ECE2 ORBIT THEORY IN GENERAL SPHERICALLY SYMMETRIC SPACE

by

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ABSTRACT

Orbit theory is developed in the most general spherically symmetric space, , m space, thus generalizing the theory of UFT414, the immediately preceding paper. Using the infinitesimal line element of m space, the kinematics of the orbit are calculated, and the method cross checked with the relevant Lagrangian and Euler Lagrange equations. The relativistic Leibniz equation is derived in m space, together with the equation of conservation of momentum in m space. The orbit is found by integrating these two equations simultaneously. The relevant spin connection is found by rotating the infinitesimal line element.

Keywords: ECE2 theory, orbits in m space, spin connection of m space.

UFT415

1. INTRODUCTION

In immediately preceding papers of this series {1 - 41}, orbital theory has been developed with a combination of concepts, notably vacuum force, frame rotation and spin connection. In Section 2 of this paper the relativistic theory of the immediately preceding paper, UFT414, is developed in the most general spherically symmetric space, named m space. The idea of m space has been used in papers such as UFT108 and UFT190 to show that a shrinking and precessing orbit can be defined without the use of gravitational radiation. In the obsolete standard physics, the incorrect Einstein field equation is used to assert that the orbit of the Hulse Taylor binary pulsar is due to gravitational radiation, but the omission of torsion means that any such inference must be rejected because it is based on incorrect geometry. Recent astronomical results from the S star systems show that the Einstein field equation is incorrect by an order of magnitude. So the mythical precision of the standard model has been shown experimentally to be a mirage.

This paper is a short synopsis of extensive calculations in the notes accompanying UFT415 on www.aias.us. Note 415(1) makes an initial development of the lagrangian and hamiltonian of m space, using the most general stationary metric in spherically symmetric spacetime, denoted m space. Note 415(2) makes an initial calculation of the orbital equations in m space, an initial calculation which is developed in Note 415(3). Note 414(4) calculates the fundamental kinematic quantities in m space, starting with the position vector. Note 415(5) makes an initial calculation using the lagrangian method. Note 415(6) uses frame rotation theory to calculate the spin connection used in the relativistic Leibniz equation of m theory. Note 415(7) develops Sagnac effect theory in m space, based on UFT45 and UFT46. Note 415(8) is the final development of the lagrangian theory, giving the same orbit equations as the kinematic theory.

Section 3 integrates the orbit equations derived in Section 2 using numerical methods developed by co author Horst Eckardt, and gives a graphical analysis of results.

2. THE ORBIT EQUATIONS

Consider the infinitesimal line element in plane polar coordinates r and ϕ of the most general spherically symmetric space {1 - 41}:

$$ds^2 = c^2 d\tau^2 = m(r)\, c^2 dt^2 - d\underline{r} \cdot d\underline{r} \quad -(1)$$

where:

$$d\underline{r} \cdot d\underline{r} = \frac{dr^2}{m(r)} + r^2 d\phi^2. \quad -(2)$$

For a stationary metric m (r) is time independent by definition. In Eq. (1):

$$d\underline{r} = \frac{\partial \underline{r}}{\partial r} dr + \frac{\partial \underline{r}}{\partial \phi} d\phi \quad -(3)$$

where $\underline{r}$ is the position vector of m space. It follows that:

$$d\underline{r} \cdot d\underline{r} = \left(\frac{\partial \underline{r}}{\partial r} dr + \frac{\partial \underline{r}}{\partial \phi} d\phi \right) \cdot \left(\frac{\partial \underline{r}}{\partial r} dr + \frac{\partial \underline{r}}{\partial \phi} d\phi \right) = \frac{dr^2}{m(r)} + r^2 d\phi^2. \quad -(4)$$

A possible solution of this equation is:

$$\left(\frac{\partial \underline{r}}{\partial r} \right)^2 dr^2 = \frac{1}{m(r)} dr^2 \quad -(5)$$

$$\left(\frac{\partial \underline{r}}{\partial \phi} \right)^2 d\phi^2 = r^2 d\phi^2 \quad -(6)$$

and:

$$\frac{\partial \underline{r}}{\partial \phi} \cdot \frac{\partial \underline{r}}{\partial r} = 0 \quad -(7)$$

so:

$$\frac{\partial \underline{r}}{\partial r} = \frac{1}{m(r)} \underline{e}_r \quad -(8)$$

$$\frac{\partial \underline{r}}{\partial \phi} = r \underline{e}_\phi \quad -(9)$$

and

$$\frac{\partial \underline{r}}{\partial \phi} \cdot \frac{\partial \underline{r}}{\partial r} = \frac{r}{m(r)^{1/2}} \underline{e}_r \cdot \underline{e}_\phi = 0. \quad -(10)$$

Therefore the position vector of m space is:

$$\underline{r} = \frac{r}{m(r)^{1/2}} \underline{e}_r \quad -(11)$$

a result that is true for any system of coordinates. It follows that the velocity of m space is:

$$\underline{v} = \dot{\underline{r}} = \frac{d}{dt}\left(\frac{r}{m(r)^{1/2}}\right) \underline{e}_r + \frac{r\dot{\phi}}{m(r)^{1/2}} \underline{e}_\phi \quad -(12)$$

in which:

$$\frac{d}{dt}\left(\frac{r}{m(r)^{1/2}}\right) = \frac{1}{m(r)^{1/2}} \dot{r} \quad -(13)$$

because by definition of a stationary metric, $m(r)$ is independent of time. It follows that

$$\underline{v} = \dot{\underline{r}} = \frac{1}{m(r)^{1/2}} \left(\dot{r} \underline{e}_r + r\dot{\phi} \underline{e}_\phi \right). \quad -(14)$$

The relativistic momentum of m space is therefore:

$$\underline{p} = \gamma m \dot{\underline{r}} \quad -(15)$$

in which the Lorentz factor of m space is:

$$\gamma = \left(m(r) - \frac{\dot{\underline{r}} \cdot \dot{\underline{r}}}{c^2} \right)^{-1/2} \quad -(16)$$

The angular momentum of m space is therefore:

$$\underline{L} = \underline{r} \times \underline{p} = \frac{\gamma m r^2}{m(r)} \dot{\phi} \, \underline{k} \quad -(17)$$

and is a constant of motion :

$$\frac{d\underline{L}}{dt} = 0 \quad -(18)$$

This is one of the orbit equations, Q. E. D.

From Eq. (18):

$$\frac{d}{dt}\left(\gamma r^2 \dot{\phi}\right) = \frac{d\gamma}{dt} r \dot{\phi} + \gamma \left(r \ddot{\phi} + 2 \dot{r} \dot{\phi} \right) = 0 \quad -(19)$$

The second orbit equation is the relativistic Leibniz equation in m space:

$$\underline{g} = \frac{d}{dt}\left(\gamma \dot{\underline{r}}\right) = -\frac{MG}{r}\left(\frac{1}{r} + \Omega_r\right) \underline{e}_r \quad -(20)$$

where:

$$\gamma = \left(m(r) - \frac{\dot{r}^2 + r^2 \dot{\phi}^2}{m(r) c^2} \right)^{-1/2} \quad -(21)$$

and in which Ω_r is the spin connection of ECE2 theory. From Eqs. (14) and (20):

$$\underline{g} = \frac{d\gamma}{dt} \dot{\underline{r}} + \gamma \ddot{\underline{r}} \quad -(22)$$

$$= \frac{1}{m(r)^{1/2}} \left[\frac{d\gamma}{dt} \left(\dot{r} \underline{e}_r + r\dot{\phi} \underline{e}_\phi \right) + \gamma \left(\left(\ddot{r} - r\dot{\phi}^2 \right) \underline{e}_r + \left(r\ddot{\phi} + 2\dot{r}\dot{\phi} \right) \underline{e}_\phi \right) \right] \quad -(23)$$

so the second orbit equation is:

$$\frac{d\gamma}{dt} \dot{r} + \gamma \left(\ddot{r} - r\dot{\phi}^2 \right) = -m(r)^{1/2} \frac{MG}{r} \left(\frac{1}{r} + \Omega_r \right). \quad -(24)$$

The orbit is obtained by solving Eqs. (19) and (24) numerically as in Section 3.

Eq. (24) can be simplified using:

$$\dot{r} = v, \quad \frac{dv}{dt} = \ddot{r} - r\dot{\phi}^2. \quad -(25)$$

It follows that:

$$F = \frac{d}{dt}(\gamma m v) = m \left(v \frac{d\gamma}{dt} + \gamma \frac{dv}{dt} \right) \quad -(26)$$

where:

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

and:

$$\frac{d\gamma}{dv} = \gamma^3 \frac{v}{c^2}. \quad -(28)$$

So the force is:

$$F = m\gamma \frac{dv}{dt} \left(1 + \gamma^2 \frac{v^2}{c^2} \right)$$

$$= m\gamma^3 m(r)\frac{dv}{dt} \quad -(29)$$

The relativistic Leibniz equation in m space is therefore:

$$g = \gamma^3\frac{dv}{dt} = -\frac{1}{m(r)^{1/2}}\frac{MG}{r}\left(\frac{1}{r}+\Omega_r\right). \quad -(30)$$

In the limit:

$$\left.\begin{array}{l} m(r)\rightarrow 1 \\ \Omega(r)\rightarrow 0 \\ v \ll c \end{array}\right\} \quad -(31)$$

it reduces to the Newtonian:

$$g = \frac{dv}{dt} = -\frac{MG}{r^2}. \quad -(32)$$

So the two orbit equations of the m space of a stationary metric are:

$$g = \gamma^3\frac{dv}{dt} = -\frac{1}{m(r)^{1/2}}\frac{MG}{r}\left(\frac{1}{r}+\Omega_r\right) \quad -(33)$$

and

$$\frac{dL}{dt} = 0. \quad -(34)$$

Methods are needed of calculating m (r) and Ω_r. In papers such as UFT108 and UFT190. It was shown in UFT108 and related papers that a shrinking orbit is produced empirically by:

$$m(r) = 1 - \frac{2MG}{c^2 r} - \frac{\alpha}{r^2} \quad -(35)$$

where α is adjustable. In UFT190 the function:

$$m(r) = 2 - \exp\left(2\exp\left(-\frac{r}{R}\right)\right) \quad -(36)$$

was introduced, whee R is a characteristic length in cosmology. As

$$R \rightarrow \infty \quad -(37)$$

the ECE2 infinitesimal line element is obtained:

$$ds^2 = c^2 d\tau^2 = c^2 dt^2 - dr^2 - r^2 d\phi^2. \quad -(38)$$

Now use the frame rotation:

$$\phi' = \phi + \omega_1 t \quad -(39)$$

$$\dot{\phi}' = \dot{\phi} + \omega_1 + t\frac{d\omega_1}{dt} \quad -(40)$$

as in UFT414. The frame rotation changes:

$$\gamma^3 = \left(m(r) - \frac{1}{c^2 m(r)}\left(\dot{r}^2 + r^2\dot{\phi}^2\right)\right)^{-3/2} \quad -(41)$$

to:

$$\gamma'^3 = \left(m(r) - \frac{1}{c^2 m(r)}\left(\dot{r}^2 + r^2\dot{\phi}'^2\right)\right)^{-3/2}. \quad -(42)$$

It follows that:

$$\frac{1}{\gamma'^2} - \frac{1}{\gamma^2} = A := \frac{r^2}{m(r)\, c^2}\left(\omega_1 + t\frac{d\omega_1}{dt}\right)\left(\omega_1 + t\frac{d\omega_1}{dt} + 2\omega\right) \quad -(43)$$

and that the spin connection is defined by:

$$\Omega_r = \frac{1}{r\, m(r)^{1/2}} - \frac{\left(1+\gamma^2 A\right)^{3/2}}{r\, m(r)^{1/2}} - \frac{\gamma^3 c^2 A}{MG} \quad -(44)$$

This equation reduces to the spin connection calculated in UFT414 for

$$m(r) \to 1. \quad -(45)$$

The $m(r)$ function can be measured experimentally using the Sagnac effect as described in Note 415(7). Consider the infinitesimal line element:

$$ds^2 = m(r)c^2dt^2 - \frac{dr^2}{m(r)} - r^2d\phi^2 \quad -(46)$$

for light traversing the Sagnac platform in a plane as in UFT45 and UFT46. In this condition:

$$v = c \quad -(47)$$

$$dr = 0 \quad -(48)$$

and:

$$m(r)c^2dt^2 = r^2d\phi^2. \quad -(49)$$

The Sagnac effect in one sense of rotation is the frame rotation:

$$d\phi \to d\phi + \omega_1 dt \quad -(50)$$

and in the other sense of rotation is the frame rotation:

$$d\phi \to d\phi - \omega_1 dt. \quad -(51)$$

It follows that:

$$dt = \frac{d\phi}{m^{1/2}(r)\,\omega \pm \omega_1} \quad -(52)$$

so:

$$\int dt = \frac{2\pi}{m^{1/2}(r)\,\omega \pm \omega_1} \quad -(53)$$

For one revolution of light around the Sagnac platform:

$$T = \frac{2\pi}{m^{1/2}(r)\,\omega \pm \omega_1} \quad -(54)$$

where T is the measurable time taken to traverse the Sagnac platform and ω_1 is the measurable frequency of rotation of the platform. Therefore $m(r)$ can be measured experimentally. Effectively, m is the effect of gravitation on the Sagnac effect, so by using large Sagnac interferometers at different altitudes, the time taken to traverse the platform is slightly different and $m(r)$ can be deduced.

The kinematic equations above can be cross checked using the lagrangian method. By definition, the relativistic momentum is:

$$\underline{p} = \frac{\gamma m}{m(r)^{1/2}}\left(\dot{r}\,\underline{e}_r + r\dot{\phi}\,\underline{e}_\phi\right) = \frac{\partial \mathcal{L}}{\partial \underline{\dot{r}}} \quad -(55)$$

and the Euler Lagrange equation is:

$$\frac{d}{dt}\left(\frac{\partial \mathcal{L}}{\partial \underline{\dot{r}}}\right) = \frac{\partial \mathcal{L}}{\partial \underline{r}} . \quad -(56)$$

The lagrangian is a priori unknown, but the choice:

$$\mathcal{L} = -m(r)^{1/2} mc^2 \left(m(r) - \frac{\dot{r}^2 + r^2\dot{\phi}^2}{m(r)c^2}\right)^{1/2} + \frac{mMG}{r} \quad -(57)$$

produces the results of the kinematic theory as follows. First note that:

$$\frac{\partial \mathcal{L}}{\partial \underline{\dot{r}}} = \frac{\partial \mathcal{L}}{\partial \dot{r}}\,\underline{e}_r + \frac{1}{r}\frac{\partial \mathcal{L}}{\partial \dot{\phi}}\,\underline{e}_\phi . \quad -(58)$$

Similarly:

$$\frac{\partial \mathcal{L}}{\partial \underline{r}} = \frac{\partial \mathcal{L}}{\partial r}\,\underline{e}_r + \frac{1}{r}\frac{\partial \mathcal{L}}{\partial \phi}\,\underline{e}_\phi = \underline{\nabla}\mathcal{L} \quad -(59)$$

The Euler Lagrange equation is therefore:

$$\frac{d}{dt}\left(\frac{\partial \mathcal{L}}{\partial \underline{\dot{r}}}\right) = \underline{\nabla}\mathcal{L}. \quad -(60)$$

From Eq. (33):

$$\underline{\nabla}\mathcal{L} = -\frac{mG}{r}\left(\frac{1}{r} + \Omega_r\right)\underline{e}_r. \quad -(61)$$

Therefore:

$$\frac{d}{dt}\left(\frac{\partial \mathcal{L}}{\partial \underline{\dot{r}}}\right) = \frac{d}{dt}\left(\frac{\partial \mathcal{L}}{\partial \dot{r}}\underline{e}_r\right) + \frac{d}{dt}\left(\frac{1}{r}\frac{\partial \mathcal{L}}{\partial \dot{\phi}}\underline{e}_\phi\right)$$

$$= \frac{d}{dt}\frac{\partial \mathcal{L}}{\partial \dot{r}}\underline{e}_r + \frac{\partial \mathcal{L}}{\partial \dot{r}}\frac{d\underline{e}_r}{dt} + \frac{d}{dt}\left(\frac{1}{r}\frac{\partial \mathcal{L}}{\partial \dot{\phi}}\right)\underline{e}_\phi + \frac{1}{r}\frac{\partial \mathcal{L}}{\partial \dot{\phi}}\frac{d\underline{e}_\phi}{dt} \quad -(62)$$

where:

$$\frac{d\underline{e}_r}{dt} = \dot{\phi}\,\underline{e}_\phi, \quad \frac{d\underline{e}_\phi}{dt} = -\dot{\phi}\,\underline{e}_r. \quad -(63)$$

It follows that:

$$\frac{d}{dt}\frac{\partial \mathcal{L}}{\partial \underline{\dot{r}}} = \left(\frac{d}{dt}\frac{\partial \mathcal{L}}{\partial \dot{r}} - \frac{\dot{\phi}}{r}\frac{\partial \mathcal{L}}{\partial \dot{\phi}}\right)\underline{e}_r + \left(\frac{\partial \mathcal{L}}{\partial \dot{r}}\dot{\phi} + \frac{d}{dt}\left(\frac{1}{r}\frac{\partial \mathcal{L}}{\partial \dot{\phi}}\right)\right)\underline{e}_\phi \quad -(64)$$

and using the lagrangian (57)

$$\frac{\partial \mathcal{L}}{\partial \dot{r}} = \frac{\gamma}{m(r)^{1/2}}\dot{r}, \quad \frac{\partial \mathcal{L}}{\partial \dot{\phi}} = \frac{\gamma}{m(r)^{1/2}}r^2\dot{\phi}. \quad -(65)$$

It follows as in Note 415(8) that:

$$\frac{d}{dt}\frac{\partial \mathcal{L}}{\partial \underline{\dot{r}}} = \frac{1}{m(r)^{1/2}}\left[\frac{d\gamma}{dt}\left(\dot{r}\underline{e}_r + r\dot{\phi}\underline{e}_\phi\right)\right. \quad -(66)$$

$$\left. + \gamma\left(\left(\ddot{r} - r\dot{\phi}^2\right)\underline{e}_r + \left(r\ddot{\phi} + 2\dot{r}\dot{\phi}\right)\underline{e}_\phi\right)\right]$$

The two orbital equations are therefore:

$$\frac{d\gamma}{dt}\dot{r} + \gamma\left(\ddot{r} - r\dot{\phi}^2\right) = -m(r)^{1/2}\frac{MG}{r}\left(\frac{1}{r} + \Omega r\right) \quad -(67)$$

and

$$\frac{d\gamma}{dt} r\dot{\phi} + r\ddot{\phi} + 2\dot{r}\dot{\phi} = 0 \quad -(68)$$

which are Eqs. (19) and (24) Q. E. D.

Therefore the kinematic and lagrangian methods give the same results.

3. NUMERICAL INTEGRATION AND GRAPHICS

Section by Dr. Horst Eckardt.

ECE2 orbit theory in general spherically symmetric space

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3 Numerical integration and graphics

3.1 Euler-Lagrange equations

Our evaluation by computer algebra starts with the explicit form of the equations of motion (19, 24). These have to be brought into Hamilton form (i.e. resolved for $\ddot{\phi}$ and $\ddot{r}$) to be solvable numerically by the Runge-Kutta algorithm. The relativistic Lagrangian is

$$\mathscr{L} = -\frac{mc^2}{\gamma} + \frac{mMG}{r} \tag{69}$$

with the γ factor of non-constant, spherically symmetric spacetime

$$\gamma = \left(\mathrm{m}(r) - \frac{\dot{r}^2 + r^2\dot{\phi}^2}{\mathrm{m}(r)c^2} \right)^{-1/2} = \left(\mathrm{m}(r) - \frac{v^2}{\mathrm{m}(r)c^2} \right)^{-1/2} \tag{70}$$

This leads to the constant of motion, the relativistic angular momentum

$$L = \frac{\gamma}{\mathrm{m}(r)}\, m\, r^2\, \dot{\phi} = \mathrm{const.} \tag{71}$$

In addition, the total relativistic energy is conserverd by definition:

$$E = (\mathrm{m}(r)\, \gamma - 1)\; mc^2 - \frac{mMG}{r} = \mathrm{const.} \tag{72}$$

In this formulation, a constant term of rest energy mc^2 has been subtracted in order to make it comparable with the Newtonian expression which does not contain the rest energy. This procedure is the same as used in relativistic quantum mechanics.

During development of this paper, we had to decide how to handle the - a priori static - function $\mathrm{m}(r)$. Assuming this function to be static in the Lagrange

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formalism leads to non-conservation of L and E in Eqs. (71, 72). Therefore the radial coordinate r appearing in $\mathrm{m}(r)$ has to be handled in the standard way as a trajectory coordinate $r(t)$. This then leads to perfect fulfillment of the conservation laws. One has to discern between fields in space like the gravitational potential and $\mathrm{m}(r)$ which are static, and their usage in the equations of motion where the trajectories $\phi(t)$ and $r(t)$ are computed and all quantities are time-dependent because the trajectory coordinates describe the temporary position of a mass point in space. The value of the static fields changes over these positions in time.

For comparison we present the full equations of motion, first for the hypothetical case with $d\mathrm{m}(r)/dt = 0$ assumed:

$$\ddot{\phi} = \frac{\frac{d}{dr}\,\mathrm{m}(r)}{\mathrm{m}(r)}\dot{\phi}\,\dot{r}\left(1 - \frac{1}{2\gamma^2\,\mathrm{m}(r)}\right) + \frac{GM\,\dot{\phi}\,\dot{r}}{\gamma c^2\,r^2\,\mathrm{m}(r)} - \frac{2\dot{\phi}\,\dot{r}}{r}, \tag{73}$$

$$\begin{aligned}\ddot{r} = {} & \frac{\frac{d}{dr}\,\mathrm{m}(r)}{\mathrm{m}(r)}\dot{\phi}^2\,r^2\left(\frac{1}{2\gamma^2\,\mathrm{m}(r)} - 1\right) \\ & + \frac{c^2\left(\frac{1}{2\gamma^2\,\mathrm{m}(r)} - 1\right)\frac{d}{dr}\,\mathrm{m}(r)}{\gamma^2} - \frac{GM\,\dot{\phi}^2}{\gamma c^2\,\mathrm{m}(r)} + \dot{\phi}^2 r - \frac{GM}{\gamma^3\,r^2}.\end{aligned} \tag{74}$$

When the time dependence of the m function is taken into account, we use

$$\frac{d\mathrm{m}(r)}{dt} = \frac{d\mathrm{m}(r)}{dr}\dot{r}, \tag{75}$$

reducing the time derivative to known expressions. The full equations of motion then are

$$\ddot{\phi} = \frac{\frac{d}{dr}\,\mathrm{m}(r)}{\mathrm{m}(r)}2\dot{\phi}\,\dot{r} + \frac{GM\,\dot{\phi}\,\dot{r}}{\gamma c^2\,r^2\,\mathrm{m}(r)} - \frac{2\dot{\phi}\,\dot{r}}{r}, \tag{76}$$

$$\begin{aligned}\ddot{r} = {} & \frac{\frac{d}{dr}\,\mathrm{m}(r)}{\mathrm{m}(r)}\left(\left(\frac{1}{2\gamma^2\,\mathrm{m}(r)} + 1\right)\dot{r}^2 + \dot{\phi}^2\,r^2\left(\frac{1}{2\gamma^2\,\mathrm{m}(r)} - 1\right)\right) \\ & + \frac{c^2\left(\frac{1}{2\gamma^2\,\mathrm{m}(r)} - 1\right)\frac{d}{dr}\,\mathrm{m}(r)}{\gamma^2} - \frac{GM\,\dot{\phi}^2}{\gamma c^2\,\mathrm{m}(r)} + \dot{\phi}^2 r - \frac{GM}{\gamma^3\,r^2}.\end{aligned} \tag{77}$$

Obviously their complexity is not greater than in the case of time-independent $\mathrm{m}(r)$. In the limit $\mathrm{m}(r) = 1$, these equations have to reduce to the relativistic equations without m function as derived in UFT 414. Obviously this is the case for the transitions

$$\mathrm{m}(r) \to 1, \tag{78}$$

$$\frac{d\mathrm{m}(r)}{dr} \to 0. \tag{79}$$

One minor point is that the gravitational potential keeps the factor $1/\gamma^3$ while in the version of UFT 414 there is only a factor $1/\gamma$. However this difference also occurs when comparing the relativistic Leibniz force equation with the Lagrangian result, leading to forward and backward precession as described in earlier papers.

3.2 Metric function m(r)

In earlier research papers (UFT 108 and UFT 190) m theory was developed and two model functions for m(r) were used. In cosmological cases (spiral galaxies) an approach based on geometrical foundations of general relativity was used:

$$m(r) = a - \exp\left(b\exp(-\frac{r}{R})\right) \tag{80}$$

with constants $a = b = 2$ and a fixed R. In the limit $r \to \infty$ we have to obtain m(r)=1, this leads to

$$1 = a - 1 \tag{81}$$

or

$$a = 2. \tag{82}$$

The parameter b determines the behaviour near to $r = 0$. Setting $b = 2$ as in UFT 190 (derived from $R \to \infty$) leads to a negative value of m$(r = 0)$. However, from the definition (70) of the γ factor it follows that the argument of the square root has to remain positive, so we request for this limit:

$$m(0) = 0. \tag{83}$$

From (80) we then obtain

$$a - \exp(b) = 0 \tag{84}$$

or

$$b = \log(a) = \log(2). \tag{85}$$

The exponent-based m function is graphed in Fig. 1 for three values of b, with $a = 2$ and $R = 1$. Using $b < \log(2)$ leads to flatter curves of m(r).

In UFT 108 we introduced a m function derived from the obsolete Schwarzschild metric, extended by an empirical term $-\alpha/r^2$ which was necessary to obtain shrinking of orbits:

$$m(r) = 1 - \frac{2MG}{c^2 r} - \frac{\alpha}{r^2}. \tag{86}$$

This function is graphed in Fig. 2 for three different values of α. A larger α means that m(r) starts dropping at higher radius values. The effect of α on the orbits will be described in the next subsection.

3.3 Results of numerical calculations

The equations (76, 77) have been solved numerically. The exponential m function (80) was used with $a = 2$, $b = \log(2)$, $R = 0.1$. The parameters in the equations were chosen in the range of unity so that a nearly ultra-relativistic case is obtained. This sometimes shows drastic relativistic effects but otherwise these effects would be too tiny to be recognizable in the graphics. When the initial velocity of the calculation is high enough, we obtain a highly elliptical orbit with forward precession (Fig. 3). With smaller initial velocities, even backward precession could be produced in some cases, showing that this behaviour strongly depends on the energetic state of the system.

The γ factor belonging to the orbit of Fig. 3 is graphed in Fig. 4, showing a variation by a factor of ten over one orbit. Because the orbit is highly elliptical, the velocity - and thereby γ - is much higher in the periastron than in the apastron. Consequently the deviations from Newtonian theory are highest at periastron. The angular momentum of this relativistic theory is well constant as required, see Fig. 5. The Newtonian version

$$L_N = m\,r^2\,\dot{\phi} \tag{87}$$

shows highest deviations in the periastron points as expected. A similar behaviour is obtained for the total energy (Fig. 6). Only at low velocities at apastron the Newtonian energy

$$E_N = \frac{1}{2}m(\dot{r}^2 + r^2\dot{\phi}^2) - \frac{mMG}{r} \tag{88}$$

is roughly equal to the relativistic energy. Figs. 5 and 6 show that the equations both are consistent and have been coded correctly. Conservation properties are very sensitive to all kinds of errors in the theory.

The same calculation as before has been executed with an initial velocity reduced by about a factor of 0.6. Now the m function comes into full effect, causing an invard spiralling of the orbiting mass until it falls into the centre. This behaviour is only possible in m space. The "normal" relativistic calculations always showed a stable orbit, albeit with strong precession. When the mass falls into the centre, the γ factor increases dramatically as shown in Fig. 8. In special relativity one would expect the orbital velocity going to the limit c, but in m theory this behaviour is quite different. After initial rising, the velocity drops to zero, i.e. the mass softly approaches the centre. This is a remarkable result.

From Fig. 9 we see that the relativistic angular momentum remains constant up to the last moment where the orbiting mass comes to rest and the calculation diverges. The Newtonian angular momentum does not contain the γ factor, therefore, at the rest point, there is $\dot{\phi} = 0$, bringing the Newtonian angular momentum to zero. A comparable behaviour is seen for the total energy (Fig. 10). The Newtonian values become meaningless near to the end point. Obviously such a singular orbit is correctly described by m theory.

The last figures present orbits obtained with the Schwarzschild-like m function (86). For the original version with $\alpha = 0$, a stable state is obtained (Fig. 11), where significant precession is visible whose details depend on the choice of parameters. Interesting is the effect of α. Even a very small value of $\alpha = 0.003$ leads to a collapsing orbit. As explained above, the γ factor diverges where $\mathrm{m}(r) \to 0$. Therefore the mass sticks at this r value and it is not possible to track the mass down to the centre. Calculation stops where $\mathrm{m}(r)$=0. In the corresponding Fig. 12 this gap can be seen clearly.

For comparison with the exponential m function, we show the γ factor and modulus of velocity v in Fig. 13. This looks very similar to Fig. 11. In both approaches of $\mathrm{m}(r)$ we have used functions with falling behaviour for $r \to 0$. This is not the only possible choice. From the condition that the argument of the square root of γ be positive, it follow from Eq. (70)

$$\mathrm{m}(r)^2 - \frac{v^2}{c^2} > 0 \tag{89}$$

or

$$\mathrm{m}(r) > \frac{v}{c}. \tag{90}$$

If we had regions with $\mathrm{m}(r) > 1$, this would mean that superluminal motion is possible there: $v > c$, without violating the principles of general relativity.

We conclude that the set of equations of motion derived in this paper can be used to investigate very intricate cases of cosmology. In section 2 the equations have been cross-checked in various ways. For computation, the Lagrangian version was used as a basis because Lagrange theory is strongly formalized and therefore best suited for being programmed on a computer. The laws of conservation for angular momentum and total energy provide a critical check for correctness and plausibility of the results.

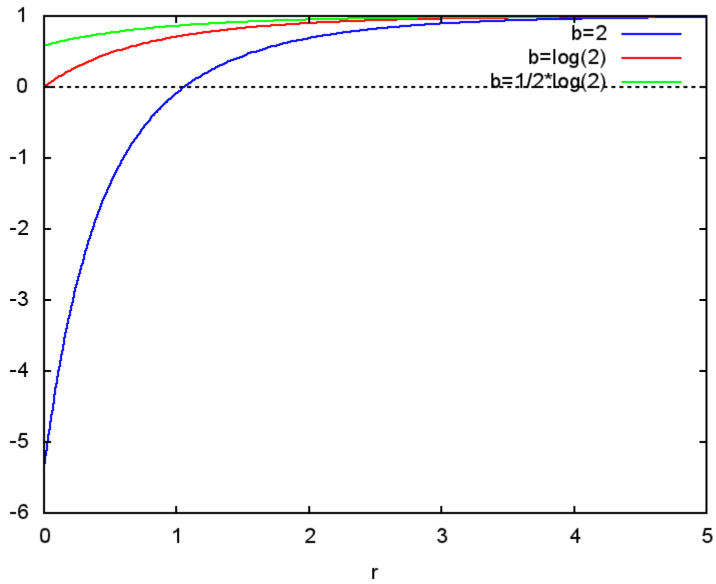

Figure 1: Exponential function $\mathrm{m}(r)$ for three values of b.

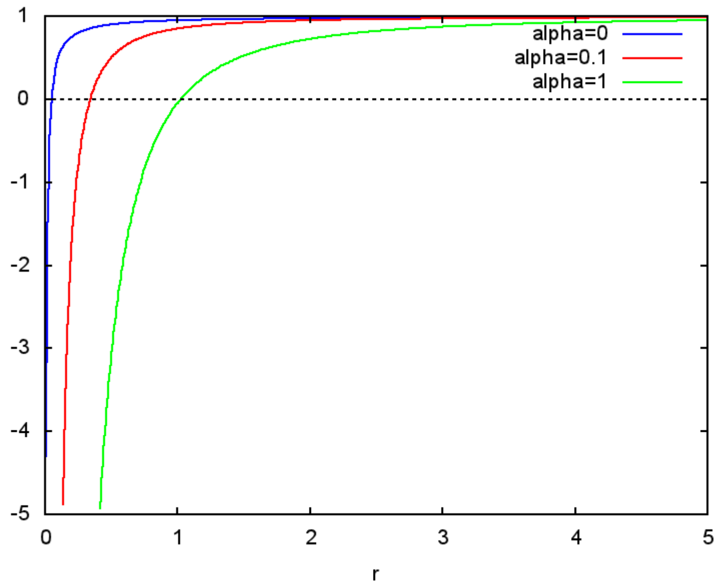

Figure 2: Schwarzschild-like function m(r) for three values of α.

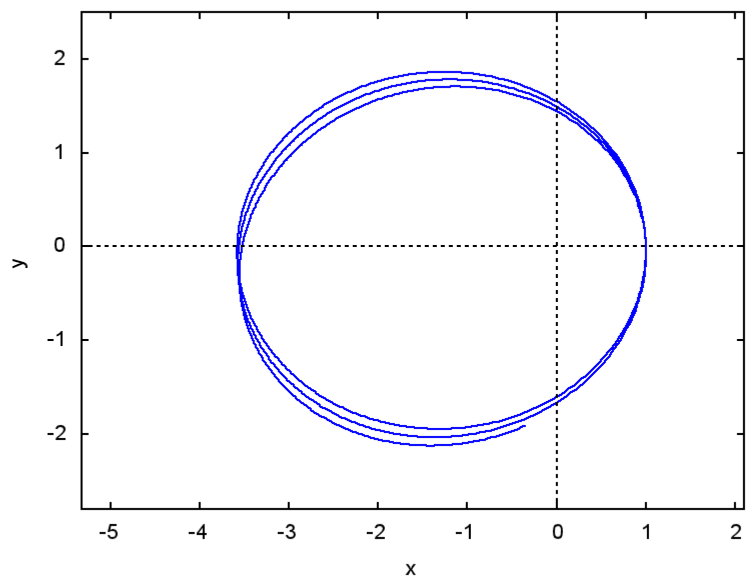

Figure 3: Orbit of relativistic motion with exponential m function.

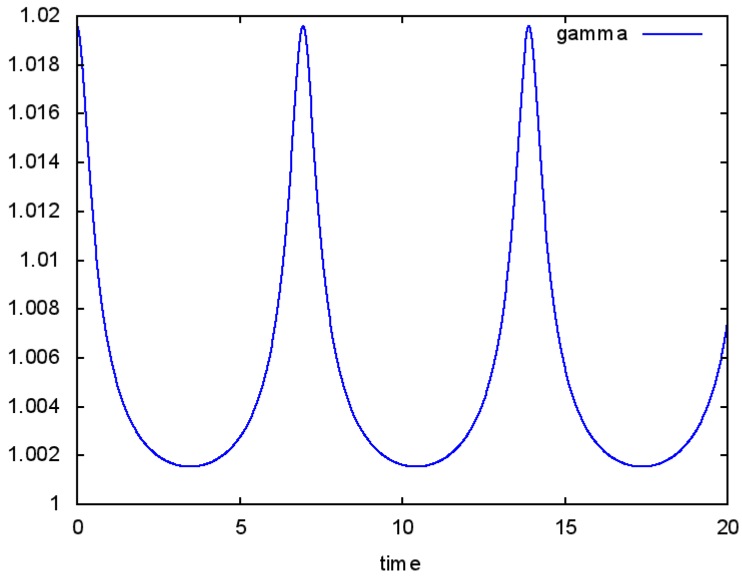

Figure 4: γ factor of motion with exponential m function.

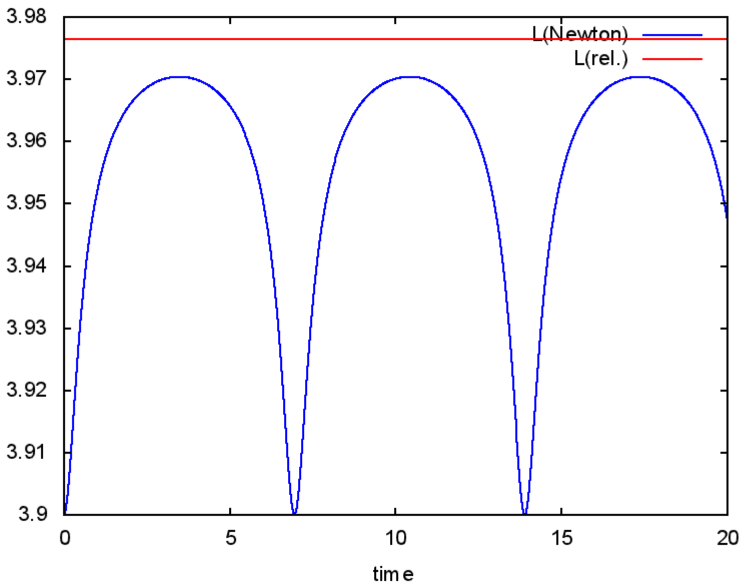

Figure 5: Angular momenta of motion with exponential m function.

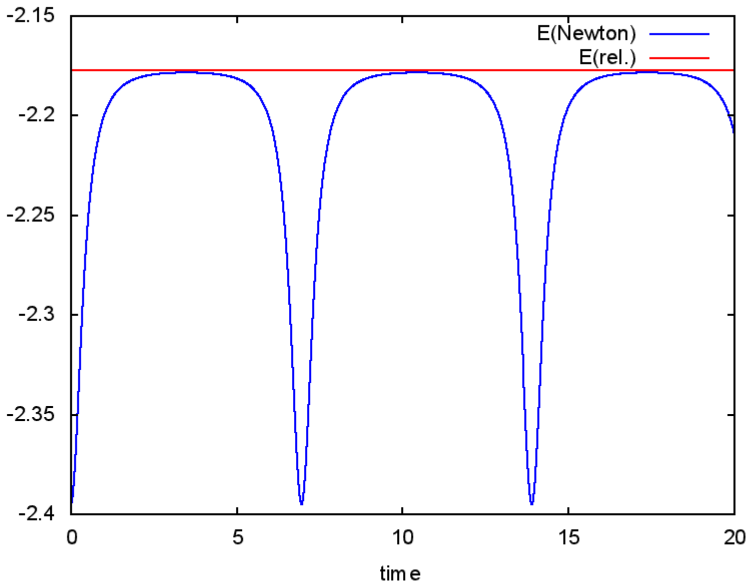

Figure 6: Total energy of motion with exponential m function.

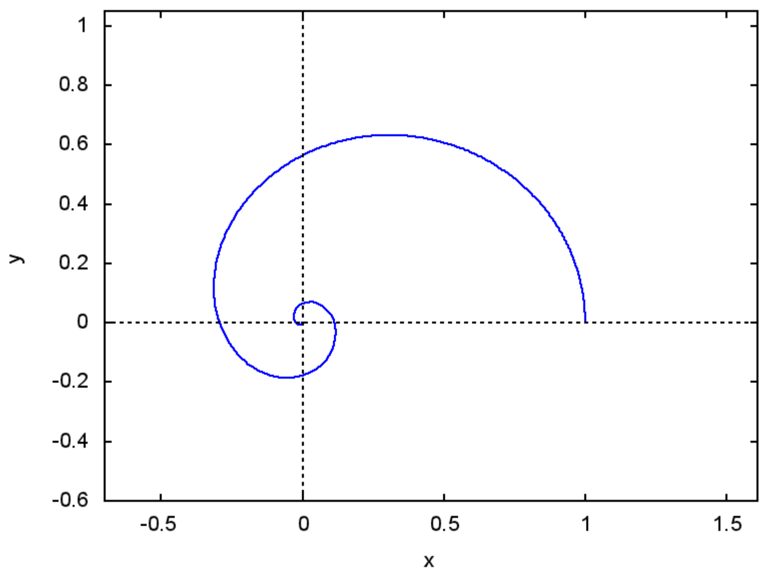

Figure 7: Collapsing orbit of exponential m function.

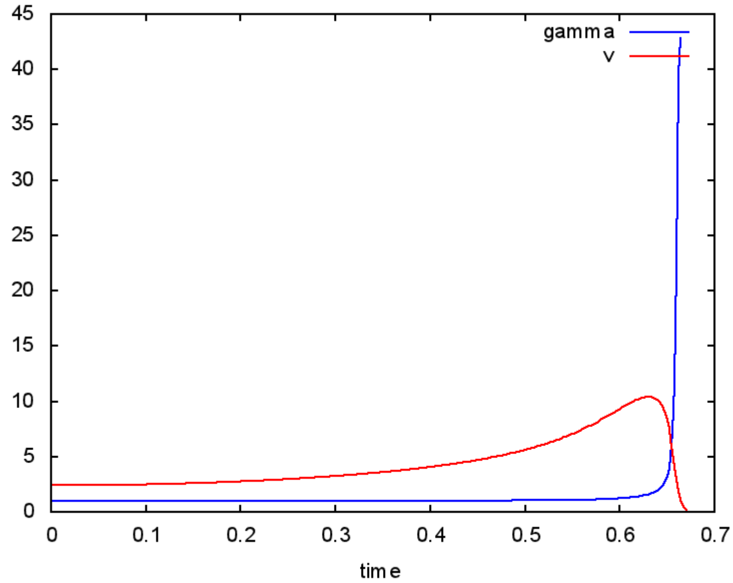

Figure 8: γ factor and velocity v of the collapsing orbit with exponential m function.

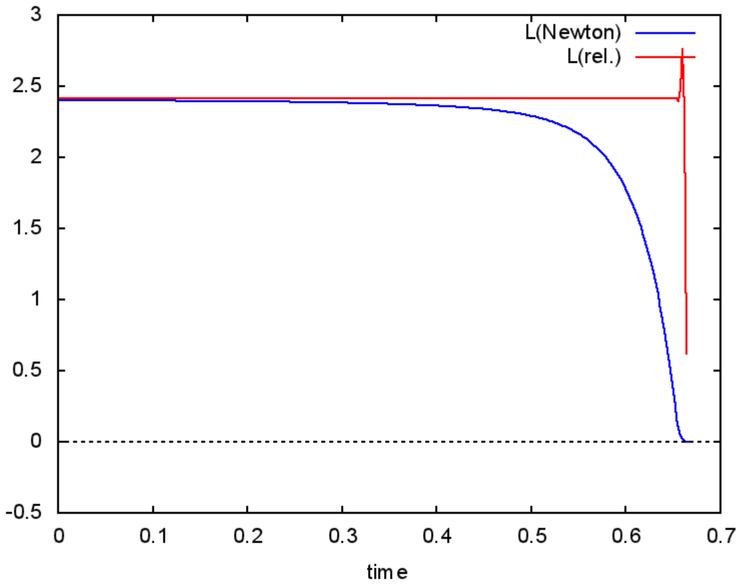

Figure 9: Angular momenta of the collapsing orbit with exponential m function.

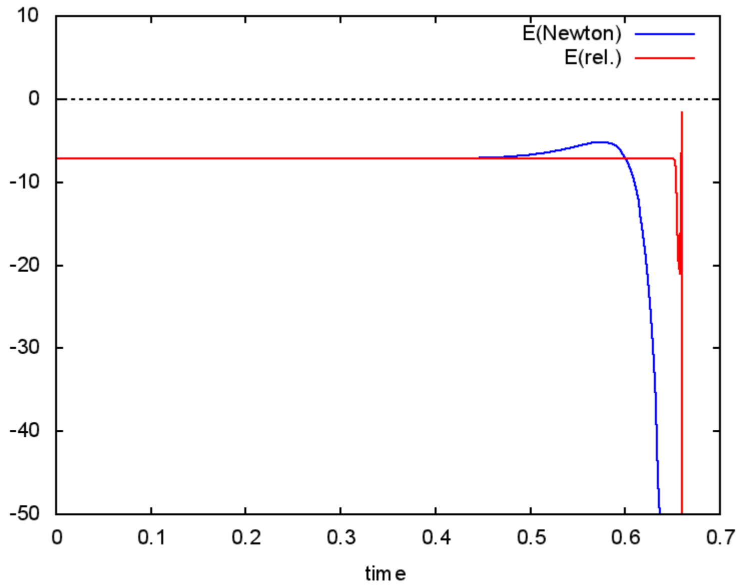

Figure 10: Total energies of the collapsing orbit with exponential m function.

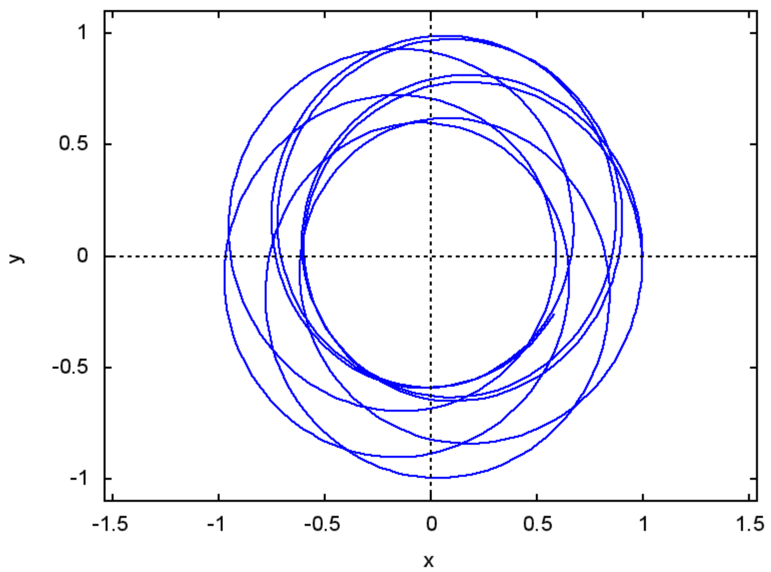

Figure 11: Stable orbit with Scharzschild-like m function, $\alpha = 0$.

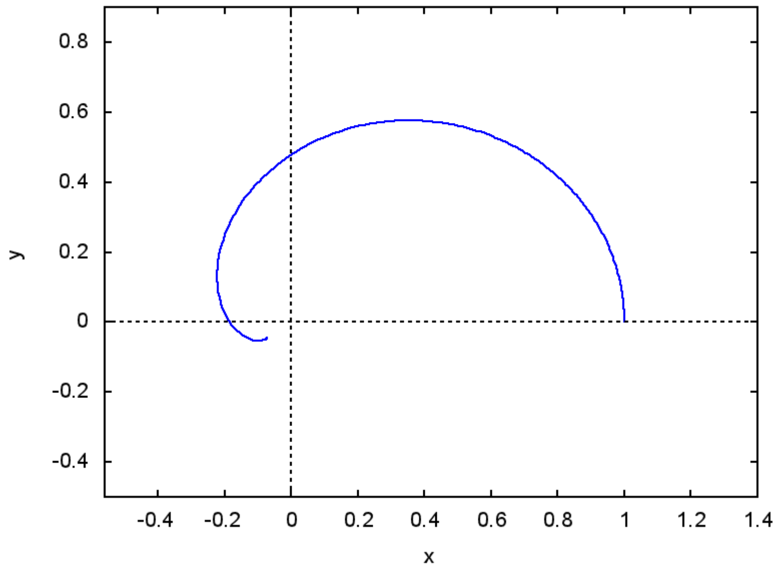

Figure 12: Collapsing orbit with Scharzschild-like m function, $\alpha = 0.003$.

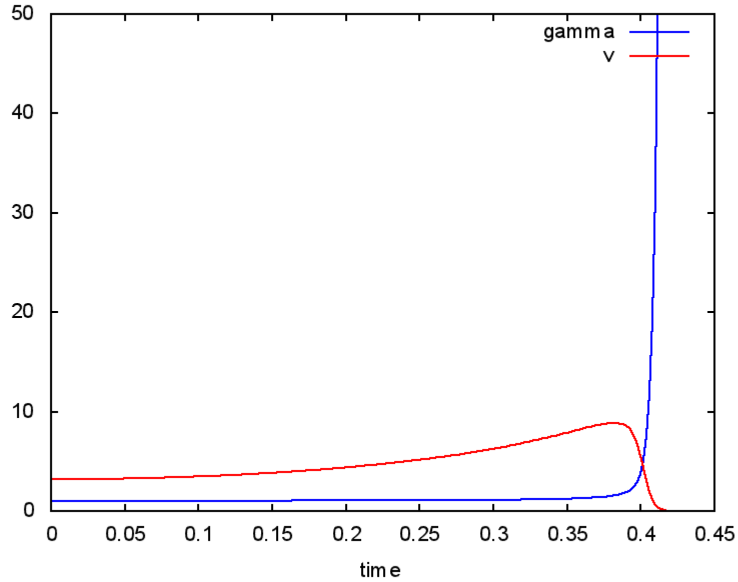

Figure 13: γ factor and velocity v of collapsing orbit with Scharzschild-like m function, $\alpha = 0.003$.

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