + v_Y^2 = \frac{2MG}{\sqrt{X^2+Y^2}} + \frac{2H}{m}. \tag{68}$$

These are two non-linear equations to express v_X, v_Y in dependence of X, Y and constants of motion. We obtain two sets of solutions, differing in sign:

$$v_X = \pm\frac{X\,\sqrt{2\,m^2 MG\,\sqrt{X^2+Y^2} + 2mH(X^2+Y^2) - L^2}}{m\,(X^2+Y^2)} - \frac{LY}{m\,(X^2+Y^2)}, \tag{69}$$

$$v_Y = \pm\frac{Y\,\sqrt{2\,m^2 MG\,\sqrt{X^2+Y^2} + 2mH(X^2+Y^2) - L^2}}{m\,(X^2+Y^2)} + \frac{LX}{m\,(X^2+Y^2)}. \tag{70}$$

H	L	$\kappa_X(0)$	$\kappa_Y(0)$	$X(0)$	$Y(0)$	$v_X(0)$	$v_Y(0)$
-1	0.5	0	-1.1716	0	0.8535	-0.5858	-0.006194
-1	0.5	0	-2.3	0	0.4348	-1.15	-1.1303
-1	0.5	0	-3.9	0	0.2564	-1.95	-1.4133
-0.5	1	0	-1	0	1	-1	0
-0.75	0.75	0	-1.5	0	0.6667	-1.125	-0.4841
-1	0.5	0	-2	0	0.5	-1	-1

Table 1: Initial values of model calculations (non-relativistic/relativistic).

Choosing the negative sign in both equations and inserting (65,66), we obtain two complicated expressions for $v_X(\kappa_X, \kappa_Y)$ and $v_Y(\kappa_X, \kappa_Y)$. Thus we can define initial conditions for H, L, κ_X, κ_Y and obtain initial values $X(0), Y(0)$, $v_X(0), v_Y(0)$ which enter the numerical integration of the orbit. The values used are listed in Table 1. The first three lines refer to the non-relativistic calculation whose orbits are shown in Fig. 1. Choosing different κ_Y's, while all other parameters remain fixed, means rotation of the ellipse. The relativistic calculation for retrograde precession requires different total energy and angular momentum, if precession is to be varied (last three lines in Table 1). From Fig. 2 can be seen that the orbits shrink in the order blue-red-green. Higher precession requires higher velocities which can be seen from the data in Table 1.

As a result we noticed that when using total energy and angular momentum as parameters for the initial conditions, it is easy to find an orbit of the wished kind of conic section (here an ellipse). From earlier calculations with specifying the input parameters $X(0), Y(0), v_X(0), v_Y(0)$ directly, it was not clear from the beginning which type of orbit would appear, and we had to make several tries to get the desired orbit.

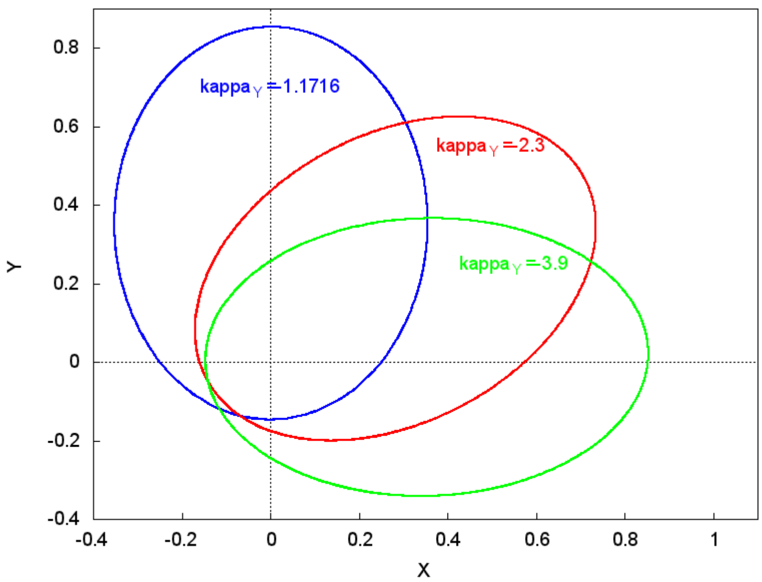

Figure 1: Non-relativistic orbits for different initial values κ_Y, with $\kappa_X = 0$.

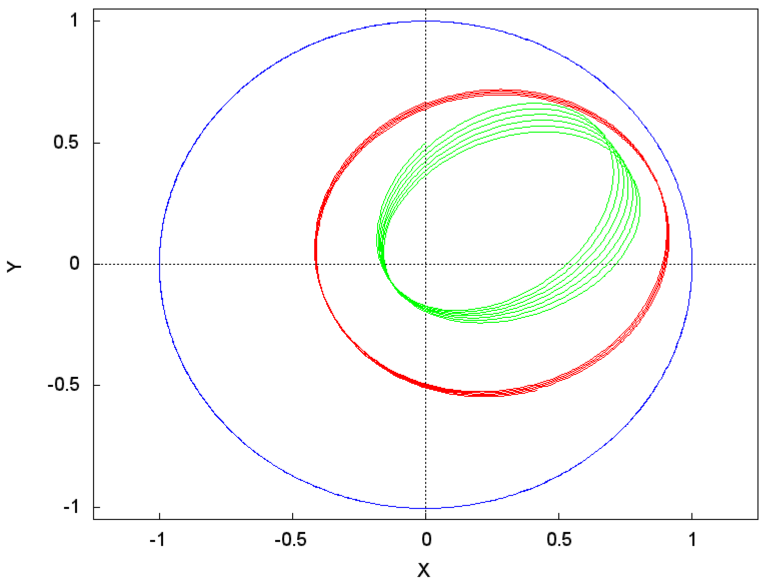

Figure 2: Relativistic orbits (retrograde precession) for different initial values $H,\ L,\ \kappa_Y$, with $\kappa_X = 0$.

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