INFINITE ENERGY AND SUPERLUMINAL MOTION IN SPHERICAL SPACETIME.

by

M. W. Evans and H. Eckardt,

Civil List and AIAS / UPITEC.

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

ABSTRACT

It is shown that force and potential energy are generated by the general spherical spacetime (denoted "m space") and under well defined conditions this energy is imparted to material matter. It is defined by an m (r) function that reduces to unity in Minkowski spacetime. The spin connection of ECE2 theory is shown to originate in m space, and the frame rotation theory of the spin connection is related to m (r). Superluminal motion is generated through the generalized Lorentz factor of m space. In a well defined classical limit the latter reduces to orbit theory that shows how m (r) may be measured by routine astronomy.

Keywords: ECE2 theory in spherical spacetime, m theory, infinite energy and superluminal motion from spherical spacetime.

UFT 417

1. INTRODUCTION

In recent papers of this series {1 - 41} the dynamics of orbits have been developed in the most general spherically symmetric spacetime, denoted "m space". The m space is characterized by a well known infinitesimal line element containing the m (r) function,(denoted "m function" for short) where m is any function of the coordinate r of the plane polar system (r, ϕ). In section 2 it is shown that m space contains force and potential energy which may be imparted as kinetic energy to material matter. Under well defined conditions the force and potential energy of m space become infinite, and the ubiquitous m space contains an infinite amount of potential energy which is observable precisely in radiative corrections such as the Lamb shift. The m space is also responsible for the spin connection of ECE2 theory, and its generalized Lorentz factor results in superluminal motion. A method is given for the astronomical observation of the m function.

This paper is a brief synopsis of detailed calculations in the notes accompanying UFT417 on www.aias.us. Note 417(1) defines the force due to m space, synonymous with "vacuum force" or "aether force". Note 417(2) is a summary of the equations of motion of m space and their Minkowski limit. Note 417(3) is a preliminary version of Note 417(4) which defines the condition for the transfer of an infinite peak of potential energy from m space to kinetic energy in material matter. Note 417(5) defines the work integral of the force of m space, or "vacuum force", and gives an outline of how the force of m space can account for the Lamb shift. Note 417(6) relates the m function to the frame rotation theory of recent UFT papers, both for forward and retrograde precessions. Note 417(7) uses well known turning point theory in differential calculus to define the general maxima, minima and inflexions of the force due to m space. The energy due to m space is included in the hamiltonian and the rest energy defined in m space. The rest energy is subtracted from the hamiltonian to give the reduced hamiltonian. A well defined approximation is used to greatly simplify the calculation of the reduced hamiltonian in the classical limit and the orbital velocity calculated in m space. This calculation gives an expression for the m function in terms of the observed orbital velocity at a point r in any orbit. The concepts and approximations used are shown to be rigorously self consistent.

In section 3, the superluminal method is demonstrated and the theory of Section 2 complemented by discussion and graphics.

2. INFINITE ENERGY, SUPERLUMINAL MOTION AND ORBIT DYNAMICS

Consider the plane polar coordinate system (r_1, ϕ) defined by:

$$r_1 = \frac{r}{m(r)^{1/2}} \quad -(1)$$

and introduced in immediately preceding UFT papers. In this coordinate system the lagrangian of m space is:

$$\mathcal{L} = -mc^2 \left(m(r) - \frac{1}{c^2} \dot{\underline{r}}_1 \cdot \dot{\underline{r}}_1 \right)^{1/2} + \frac{mMG}{r_1} \quad -(2)$$

where the m function is defined by the infinitesimal line element and the Lorentz factor:

$$\gamma = \left(m(r) - \frac{1}{c^2} \dot{\underline{r}}_1 \cdot \dot{\underline{r}}_1 \right)^{-1/2} \quad -(3)$$

of m space. The gravitational potential energy of attraction between m orbiting M in the lagrangian (2) is:

$$U = -\frac{mMG}{r_1} \quad -(4)$$

where G is Newton's constant. The Euler Lagrange equation is:

$$\frac{d}{dt}\frac{\partial \mathcal{L}}{\partial \dot{\underline{r}}_1} = \frac{\partial \mathcal{L}}{\partial \underline{r}_1} = \underline{\nabla}\mathcal{L} = \frac{\partial \mathcal{L}}{\partial r_1}\underline{e}_r \quad -(5)$$

in which the relativistic linear momentum of m space is:

$$\underline{p}_1 = \frac{\partial \mathcal{L}}{\partial \dot{\underline{r}}_1}. \quad -(6)$$

The Euler Lagrange equation is therefore the orbit equation:

$$\underline{F}_1 = \frac{d\underline{p}_1}{dt} = \frac{\partial \mathcal{L}}{\partial r_1}\underline{e}_r \quad -(7)$$

in which the relativistic linear momentum is:

$$\underline{p}_1 = \gamma m \dot{\underline{r}}_1 = \frac{\gamma m \dot{\underline{r}}}{m(r)^{1/2}}. \quad -(8)$$

The orbit equation (7) is the relativistic generalization in m space of the well known

classical orbit equation

$$\underline{F} = \frac{d\underline{p}}{dt} = -\frac{mMG}{r^2}\underline{e}_r. \quad -(9)$$

In Eq. (7):

$$\frac{\partial \mathcal{L}}{\partial r_1} = -\frac{mc^2}{2}\gamma\frac{dm(r)}{dr_1} - \frac{mMG}{r_1^2} \quad -(10)$$

so:

$$\underline{F}_1 = \frac{d\underline{p}_1}{dt} = \left(-\frac{mc^2}{2}\gamma\frac{dm(r)}{dr_1} - \frac{mMG}{r_1^2}\right)\underline{e}_r \quad -(11)$$

and the m space produces an entirely new type of force:

$$\underline{F}(\mathrm{vac}) = -\frac{mc^2}{2}\gamma\frac{dm(r)}{dr_1}\underline{e}_r \quad (12)$$

which does not exist in Minkowski spacetime or in classical orbit theory. This is the force due to m space or "vacuum force" denoted F(vac). In ECE theory:

$$\underline{F}(\mathrm{vac}) = \underline{\Omega}_r \, \Phi \quad -(13)$$

where Φ is the gravitational potential and $\underline{\Omega}_r$ the radial spin connection vector:

$$\underline{\Omega}_r = \Omega_r \, \underline{e}_r. \quad -(14)$$

Therefore:

$$\underline{F}(\mathrm{vac}) = \underline{\Omega}_r \, \Phi = -\frac{mc^2}{2} \gamma \frac{dm(r)}{dr_1} \underline{e}_r. \quad -(15)$$

In this equation:

$$\frac{dm(r)}{dr_1} = \frac{dm(r)}{dr} \frac{dr}{dr_1} \quad -(16)$$

Therefore using computer algebra, the force due to m space, synonymous with vacuum force,

is:

$$\underline{F}(\mathrm{vac}) = \frac{\gamma mc^2 m(r)^{3/2} \frac{dm(r)}{dr} \underline{e}_r}{r\frac{dm(r)}{dr} - 2m(r)} \quad -(17)$$

It becomes infinite at the point:

$$r\frac{dm(r)}{dr} = 2m(r) \quad -(18)$$

form which the m function for infinite transfer of energy may be found. This is graphed in

Section 3.

The equations of motion of the orbit in m space are:

$$\frac{dH}{dt} = 0 \quad -(19)$$

and

$$\frac{dL}{dt} = 0 . \quad -(20)$$

In the usual (r , ϕ) plane polar coordinate system the hamiltonian is:

$$H = \gamma m c^2 m(r) - m(r)^{1/2} \frac{mMG}{r} \quad -(21)$$

and the angular momentum is:

$$L = \frac{\gamma m r^2}{m(r)} \dot{\phi} \quad -(22)$$

The orbit equations are those of conservation of the m space hamiltonian and angular momentum. In these equations the Lorentz factor of m space is:

$$\gamma = \left(m(r) - \frac{v^2}{m(r) c^2} \right)^{-1/2} . \quad -(23)$$

In the immediately preceding UFT papers it was demonstrated numerically that the orbit equations of m space rigorously conserve H and L. The theory and computation therefore pass this severe and rigorous test of correctness.

By computer algebra the orbit equations of m space are:

$$\ddot{r} - r\dot{\phi}^2 = \frac{dm(r)}{dr} \left(c^2 m(r) + \frac{MG}{2\gamma^3 r\, m(r)^{1/2}} - \frac{3c^2}{2\gamma^2} \right) - \frac{1}{m(r)} \frac{dm(r)}{dr} \dot{\phi}^2 r^2 \left(2 - \frac{MG}{2\gamma c^2 m(r)^{1/2}} \right) - MG \left(\frac{m(r)^{1/2}}{\gamma^3 c^2} + \frac{\dot{\phi}^2}{\gamma c^2 m(r)^{1/2}} \right) \quad -(24)$$

and

$$r\ddot{\phi} + 2\dot{\phi}\dot{r} = r\dot{\phi}\dot{r} \left(\frac{1}{m(r)} \frac{dm(r)}{dr} \left(2 - \frac{MG}{2\gamma c^2 r\, m(r)^{1/2}} \right) + \frac{MG}{\ldots m(r)^{1/2}} \right) \quad -(25)$$

In the preceding paper these were integrated numerically to give any observable orbit in terms of any function m. This procedure goes considerably beyond the standard model, in which m is restricted to:

$$m(r) = 1 - \frac{2MG}{c^2 r} \quad -(26)$$

by the incorrect Einstein field equation. The m theory of this paper gives startlingly original results such as infinite vacuum energy and superluminal motion and retrograde orbits observable in the newly discovered S2 star {1 - 41}. The incorrect Einstein field equation is wholly incapable of giving any of these results.

In the Minkowski limit (Note 417(2)), Eqs. (24) and (25) reduce to:

$$\ddot{r} - r\dot{\phi}^2 = -\frac{MG}{\gamma}\left(\frac{1}{\gamma^2 r^2} - \frac{\dot{\phi}^2}{c^2}\right) \quad -(27)$$

and

$$2\dot{\phi}\dot{r} + r\ddot{\phi} = MG\left(\frac{\dot{\phi}\dot{r}}{\gamma c^2 r}\right) \quad -(28)$$

given in an earlier UFT paper. In the limit:

$$\gamma \rightarrow 1, \quad c \rightarrow \infty \quad -(29)$$

Eqs. (27) and (28) reduce to the classical orbit equations:

$$\ddot{r} - r\dot{\phi}^2 = -\frac{MG}{r^2} \quad -(30)$$

and

$$2\dot{\phi}\dot{r} + r\ddot{\phi} = 0. \quad -(31)$$

Eq. (30) is the Leibniz equation and Eq. (31) is equivalent to the conservation of classical angular momentum:

$$\frac{dL}{dt} = \frac{d}{dt}\left(mr^2\dot{\phi}\right) = 0. \quad -(32)$$

Consider the force generated by m space (or vacuum force):

$$\underline{F}(vac) = \left(\frac{\gamma m c^2 m(r)^{3/2}}{r\frac{dm(r)}{dr} - 2m(r)}\right)\frac{dm(r)}{dr}\underline{e}_r \quad -(33)$$

The work done by this force is:

$$W_{12} = \int_1^2 \underline{F}(vac)\cdot d\underline{r} = T_2 - T_1 = U_1 - U_2 \quad -(34)$$

where $T_2 - T_1$ is the change in kinetic energy and $U_1 - U_2$ is the change in potential energy. The hamiltonian is conserved:

$$H = T_1 + U_1 = T_2 + U_2 \quad -(35)$$

so:

$$U_1 - U_2 = T_2 - T_1. \quad -(36)$$

The potential energy equation:

$$U_1 - U_2 = \int \underline{F}\cdot d\underline{r} \quad -(37)$$

is satisfied by:

$$\underline{F} = -\underline{\nabla} U \quad -(38)$$

so the potential energy of m space is:

$$U(\mathrm{vac}) = -\int \frac{\gamma m c^2 m(r)^{3/2}}{r\frac{dm(r)}{dr} - 2m(r)} \frac{dm(r)}{dr}\, dr \quad -(39)$$

and the energy becomes infinite under the condition (18). The potential energy (39) imparts the kinetic energy:

$$T(\mathrm{vac}) = -U(\mathrm{vac}) \quad -(40)$$

to material matter. This is denoted "energy from m space" or energy from spacetime.

This energy reveals itself in the radiative corrections for example and can be trapped in a circuit as described in UFT311, UFT321, UFT364, UFT382 and UFT383. In a thought experiment it is possible to consider the Coulomb law in m space as follows:

$$\underline{F} = \frac{d\underline{p}}{dt} = -\frac{e^2 m(r)^{1/2}}{4\pi\epsilon_0 r}\underline{e}_r \quad -(41)$$

where the relativistic momentum in m space is:

$$\underline{p} = \frac{\gamma m \dot{\underline{r}}}{m(r)^{1/2}} \quad -(42)$$

and the Lorentz factor in m space is:

$$\gamma = \left(m(r) - \frac{v^2}{m(r)c^2}\right)^{-1/2}. \quad -(43)$$

In Section 3 it is shown that the Lorentz factor in m space gives superluminal motion, opening up the possibility of superluminal motion between planets of the solar system, and between stars known to have planets. The vacuum force on one electron is given by Eq. (33). In immediately preceding UFT papers we have considered this vacuum force in terms of shivering and zitterbewegung as in Lamb shift theory. Isotropic averages of zitterbewegung as in Lamb shift theory can be now be developed in terms of the force (33).

The m function is defined by the well known infinitesimal line element of the most general spherically symmetric spacetime:

$$ds^2 = c^2 d\tau^2 = m(r) c^2 dt^2 - \frac{dr^2}{n(r)} - r^2 d\phi^2 \quad -(44)$$

in plane polar coordinates (r, ϕ). In m space, the m function is not constrained by the incorrect Einstein field equation. This property introduces large number of possibilities in cosmology.

There is nothing equivalent to m force in Minkowski spacetime, whose lagrangian is:

$$\mathcal{L} = -mc^2 \left(1 - \frac{v^2}{c^2}\right)^{1/2} - U$$
$$= -mc^2 \left(1 - \frac{1}{2}\frac{v^2}{c^2} + \dots\right) - U \sim \frac{1}{2} mv^2 - mc^2 - U$$
$$= \mathcal{L}_c - mc^2 \quad -(45)$$

where the classical lagrangian is:

$$\mathcal{L}_c = \frac{1}{2} mv^2 - U. \quad -(46)$$

In the m space the lagrangian is:

$$\mathcal{L} = -mc^2 \left(m(r) - \frac{v^2}{m(r)c^2}\right)^{1/2} - U \quad -(47)$$
$$= -mc^2 m(r)^{1/2} \left(1 - \frac{1}{2}\left(\frac{v}{m(r)c}\right)^2 + \dots\right) - U$$
$$\sim \frac{1}{2}\frac{mv^2}{m(r)^{3/2}} - m(r)^{1/2} mc^2 - U.$$

So the rest energy in m space is:

$$E_0 = m(r)^{1/2} mc^2 \quad -(48)$$

and the classical kinetic energy in m space is:

$$T = \frac{1}{2} \frac{m v^2}{m(r)^{3/2}} \quad -(49)$$

The infinitesimal line element of m space, Eq. (44), is the origin of the frame rotation due to underlying spacetime torsion:

$$ds^2 = c^2 d\tau^2 = c^2 dt^2 - dr^2 - r^2 d\phi'^2 \quad -(50)$$

where:

$$d\phi' = d\phi + \omega dt \quad -(51)$$

and ω is the angular velocity of the frame rotation. As shown in Note 410(7) the newly discovered retrograde precession of the S2 star is explained by:

$$d\phi' = d\phi - \omega dt \quad -(52)$$

but has no explanation in the Einstein field equation. In these equations the orbital linear velocity of frame rotation is:

$$v_\phi = \omega r \quad -(53)$$

where:

$$\omega = \frac{d\phi}{dt} \quad -(54)$$

As shown in Note 417(6), forward precession is described by:

$$ds^2 = (c^2 - 3 v_\phi^2) dt^2 - dr^2 - r^2 d\phi^2 \quad -(55)$$

and retrograde precession by:

$$ds^2 = (c^2 + v_\phi^2)\,dt^2 - dr^2 - r^2 d\phi^2 \quad -(56)$$

For forward precession in the classical limit, the orbit is:

$$r = \frac{\alpha}{1 + \epsilon\cos(\phi + \omega t)} \quad -(57)$$

with precession:

$$\Delta\phi = \omega T \quad -(58)$$

where T is the time needed to complete one orbit.

For retrograde precession the orbit is:

$$r = \frac{\alpha}{1 + \epsilon\cos(\phi - \omega t)} \quad -(59)$$

and the precession is:

$$\Delta\phi = -\omega T \quad -(60)$$

This equation explains the retrograde precession of - 1 degree per orbit of the S2 star by using the observed T of the S2 star - about fifteen earth years and measuring ω by observation. The result from the Einstein field equation is completely incorrect. It is + 0.2 degrees per orbit of the S2 star.

Comparing Eqs. (44) and (55):

$$\frac{3v_\phi^2}{c^2} = 1 - m(r) + \frac{1}{c^2}\left(\frac{1}{m(r)} - 1\right)\left(\frac{dr}{dt}\right)^2 \quad -(61)$$

and m (r) can be found by computer algebra. It is discussed and graphed in Section 3. If:

$$\frac{dr}{dt} \ll c \quad -(62)$$

then

$$m(r) \sim 1 - \frac{3v_\phi^2}{c^2}. \quad -(63)$$

Similarly for retrograde precession:

$$m(r) \sim 1 + \frac{v_\phi^2}{c^2}. \quad -(64)$$

By expanding the Lorentz factor of m space:

$$\gamma = \left(m(r) - \frac{v^2}{m(r)c^2}\right)^{-1/2} = m(r)^{1/2}\left(1 - \left(\frac{v}{m(r)c}\right)^2\right)^{-1/2} \quad -(65)$$

it follows that the hamiltonian (21) of m space can be developed as:

$$H = m(r)^{1/2}\left[\left(1 - \left(\frac{v}{m(r)c}\right)^2\right)^{-1/2} mc^2 - \frac{mMG}{r}\right] \quad -(66).$$

as in Note 417(7). In the classical limit:

$$H \sim m(r)^{1/2}\left[\left(1 + \frac{1}{2}\frac{v^2}{m^2(r)c^2}\right)mc^2 - \frac{mMG}{r}\right] \quad -(67)$$

Now subtract the rest energy (48) from the hamiltonian to give the reduced hamiltonian:

$$H_0 = H - m(r)^{1/2} mc^2. \quad -(68)$$

In the (r, ϕ) coordinate system:

$$H_0 = \frac{1}{2} m \frac{\left(\dot{r}^2 + r^2\dot{\phi}^2\right)}{m(r)^{3/2}} - m(r)^{1/2}\frac{mMG}{r}. \quad -(69)$$

The angular momentum in m space is:

$$L = \frac{\gamma m r^2 \dot{\phi}}{m(r)} \quad -(70)$$

so the reduced hamiltonian is:

$$H_0 = \frac{1}{2}\frac{m\dot{r}^2}{m(r)^{3/2}} + \frac{1}{2}m(r)^{1/2}\frac{L^2}{\gamma^2 m r^2} - m(r)^{1/2}\frac{mMG}{r}. \quad -(71)$$

Now use the approximation:

$$\frac{1}{\gamma^2} = m(r) - \frac{v^2}{m(r)c^2} \xrightarrow[v \ll c]{} m(r) \quad -(72)$$

in the classical limit:

$$v \ll c \quad -(73)$$

$$-(74)$$

to give the reduced hamiltonian:

$$H_0 \sim \frac{1}{2}\frac{m\dot{r}^2}{m(r)^{3/2}} + \frac{1}{2}m(r)^{3/2}\frac{L^2}{mr^2} - m(r)^{1/2}\frac{mMG}{r}$$

In the limit:

$$m(r) \to 1 \quad -(75)$$

this reduces to the well known classical result:

$$H_0 = \frac{1}{2}m\dot{r}^2 + \frac{1}{2}\frac{L^2}{mr^2} - \frac{mMG}{r} \quad -(76)$$

which gives the static conic section

$$r = \frac{\alpha}{1+\epsilon\cos\phi}. \quad -(77)$$

The approximation (72) considerably simplifies the calculation, because γ^2 in the original equation (71) contains v, and in the approximate expression (74) does not contain v.

From Eq. (74):

$$\left(\frac{dr}{dt}\right)^2 = \frac{2m(r)^{3/2}}{m}\left(H_0 - \frac{1}{2}m(r)^{3/2}\frac{L^2}{mr^2} + m(r)^{1/2}\frac{mMG}{r}\right) \quad -(78)$$

which in the classical limit becomes:

$$\left(\frac{dr}{dt}\right)^2 \xrightarrow[m(r)\to 1]{} \frac{2}{m}\left(H_0 - \frac{1}{2}\frac{L^2}{mr^2} + \frac{mMG}{r}\right). \quad -(79)$$

The orbital velocity in m space is therefore given by:

$$v^2 = \left(\frac{dr}{dt}\right)^2 + r^2\left(\frac{d\phi}{dt}\right)^2 \quad -(80)$$

$$= \left(\frac{dr}{dt}\right)^2 + \frac{m(r)^2 L^2}{r^2 m^2 r^2} \sim \left(\frac{dr}{dt}\right)^2 + \frac{m(r)^3 L^2}{m^2 r^2}.$$

in the classical limit (72). Therefore the orbital velocity in m space is, in approximation (72):

$$v^2 = \frac{2m(r)^{3/2}}{m}\left(H_0 + m(r)^{1/2}\frac{mMG}{r}\right) \quad -(81)$$

From Eq. (69):

$$H_0 = \frac{1}{2}\frac{mv^2}{m(r)^{3/2}} - m(r)^{1/2}\frac{mMG}{r} \quad -(82)$$

so using Eq. (82) in (81) gives:

$$H_0 = H_0 + m(r)^{1/2}\left(\frac{mMG}{r} - \frac{mMG}{r}\right). \quad -(83)$$

This shows that Eqs. (81) and (82) are self consistent, Q. E. D.

For small departures from Newtonian theory:

$$H_0 \sim -\frac{mMG}{2a} \quad -(84)$$

where a is the semi major axis of the orbit. So

$$v^2 = m(r)^{3/2} MG \left(\frac{2m(r)^{1/2}}{r} - \frac{1}{a} \right) \quad -(85)$$

In the limit:

$$m(r) \rightarrow 1 \quad -(86)$$

this correctly reduces to the well known Newtonian result:

$$v^2 = MG \left(\frac{2}{r} - \frac{1}{a} \right) \quad -(87)$$

Q. E. D. Eq. (85) gives a method of measuring the m function from observations of v and r in any orbit. Eq. (85) gives the quartic equation:

$$2ax^4 - rx^3 = \frac{v^2 ra}{MG} \quad -(88)$$

where:

$$x = m(r)^{1/2} \quad -(89)$$

This is solved for the four roots in Section 3, and the results graphed. Note that Eq. (88) is true for any orbit within the approximations used.

3. SUPERLUMINAL MOTON, GRAPHICS AND DISCUSSION.

Section by dr. Horst Eckardt.

Infinite energy and superluminal motion in spherical spacetime

M. W. Evans[*], H. Eckardt[†]
Civil List, A.I.A.S. and UPITEC

(www.webarchive.org.uk, www.aias.us,
www.atomicprecision.com, www.upitec.org)

3 Superluminal motion, graphics and discussion

In this section we deepen several aspects described in section 2.

3.1 Vacuum force

The vacuum force as given in Eq. (17) is

$$\mathbf{F}(\mathrm{vac}) = \mathrm{m}(r)^{\frac{3}{2}} \frac{d\,\mathrm{m}(r)}{dr} \frac{\gamma m c^2}{r \frac{d\,\mathrm{m}(r)}{dr} - 2\,\mathrm{m}(r)} \mathbf{e}_r. \tag{90}$$

It can be seen that $\mathbf{F}(\mathrm{vac})$ vanishes for a constant $\mathrm{m}(r)$. Only a cosmology with the most general spherical spacetime gives a vacuum force which is contained in the constants of motion H and L. When vacuum effects not originating in this force are present, we have to introduce them via

$$\mathbf{F}_{\mathrm{ext}}(\mathrm{vac}) = -\boldsymbol{\nabla}\Phi + m\,\boldsymbol{\Omega}\,\Phi \tag{91}$$

where Φ is the gravitational potential and $\boldsymbol{\Omega}$ is the vector spin connection. In this case H and L will not be conserved. The same holds when $\mathbf{F}_{\mathrm{ext}}(\mathrm{vac})$ is reduced to its radial component.

We computed the vacuum force for the exponential $\mathrm{m}(r)$ function we used in preceding papers, given by:

$$\mathrm{m}(r) = 2 - \exp\left(\log(2)\,\exp\left(-\frac{r}{R}\right)\right). \tag{92}$$

$\mathrm{m}(r)$ and $d\mathrm{m}(r)/dr$ are graphed in Fig. 1. The derivative increases significantly for $r \to 0$. We recomputed the dynamics of the collapsing orbit presented in Fig. 2 of UFT 416. From the trajectory results we computed the vacuum force (90) which is graphed in Fig. 2. As expected it vanishes for large r and drops to negative infinite values for $r \to 0$.

[*]email: emyrone@aol.com
[†]email: mail@horst-eckardt.de

The vacuum force can be computed without solution of dynamics if we assume a constant γ factor. Using the Schwarzschild-like m function

$$\mathrm{m}(r) = 1 - \frac{r_0}{r} - \frac{\alpha}{r^2} \tag{93}$$

we computed the vacuum force in this way. Inserting the above $\mathrm{m}(r)$ into Eq. (90) the denominator vanishes for certain values of r:

$$r\,\frac{d\,\mathrm{m}(r)}{dr} - 2\,\mathrm{m}(r) = 0. \tag{94}$$

Inserting the m function (93) into this equation gives the solutions

$$r_{1,2} = \frac{3\,r_0}{4} \pm \frac{1}{4}\sqrt{9{r_0}^2 + 32\alpha}. \tag{95}$$

For $\alpha = 0$ the original Schwarzschild m function is obtained with the divergence point

$$r_1 = \frac{r_0}{2}. \tag{96}$$

This vacuum force has been graphed in Fig. 3 for $r_0 = 1$ and two values of α. There is a pole at $r = 1.5$, indicating infinite energy from spacetime at this point. For $r < 1$ the function is imaginary and not defined. Increasing α shifts the pole to the right.

The same graph was computed with the exponential $\mathrm{m}(r)$ of Eq. (92) for two values of the parameter R, see Fig. 4. There is a minimum of $F(\mathrm{vac})$ which moves to $r = 0$ for $R \to 0$. This explains that for small R (which was used in the Lagrange solutions) the vacuum force seems to go to infinity for $r \to 0$ like a hyperbola. This m function is much more well behaved than the Schwarzschild-like function because it is positive and does not contain zero crossings for $r \to 0$ which would represent event horizons.

As explained, the vacuum force becomes maximal if the denominator of Eq. (90) goes to zero, leading to Eq. (94). This equation can be consideres as a differential equation for $\mathrm{m}(r)$ which has the general solution

$$\mathrm{m}(r) = c_1 r^2 \tag{97}$$

with a constant c_1. This means that for such a quadratic $\mathrm{m}(r)$ the vacuum force is infinite everywhere. However the m function has to have the limit $\mathrm{m}(r)$=1 for large r. Therefore we compose a function which is quadratic for $r \to 0$ and constant for $r \to \infty$:

$$\mathrm{m}(r) = \begin{cases} \frac{r^2}{2a^2} & \text{for } r < a, \\ 1 - \frac{a}{4\left(r - \frac{a}{2}\right)} & \text{for } r \geq a. \end{cases} \tag{98}$$

It can be checked that $\mathrm{m}(r)$ is continuous and continuously differentiable at $r = a$. Both cases in (98) give

$$\mathrm{m}(a) = \frac{1}{2}, \tag{99}$$

$$\frac{d\mathrm{m}(r)}{dr}(a) = \frac{1}{a}. \tag{100}$$

This function is graphed in Fig. 5 for $a = 1/2$, The corresponding vacuum force and its denominator are graphed in Fig. 6. It is seen that the vacuum force drops massively when r approaches $1/2$.

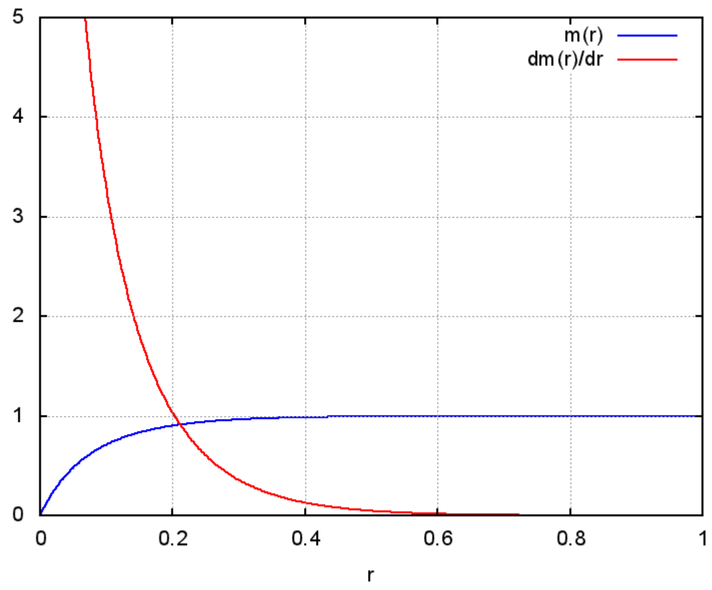

Figure 1: Exponential m function and its derivative.

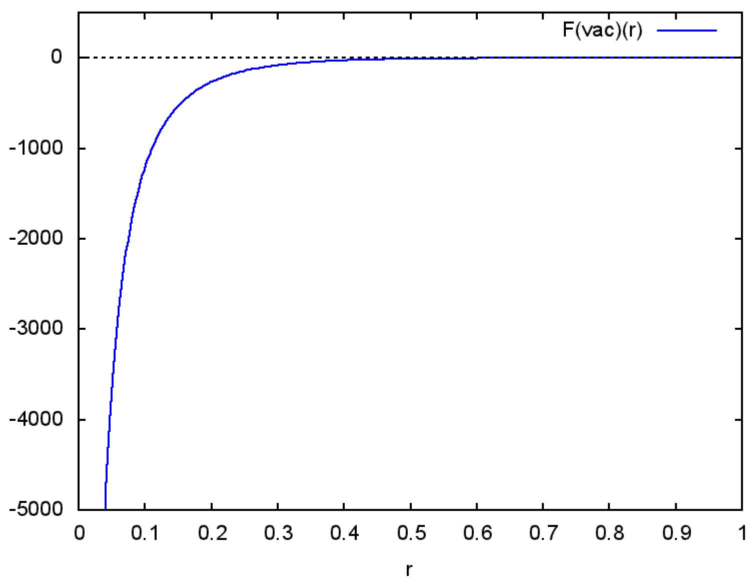

Figure 2: Vacuum force from the trajectories of relativistic Lagrangian dynamics.

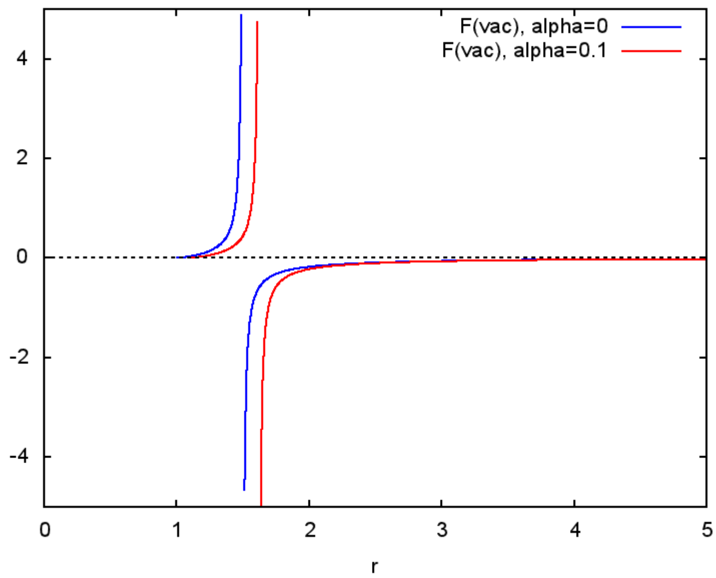

Figure 3: Vacuum force of Schwarzschild-like functions m(r).

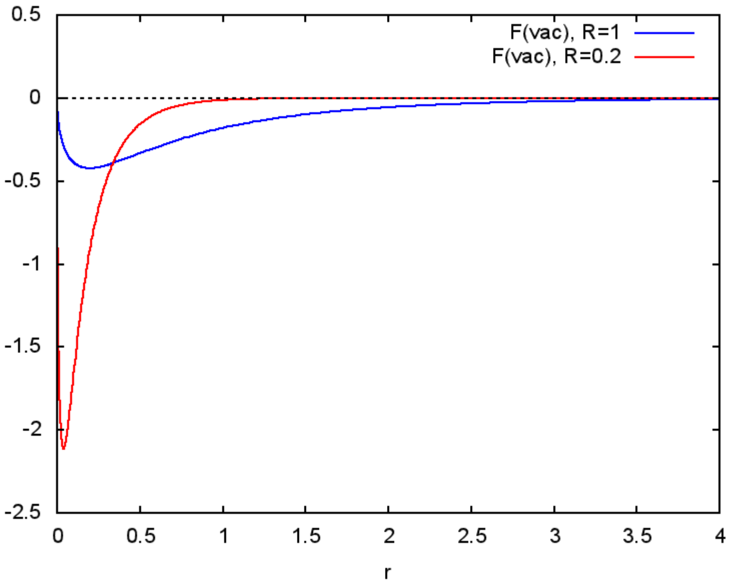

Figure 4: Vacuum force of exponential functions m(r).

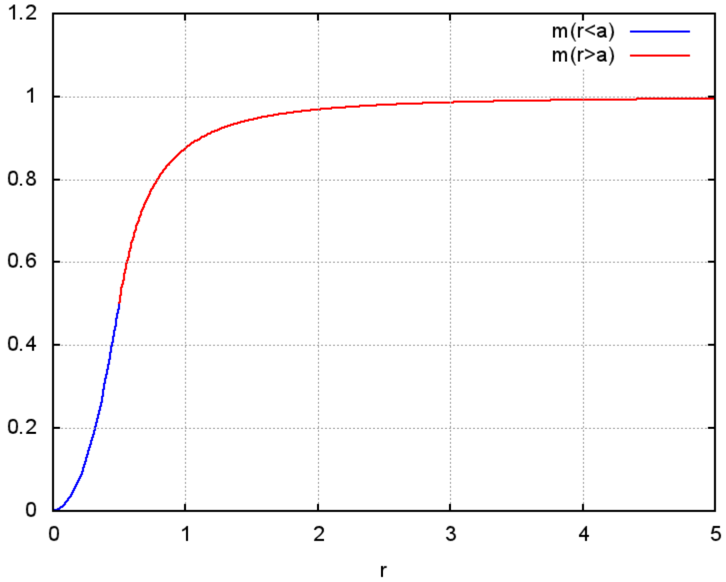

Figure 5: m function composed of terms r^2 and $1/r^2$.

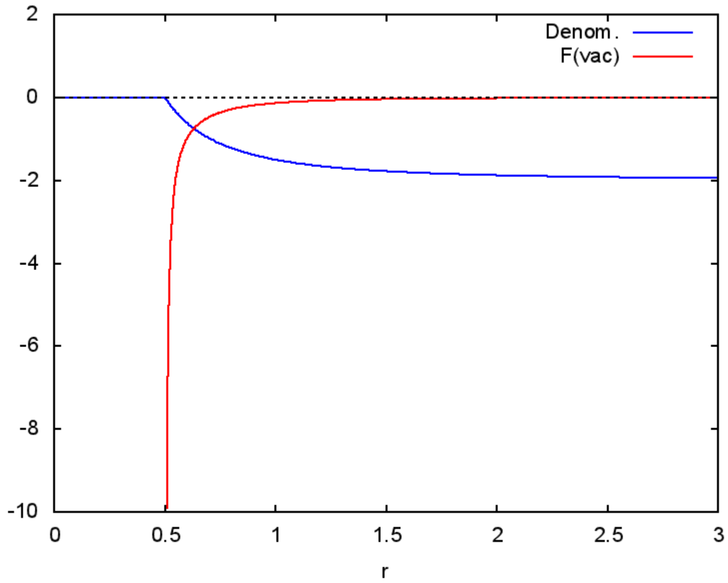

Figure 6: Denominator of vacuum force and vacuum force of composite m function from Fig. 5.

3.2 Rotational m theory and superluminal motion

Spacetime rotation was described by angular rotation of the line element in previous papers, leading to the results (55, 56) for forward and retrograde precession. Comparing these line elements with that of m theory (44) leads to the equations

$$3\frac{{v_\phi}^2}{c^2} = \frac{\left(\frac{1}{\mathrm{m}(r)}-1\right)\,{v_r}^2}{c^2} - \mathrm{m}(r) + 1, \tag{101}$$

$$-\frac{{v_\phi}^2}{c^2} = \frac{\left(\frac{1}{\mathrm{m}(r)}-1\right)\,{v_r}^2}{c^2} - \mathrm{m}(r) + 1 \tag{102}$$

for both precessions respectively. $v_\phi = \omega\, r$ is the angular component of spacetime rotation frequency ω at radius r. These equations are quadratic in $\mathrm{m}(r)$. Their solutions can be determined by computer algebra for forward precession:

$$\begin{aligned}\mathrm{m}_{1,2,f}(v) =& \frac{1}{2} + \frac{1}{2c^2}\Big(-v_r^2 - v_\phi^2 \\ & \mp \sqrt{{v_r}^4 + 6{v_\phi}^2{v_r}^2 + 2c^2\,{v_r}^2 + 9{v_\phi}^4 - 6c^2\,{v_\phi}^2 + c^4}\Big)\end{aligned} \tag{103}$$

and for retrograde precession:

$$\begin{aligned}\mathrm{m}_{1,2,r}(v) =& \frac{1}{2} + \frac{1}{2c^2}\Big(-v_r^2 + v_\phi^2 \\ & \mp \sqrt{{v_r}^4 + (2c^2 - 2{v_\phi}^2)\,{v_r}^2 + {v_\phi}^4 + 2c^2\,{v_\phi}^2 + c^4}\Big).\end{aligned} \tag{104}$$

$\mathrm{m}(r)$ depends on velocity components v_ϕ and v_r only, therefore we have written $\mathrm{m}(v)$. Please notice that v_r is the radial component of the regular orbital velocity while v_ϕ does not has its origin in dynamics but in spacetime rotation. The orbital dependence (r, ϕ) has to be derived from the dynamics of a specific system. $\mathrm{m}(r)$ is pre-defined in this way, i.e. for frame rotation there is no arbitrary choice of $\mathrm{m}(r)$ possible or required, respectively.

Simple approximations for (103, 104) for $v \ll c$ were given by Eqs. (63, 64):

$$\mathrm{m}_f(v) = 1 - \frac{3\,v_\phi^2}{c^2}, \tag{105}$$

$$\mathrm{m}_r(v) = 1 + \frac{v_\phi^2}{c^2}. \tag{106}$$

The exact and approximate solutions were graphed. To obtain a simple parameter dependence, we assumed $v_r = 0.2\, v_\phi$ for simplicity so that m depends only on one parameter: $\mathrm{m}(v_\phi)$. The curves (Figs. 7, 8) are quite different for forward and backward rotation. For forward rotation (Fig. 7), the first solution is negative and unphysical, the second starts at $\mathrm{m}(v_\phi)$=1 (non-relativistic limit) and approaches low values for $v_\phi \to c$, where c has been set to unity here. The simple formula (105) deviates from the exact formula (103) above $v_\phi \approx c/2$ and drops to negative values then. It holds only in the low velocity limit as expected.

For retrograde precession (Fig. 8) we have to take the second solution again. m starts at unity and goes up to 2 for $v_\phi = c$. The conformance to the simple formula is good over the whole range of $v_\phi \leq c$. The fact than $\mathrm{m}(v)$ exceeds unity can be interpreted as superluminal motion as follows: From the generalized γ factor (43),

$$\gamma = \frac{1}{\sqrt{\mathrm{m}(r) - \frac{v^2}{\mathrm{m}(r)\,c^2}}}, \tag{107}$$

we see that the m function alters the effective velocity of light by

$$c^2 \to \mathrm{m}(r)\,c^2. \tag{108}$$

Therefore $\mathrm{m}(r) > 1$ means superluminal motion; at least it is possible from the dynamics in this case. The curves in Fig. 8 are continuing to $v_\phi > c$ without singularities. It seems that the asymptotic velocity barrier $v = c$ is is suspended here. The dependence of the genealized γ factor on the m function has been graphed in Fig. 9. The ratio v/c has been taken as a parameter. As can be seen, the γ factor goes to infinity for $m(r) \to 0$ as found in the dynamics calculations. For $v/c > 1$ this limit is reached already above $\mathrm{m}(r)$=1. For cases $\mathrm{m}(r) > 1$ the γ factor takes values smaller than unity. This behaviour is unknown in Einsteinian special relativity.

Another point is why forward and backward frame rotation behave so differently. Formally this comes from the line element which is not symmetric for $d\phi + \omega\,dt$ and $d\phi - \omega\,dt$. Forward precession means that spacetime is rotated in direction of the orbiting mass while retrograde precession is a motion of the mass against spacetime rotation. Therefore v_ϕ may exceed c in the observer system. Details depend on the complete γ factor and the dynamics. The enormous consequences are to be developed by continuative investigations in theory and experimentally in astronomy.

3.3 Quartic equation

The quartic equation (88) provides a connection between an orbital velocity v and the geometry function m: The equation

$$2ax^4 - rx^3 = \frac{v^2 ra}{MG} \tag{109}$$

has to be solved for $x = \sqrt{\mathrm{m}(r)}$ to obtain $\mathrm{m}(r)$. This is a method of determining the m function from experimental data pairs (v, r). Computer algebra gives two imaginary solutions and two real solutions of Eq. (88) which are highly complicated. We used the real solutions m_3 and m_4 in the following. First we defined the velocity by

$$v^2 = MG\left(\frac{2}{r} - \frac{1}{a}\right) \tag{110}$$

which is the Newtonian dependence for $\mathrm{m}(r)$=1. a is the semi-major axis of the orbit. The solutions m_3 and m_4 are graphed in Fig. 9. Obviously m_3 goes down to zero and up again, while m_4 gives the straight line m=1 as is expected from the input form of $v(r)$. The predefined "input" function $\mathrm{m}(r)$=1 was graphed additionally. Obviously m_3 coincides with this function over the full range of r investigated. This proves that the method works as expected.

In Fig. 10 we have shown the general case

$$v^2 = \mathrm{m}(r)^{\frac{3}{2}} MG \left(\frac{2\sqrt{\mathrm{m}(r)}}{r} - \frac{1}{a} \right) \tag{111}$$

where v has been calculated with

$$\mathrm{m}(r) = 1 - \frac{0,5}{r^2}. \tag{112}$$

In principle we obtain the same result as before: the given $\mathrm{m}(r)$ is reproduced by the third solution of the quartic equation (108). When applying the method as proposed, one would use pairs of data (r_i, v_i) from astronomical measurements. Inserting these into the solution m_3 gives points $\mathrm{m}_3(r_i, v_i)$ from which the function $\mathrm{m}(r)$ can be reconstructed. The problem of contemporary astronomy is that velocities and distances cannot be measured very precisely so it will not be possible to determine small deviations from $\mathrm{m}(r)$=1 experimentally. However in special cases as pulsars quite precise astronomical data are available.

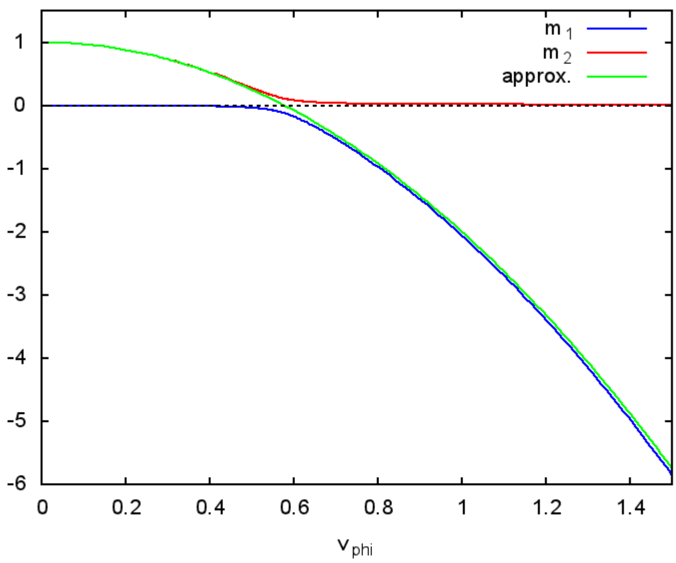

Figure 7: m functions for forward precession and approximation for small velocities.

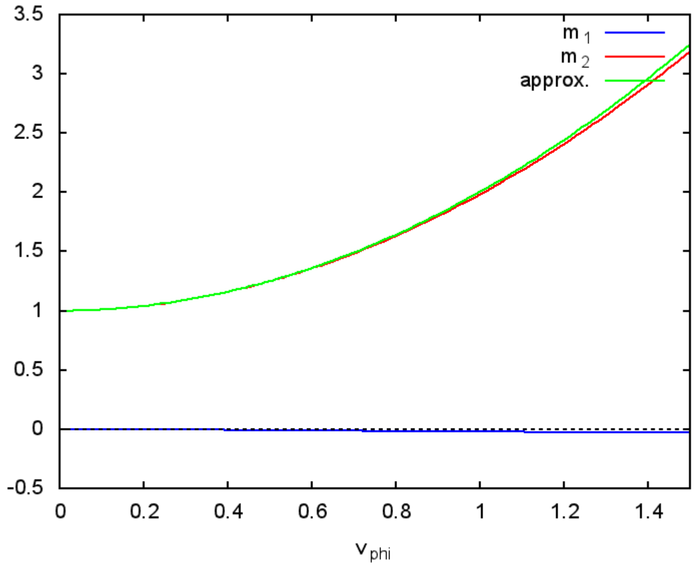

Figure 8: m functions for retrograde precession and approximation for small velocities.

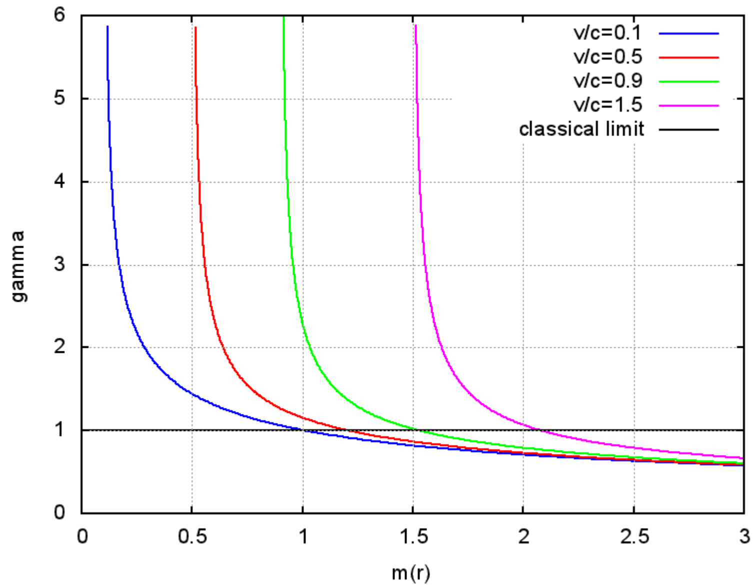

Figure 9: Generalized gamma factor in dependence of m(r) for some values of v/c.

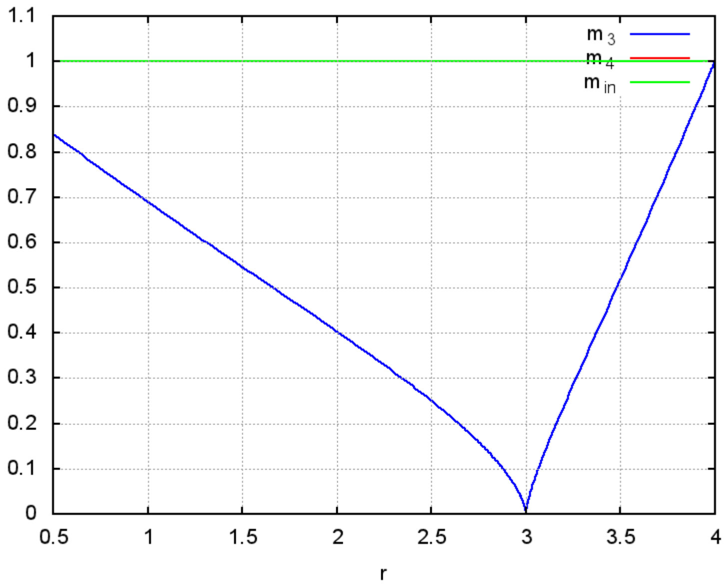

Figure 10: Solutions of the quartic equation with $\mathrm{m}(r) = 1$.

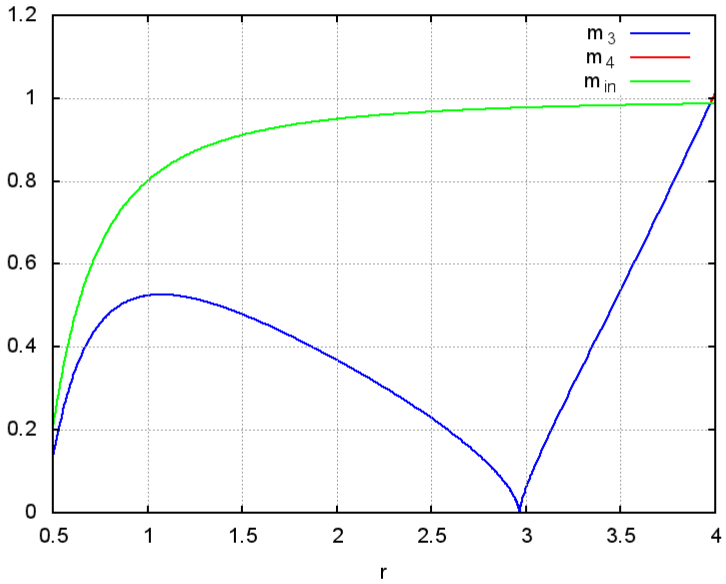

Figure 11: Solutions of the quartic equation with $\mathrm{m}(r) = 1 - 0.5/r^2$.

ACKNOWLEDGMENTS

The British Government is thanked for a Civil List Pension and the staff of AIAS and others for many interesting discussions. Dave Burleigh, CEO of Annexa Inc., is thanked for voluntary posting, site maintenance and feedback maintenance. Alex Hill is thanked for many translations, and Robert Cheshire nd Michael Jackson for broadcasting and video preparation.

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