Infinite energy and superluminal motion in spherical spacetime

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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 $r \to 0$.

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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.

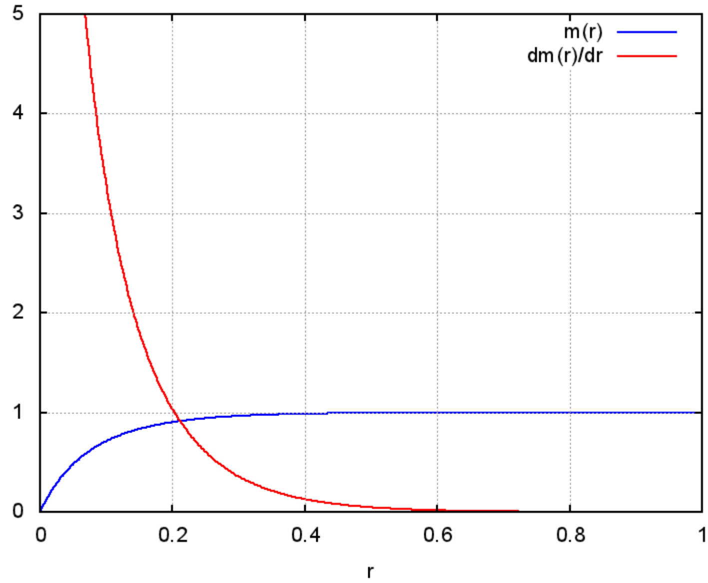

Figure 1: Exponential m function and its derivative.

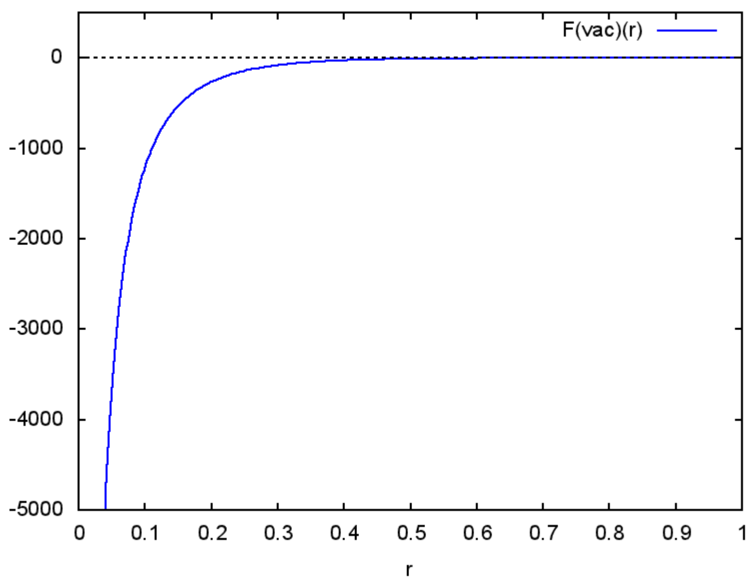

Figure 2: Vacuum force from the trajectories of relativistic Lagrangian dynamics.

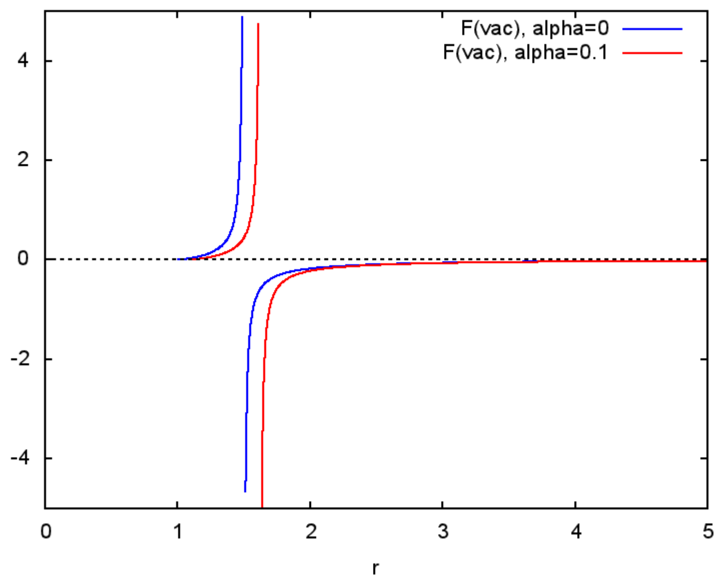

Figure 3: Vacuum force of Schwarzschild-like functions m(r).

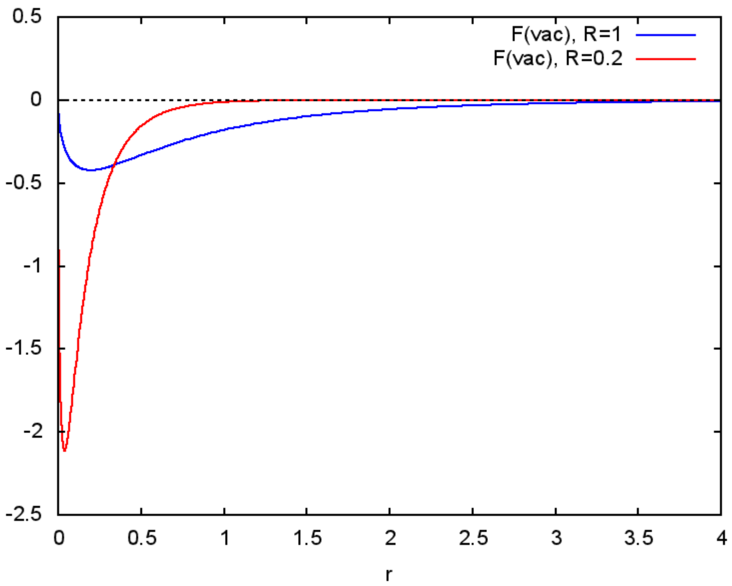

Figure 4: Vacuum force of exponential functions m(r).

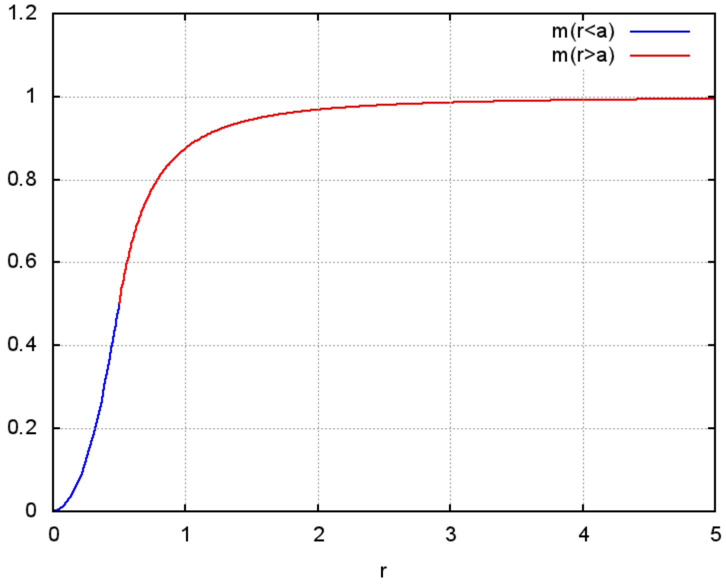

Figure 5: m function composed of terms r^2 and $1/r^2$.

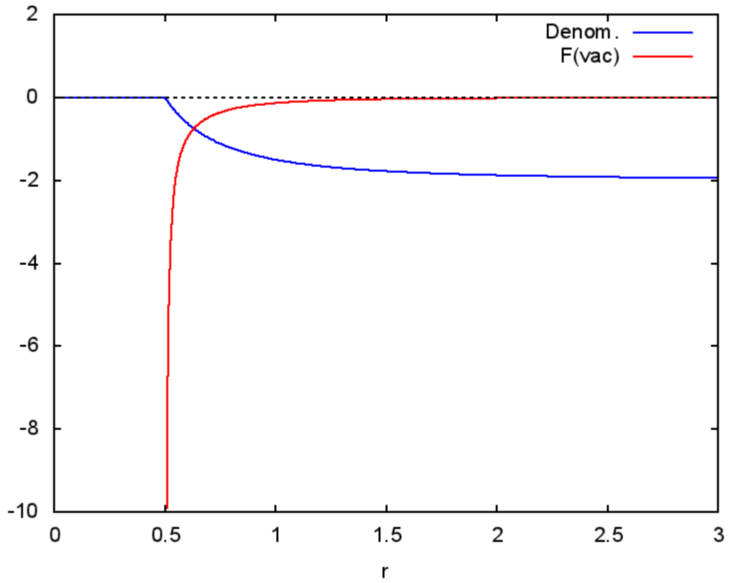

Figure 6: Denominator of vacuum force and vacuum force of composite m function from Fig. 5.

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.

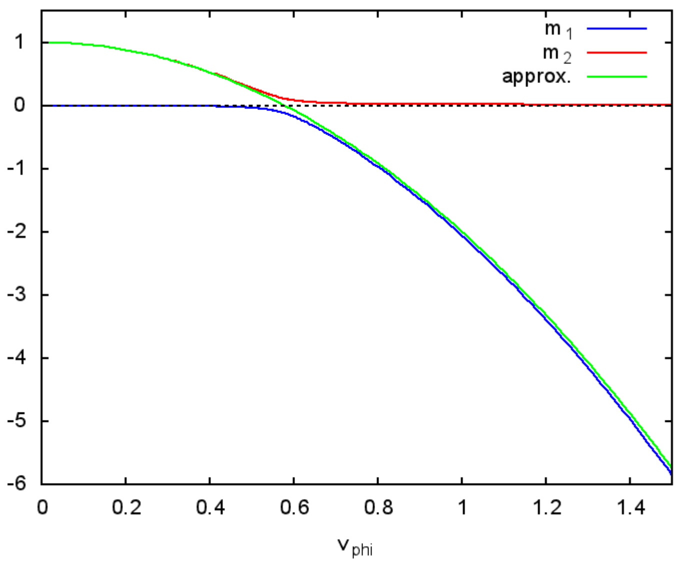

Figure 7: m functions for forward precession and approximation for small velocities.

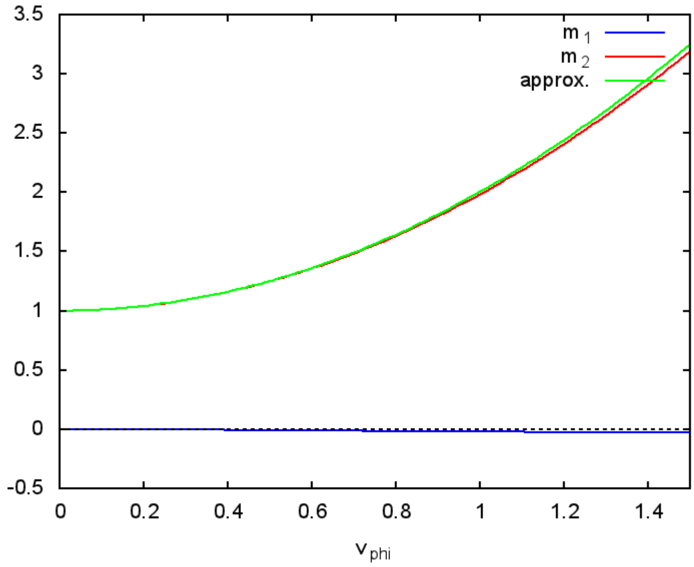

Figure 8: m functions for retrograde precession and approximation for small velocities.

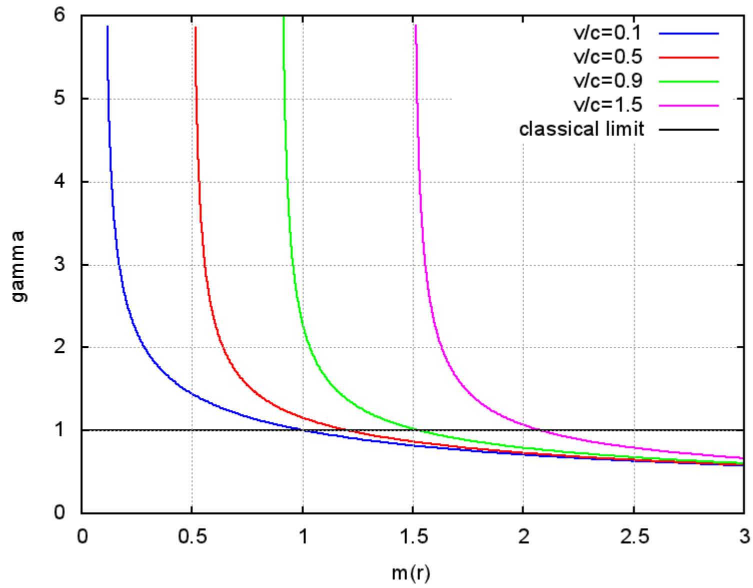

Figure 9: Generalized gamma factor in dependence of m(r) for some values of v/c.

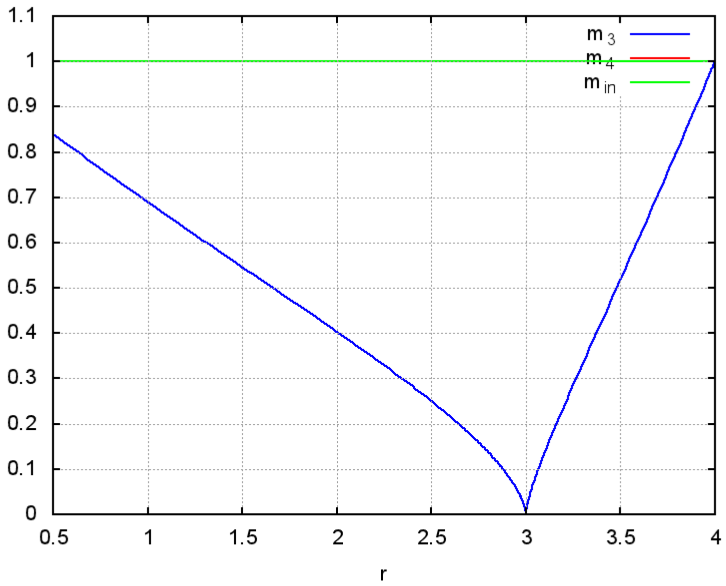

Figure 10: Solutions of the quartic equation with $\mathrm{m}(r) = 1$.

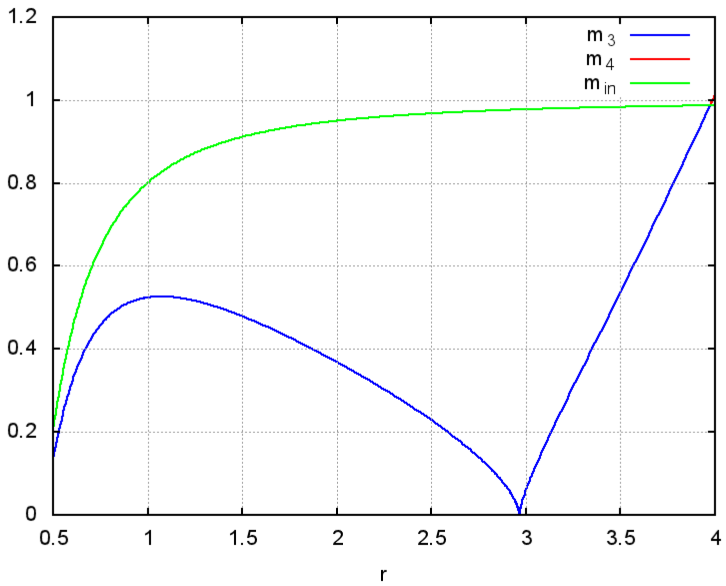

Figure 11: Solutions of the quartic equation with $\mathrm{m}(r) = 1 - 0.5/r^2$.