Dark stars, escape velocities and light deflection in m theory

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Abstract

Dark stars are astronomical objects with heavy masses so high that no mass and even no light should escape. In this paper we apply the dynamics of m theory to such objects. First, the equations of Evans-Eckardt theory are shown to be identical to those of Lagrangian m theory. Then, escape velocities are computed for Newtonian theory, special relativity and generally relativistic m theory. A new view of deflection of light is developed, based on m theory. In contrast to special relativity, light quanta with a rest mass can be described by m theory. For the first time, it becomes possible to compute the trajectories of light by standard dynamical methods. As a result, the interaction of light with spacetime is different than known for ordinary matter. While for ordinary matter we have m≈1, light can be described consistently with an m value of the "golden ratio" m=1.618. This has implications for the structure of photons.

Keywords: ECE theory, equations of motion, dark star, escape velocity, light deflection.

1 Introduction

In astronomy, the opinion has prevailed that a black hole is located in the center of each galaxy. The mass of such objects is at least one million sun masses. Therefore, we can speak of very heavy objects. In the common understanding, such objects are black holes, which means that nothing can escape from their surfaces (if they exist), not even light. By ECE theory [1–3] and other authors [4, 5] has been shown that the mathematical description of black holes is erroneous. Therefore, the question is open again, whether anything can escape from such massive stars.

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Within the framework of ECE theory, m theory has been developed for describing effects of general relativity in a centrally symmetric spacetime [7]. Space is deformed around masses, as is assumed in Einstein's theory, but the description is based on the generally relativistic line element, not on the Einstein field equation. Thus, generally relativistic dynamics can be applied, and there is no restriction to only one field-generating object as in Einstein's theory. The motion of the S2 star around Sagittarius A*, the center of our galaxy, has been successfully described in this way [8]. In earlier papers, we developed the equations of Evans-Eckardt theory by requesting conservation of energy and angular momentum in a centrally symmetric spacetime. Here, we give arguments that the resulting equations of motion are identical to those of Lagrangian m theory. This was not clear in our preceding work.

An often-discussed question is, which objects can escape from a heavy star. In standard theory an event horizon is purported to exist, although this is an artifact of the Schwarzschild solution for black holes. In m theory, such an event horizon does not exist a priori (although it could be constructed by the theory artificially [10]), and escape velocities alone are required to decide if an object can move away from a heavy mass or not. This even holds for light.

In section 2, we derive the escape velocities for Newtonian theory, special relativity and m theory. We consider the special case of light, for which special relativity cannot be applied, if a rest mass of light quanta exists. In contrast, m theory is able to handle this case for $\mathrm{m}(r) > 1$. We show that for light the value of m must be quite large, it is the "golden ratio" 1.61803. In section 3 we demonstrate how Lagrangian m theory is able to predict the trajectories of light. We are able to compute the deflection angle of light grazing the sun. This is the first time the dynamical motion of light can be computed directly from a theory of relativistic dynamics. The result is in agreement with the experimental value within 2%.

We follow the original accompanying notes 1-4 of this UFT paper (numbered originally no. 438) by Myron Evans. His comment on the dynamical computation of light deflection in note 438(4) was the last scientific statement he left us: *This theory can now be improved by solving Eqs. [(6-7)] without using the Newtonian approximation at all. This would be an extension of the calculations carried out in note 438(3) for the dark star.*

2 Orbits around a heavy mass

2.1 Equations of motion

Two approaches have been used for describing the equations of motion in m theory: the Lagrangian method and the Evans-Eckardt equations [9]. The latter are based on conservation of energy and angular momentum in a 2-dimensional space with polar coordinates. The conservation equations are

$$\frac{dH}{dt} = 0, \quad \frac{dL}{dt} = 0 \tag{1}$$

for the Hamiltonian H and angular momentum L. From these equations follow the equations of motion which can be formulated in two coordinate systems of m space: the rest system of the orbiting mass (r_1, ϕ) and the observer system

(r, ϕ), where r_1 and r are the radial coordinates and ϕ is the azimuthal angle. Here we use the observer coordinates exclusively. Then the Hamiltonian of m theory is

$$H = \mathrm{m}(r)\gamma\, m\, c^2 - \frac{mMG\sqrt{\mathrm{m}(r)}}{r}, \tag{2}$$

and the angular momentum is

$$L = \frac{\gamma\, m\, r^2\, \dot{\phi}}{\mathrm{m}(r)}, \tag{3}$$

with central mass M, orbiting mass m, Newton's gravitational constant G and the radial m function $\mathrm{m}(r)$. The generalized γ factor of m theory is

$$\gamma = \left(\mathrm{m}(r) - \frac{\dot{r}^2 + r^2\dot{\phi}^2}{c^2\, \mathrm{m}(r)} \right)^{-1/2}. \tag{4}$$

Alternatively, the equations of motion can be derived from the the Lagrangian

$$\mathscr{L} = -\frac{mc^2}{\gamma} + \frac{mMG\sqrt{\mathrm{m}(r)}}{r} \tag{5}$$

with the same γ factor.

In UFT 420 [9] it was found that both methods lead to slightly different equations of motion concerning the relativistic terms. We stated that the Evans-Eckardt approach is more fundamental than the Lagrange method because the Lagrangian has to be defined suitably so that the correct equations of motion are obtained and, consequently, has a certain ambiguity. For this paper, we have worked out the Evans-Eckardt equations of motion by a different code and found that the results are identical to those of the Lagrange method. In both cases, Eqs. (1) were evaluated. Currently, the reason for the differing result is not clear. It may be a coding error or a problem of the computer algebra system itself. Since both the Lagrangian and Evans-Eckardt approach describe the same physical situation, it can be argued that the results of both methods should be identical. Therefore, we use the results of the Euler-Lagrange equations throughout this paper. This relativises some statements of preceding papers where the differences between both methods were discussed and interpreted in a certain way, for example in form of constraints for the m function.

The equations of motion for an object moving in general-relativistic m space are:

$$\boxed{\begin{aligned}\ddot{\phi} =&\dot{\phi}\,\dot{r}\left(\frac{1}{\mathrm{m}\,(r)}\frac{d\,\mathrm{m}\,(r)}{dr}\left(2-\frac{GM}{2\gamma\,c^2\,r\sqrt{\mathrm{m}\,(r)}}\right)\right. \qquad (6)\\ &\left.+\frac{GM}{\gamma\,c^2\,r^2\sqrt{\mathrm{m}\,(r)}}-\frac{2}{r}\right),\\ \ddot{r} =&\frac{d\,\mathrm{m}\,(r)}{dr}\left(-\frac{2\dot{\phi}^2\,r^2}{\mathrm{m}\,(r)}+c^2\left(\mathrm{m}\,(r)-\frac{3}{2\gamma^2}\right)+\frac{GM}{2\gamma^3 r\sqrt{\mathrm{m}(r)}}\right. \qquad (7)\\ &\left.+\frac{GM\dot{\phi}^2 r}{2\gamma\,c^2\mathrm{m}(r)^{3/2}}\right)\\ &-\frac{GM\,\dot{\phi}^2}{\gamma\,c^2\,\sqrt{\mathrm{m}\,(r)}}-\frac{GM\sqrt{\mathrm{m}\,(r)}}{\gamma^3\,r^2}+\dot{\phi}^2\,r.\end{aligned}}$$

They are independent of the orbiting mass m and turn into the Newtonian equations for $c\to\infty$, $\mathrm{m}(r)\to 1$.

2.2 Escape velocity

The escape velocity of a mass m from a heavy gravitating mass M is found from the conservation of energy:

$$T_i + U_i = T_f + U_f \tag{8}$$

with kinetic energy T, potential energy U and indices i and f for initial and final states. In the Newtonian case, a mass m has the initial kinetic and potential energy

$$T_i = \frac{1}{2}mv^2, \tag{9}$$

$$U_i = -\frac{mMG}{r}, \tag{10}$$

and after escaping from the central mass it is $v=0$, $r\to\infty$, i.e.,

$$T_f = U_f = 0. \tag{11}$$

Therefore, the escape velocity is

$$v_{\mathrm{esc}} = \left(\frac{2MG}{r_0}\right)^{1/2}, \tag{12}$$

where the escaping mass starts at the radius r_0. For a dark star, we have

$$M\to\infty, \tag{13}$$

so the escape velocity approaches infinity. In Newtonian dynamics, no object can escape a dark star.

In special relativity, it is

$$T_i + U_i = \gamma mc^2 - \frac{mMG}{r}, \tag{14}$$

$$T_f + U_f = mc^2, \tag{15}$$

because the rest energy enters the calculation. The γ factor is

$$\gamma = \left(1 - \frac{v^2}{c^2}\right)^{-1/2}. \tag{16}$$

From Eq. (8) we have with start radius r_0:

$$(\gamma - 1)mc^2 = \frac{mMG}{r_0}. \tag{17}$$

The left-hand side is kinetic energy. It follows

$$\gamma = 1 + \frac{MG}{c^2 r_0}. \tag{18}$$

In the dark star with $M \to \infty$ we have

$$\frac{MG}{c^2 r_0} \to \infty, \tag{19}$$

so

$$\gamma \to \infty, \tag{20}$$

which means

$$v_{\mathrm{esc}} \to c. \tag{21}$$

The escape velocity in special relativity is the speed of light. However, at the speed of light, the relativistic total energy is

$$E = \gamma mc^2 \to \infty, \tag{22}$$

so infinite total energy is needed to escape from a dark star in the theory of special relativity.

In m theory, the energy balance equation (8) reads

$$\mathrm{m}(r)\gamma mc^2 - \mathrm{m}(r)^{1/2}\frac{mMG}{r} = \mathrm{m}(r)^{1/2} mc^2 \tag{23}$$

with the γ factor

$$\gamma = \left(\mathrm{m}(r) - \frac{v^2}{c^2\,\mathrm{m}(r)}\right)^{-1/2}. \tag{24}$$

On the left-hand side of Eq. (23) we have to insert the initial radius r_0. On the right-hand side, r approaches infinity. Assuming there an asymptotic value m_∞ for the m function, we obtain

$$\mathrm{m}(r_0)\gamma mc^2 - \mathrm{m}(r_0)^{1/2}\frac{mMG}{r_0} = {\mathrm{m}_\infty}^{1/2} mc^2, \tag{25}$$

which, resolved for γ, gives

$$\gamma = \frac{GM}{\mathrm{m}(r_0)^{1/2} c^2 r_0} + \frac{\mathrm{m}_\infty{}^{1/2}}{\mathrm{m}(r_0)}. \tag{26}$$

This is the generalization of (18), which was derived for special relativity. In a dark star with $M \to \infty$, we have $\gamma \to \infty$, so from (24):

$$\mathrm{m}(r) \to \frac{v^2}{c^2 \mathrm{m}(r)} \tag{27}$$

or

$$v \to \mathrm{m}(r) c. \tag{28}$$

In cases where $\mathrm{m}(r){>}1$, superluminal motion is possible, but for leaving a dark star, the required total energy

$$E = \gamma \mathrm{m}(r) m c^2 \tag{29}$$

becomes infinite. So, no object can leave a dark star in m theory. If there were an event horizon, we would have

$$\mathrm{m}(r) = 0 \tag{30}$$

and, consequently

$$v_{\mathrm{esc}} = 0 \tag{31}$$

which makes no sense. The Einsteinian event horizon of a black hole, described by

$$\mathrm{m}(r) = 1 - \frac{r_S}{r} \tag{32}$$

with Schwarzschild radius r_S, is meaningless, because at $r = r_S$ we have $v_{\mathrm{esc}} = 0$.

2.3 Gravitational light deflection

In ECE theory, light quanta have a small rest mass. Therefore, they can be analyze and modeled using gravitational theories. The conventional theory of deflection of light due to gravitation is based on the Newtonian velocity

$$v_{\mathrm{N}}^2 = MG \left(\frac{2}{R_0} - \frac{1}{a} \right), \tag{33}$$

where R_0 is the radius of the sun and a the half-right latitude of a hyperbolic orbit. Note that it is defined $a < 0$ for hyperbolic orbits. The Newtonian theory is summarized in Note 4 of this paper and was extended to m theory in UFT 419 [8]. In earlier papers (UFT 406 [6]), the orbital velocity of Newtonian theory v_{N} was related to the relativistic velocity v, which is the observed value, via a relativistic factor γ_N of special relativity:

$$v^2 = \frac{v_{\mathrm{N}}^2}{1 - \frac{v_{\mathrm{N}}^2}{c^2}} \tag{34}$$

which can be written as

$$v = \gamma_{\rm N} v_{\rm N} \tag{35}$$

with

$$\gamma_{\rm N} = \left(1 - \frac{v_{\rm N}^2}{c^2}\right)^{-1/2}. \tag{36}$$

It was shown [6] that, for Newtonian theory,

$$v_{\rm N}^2 = \frac{MG}{R_0}(1+\epsilon). \tag{37}$$

For light grazing the sun, the eccentricity ϵ is

$$\epsilon >> 1, \tag{38}$$

therefore

$$\epsilon \approx \frac{R_0 v_{\rm N}^2}{MG}. \tag{39}$$

Then the angle of light deflection at its closest approach to the sun is

$$\Delta\psi_{\rm N} \approx \frac{2}{\epsilon} = \frac{2MG}{R_0 v_{\rm N}^2}, \tag{40}$$

where R_0 is the radius of the sun. This value of Newtonian theory is only half the value observed experimentally. From (34) follows

$$v_{\rm N}^2 = \frac{v^2}{1+\frac{v^2}{c^2}}. \tag{41}$$

For the limit $v \to c$ we have

$$v_{\rm N}^2 \to \frac{c^2}{2} \tag{42}$$

and

$$\Delta\psi_{\rm exp} = \frac{4MG}{R_0 c^2}, \tag{43}$$

which is the experimentally observed value.

m theory can be used to explain the deviation of the factor $\gamma_{\rm N}$ (Eq. (36)) from the γ factor (16) of special relativity. In m theory, the general-relativistic γ factor is, according to Eq. (24),

$$\gamma = \left(\mathrm{m}(r) - \frac{v^2}{c^2\,\mathrm{m}(r)}\right)^{-1/2}. \tag{44}$$

To allow the case $v = c$, we must have $\mathrm{m}(r)>1$, otherwise the γ factor would diverge for $v \to c$. To fulfill Eq. (35) for the case $v = c$, we must require with the γ factor of m theory:

$$\gamma^2(v\to c)\ v^2(v\to c) = \gamma_{\rm N}^2(v\to c)\ v_{\rm N}^2(v\to c), \tag{45}$$

which means $\gamma = 1$ and leads to

$$\frac{c^2}{\mathrm{m} - \frac{1}{\mathrm{m}}} = \frac{c^2}{2(1 - \frac{1}{2})} \tag{46}$$

or

$$\mathrm{m} - \frac{1}{\mathrm{m}} = 1, \tag{47}$$

where we have assumed that $\mathrm{m}(r)$ is constant. This is a quadratic equation for m with solutions

$$m_{1,2} = \frac{1}{2}\left(1 \pm \sqrt{5}\right), \tag{48}$$

numerically:

$$\mathrm{m}_1 = -0.61803, \quad \mathrm{m}_2 = 1.61803, \tag{49}$$

which is exactly the golden ratio Φ:

$$\mathrm{m}_1 = -(\Phi - 1), \quad \mathrm{m}_2 = \Phi. \tag{50}$$

This is a startling result. m_2 can be inserted into the Lagrange equation set (6-7). The results are discussed in the next section.

For photons, this means $\gamma = 1$ in m theory. Then the energy of a photon with rest mass m_0 is

$$E = \hbar\omega = \mathrm{m}(r)\gamma m_0 c^2 = \Phi m_0 c^2. \tag{51}$$

The rest energy $m_0 c^2$ is increased by a factor of Φ and the rest mass depends on the wave energy $\hbar\omega$. The photon momentum is

$$p = \frac{E}{c} = \Phi m_0 c. \tag{52}$$

The photon with mass fits into the frame of general-relativistic theory, for example via the Proca equation [2, 3]. In contrast to special relativity, there is no problem with the γ factor for $v \to c$.

3 Computational results and discussion

First, we compare escape velocities of different theories in dependence of the central mass M. The mass of the sun is about $2 \cdot 10^{30}$ kg. The graph in Fig. 1 starts at about this value. The escape velocities are quite small there, compared to the velocity of light of about $3 \cdot 10^8$ m/s. It is seen that this region is reached for $M > 10^{36}$ kg which is the order of magnitude of Sagittarius A*, the center of the milky way. For the three theories, the escape velocities are

$$v_{\mathrm{Newton}} = \sqrt{\frac{2GM}{r}}, \tag{53}$$

$$v_{\mathrm{s-r}} = \frac{c}{c^2 r + GM}\sqrt{\frac{GM(2c^2 r + GM)}{c^2 r + GM}}, \tag{54}$$

$$v_{\mathrm{m-theory}} = \mathrm{m}(r)\frac{c}{c^2 r + GM}\sqrt{\frac{GM(2c^2 r + GM)}{c^2 r + GM}} \tag{55}$$

These are obtained from Eqs. (12), (18) and (26), where the γ factor has been inserted and the equations been resolved for v. All velocities are calculated for the doubled radius of the sun: $r = 2 \cdot 6.95508 \cdot 10^8$ m. In case of m theory, we have assumed a constant value of $\mathrm{m}(r) = \mathrm{m}_\infty = 1.1$. Therefore, we obtain a limit $v > c$ for $M \to \infty$. The value of special relativity appraches c, and the Newtonian escape velocity increases beyond all limits.

The second graph shows the escape radii in dependence of the central mass, each computed for the escape velocity $v = c$. The escape radii are obtained from the inverted formulas (53-55):

$$r_{\mathrm{Newton}} = \frac{2GM}{c^2}, \tag{56}$$

$$r_{\mathrm{s-r}} = 0, \tag{57}$$

$$r_{\mathrm{m-theory}} = \frac{GM}{c^2}\left(\pm \mathrm{m}(r)\sqrt{\mathrm{m}(r)^2 - 1} - 1\right). \tag{58}$$

There are two solutions for m theory. As can be seen from Fig. 2, The Newtonian value grows infinitely, as does the positive solution of m theory. The other solution is always negative and unphysical. Obviously, there is always an escape radius for $v = c$ in m theory, as far as m>1. For m<1, the square root term becomes imaginary, and there is no escape at this velocity. For special relativity, there is always $r_{\mathrm{esc}} = 0$, i.e., the mass could escape from any radius, but this would require infinite energy. For m theory, we have shown that m>1 and, according to Eq. (28), light cannot escape from any heavy star, as long as the local value of $\mathrm{m}(r)$ does not diminish the effective m below unity.

The subsequent results were obtained by solving the Lagrangian equations of motion (6-7). The orbits around a heavy mass were studied, where the mass has been increased stepwise. We used a model system with arbitrary units and an exponential $\mathrm{m}(r)$ as in earlier papers. The initial values were kept the same for all calculations. For not too heavy masses M, the orbit is near to an ellipse. Increasing M means growing precession effects. Both can be seen from Fig. 3. When M is increased further, the orbiting mass spirals into the center, see Fig. 4. It arrives gently with $v = 0$. This behaviour is obtained from m theory only. Such examples were already considered in earlier papers. The central mass attracts matter with no return like a black hole. Light, however, could escape, if the space contraction through the mass is so high that there is an effective value of the m function of m<1. With $\mathrm{m}_{\mathrm{light}} \approx 1.6$ the m value of the heavy mass would have to be $\mathrm{m} < 0.4$ at the surface.

By application of the equations of motion (6-7), it is possible to compute the trajectories of photons by a classical theory. With special relativity, this is not possible, because the γ factor diverges for $v \to c$. Within m theory, however, $v = c$ is possible for m>1. The scales within such calculations require special adaptations because the masses and velocities are quite high. For computing the orbit of the S2 star, we had used adapted units (see Table 3 of UFT 375). Here we applied the same units. The length, for example, is measured in 10^{-9}m. Using the golden ratio value of m from Eq. (49), we obtain the orbit graphed in Fig. 5. Please notice that the photon moves from right to left, the sun is at $x = 0$. Since the angle of deflection is so small, the y axis had to be adapted.

m	$\Delta\psi$
1.28	$4.29 \cdot 10^{-6}$
1.43	$6.14 \cdot 10^{-6}$
1.57	$7.99 \cdot 10^{-6}$
1.61803	$8.65 \cdot 10^{-6}$
1.78	$11.0 \cdot 10^{-6}$
exp.	$8.48 \cdot 10^{-6}$

Table 1: Deflection angle of light $\Delta\psi$ for several values of m function.

The deflection angle is approximately determined by

$$\Delta\psi = -\frac{\Delta y}{\Delta x}, \tag{59}$$

where Δx is measured from $x = 0$. The result is precise when the negative x value is far enough away from the center. The computed dependence of the deflection angle on x is shown in Fig. 6. The asymptotic value is $8.65 \cdot 10^{-6}$ radians, compared to the experimental value of $8.48 \cdot 10^{-6}$. This is coincidence within 2% and shows very good conformance. To see how this value depends on the m value, we have varied the m value in a wider range as presented in Table 1. It is seen that there is a significant variation of $\Delta\psi$ with m. The orbit calculation of a photon grazing the sun impressively proves the m value, having been computed analytically for an effective constant m function.

From earlier results of m theory (for example for the S2 star), we know that we have to expect m≈1 for ordinary matter. The value of m for photons is far above this range. Since our numerical calculation has impressively confirmed the analytical result, we are lead to the conclusion that light (or electromagnetic radiation in general) shows a different interaction with the spacetime or background field, compared to dense matter. This may be explained by the fact that the mass of the photon is expanded in any form over space. In electrodynamics, light is often modeled by plane waves which are even infinitely extended in theory. A spatial restriction is possible, leading to wave packets as in quantum mechanics. For photons, space appears "less dense" than for ordinary matter. All of these results have been obtained from a classical theory, without quantum effects being taken into account.

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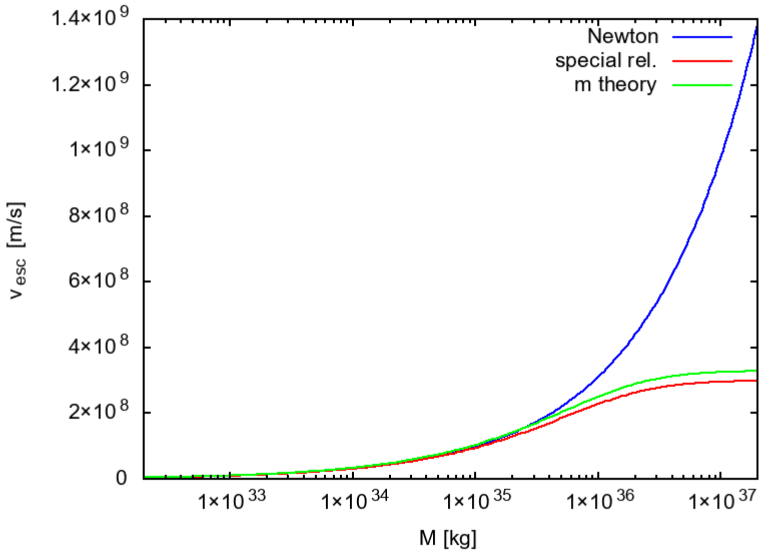

Figure 1: Escape velocities from different theories.

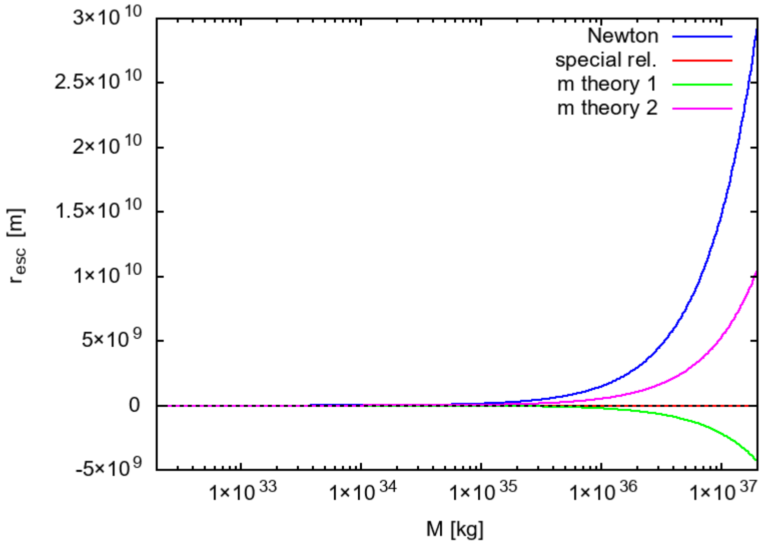

Figure 2: Escape radii from different theories.

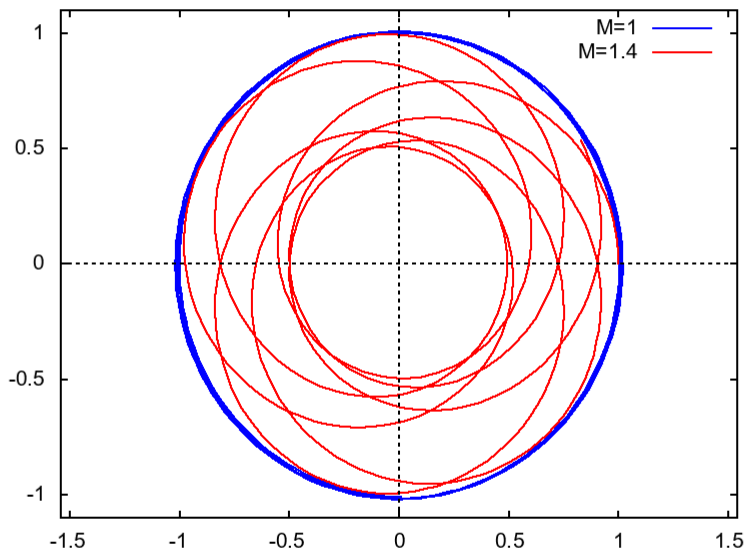

Figure 3: Orbits around a heavy mass, modest M values.

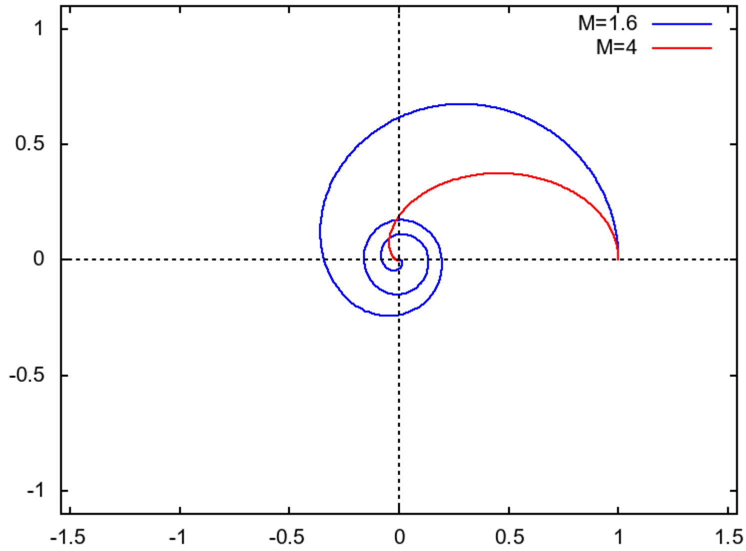

Figure 4: Orbits around a heavy mass, high M values.

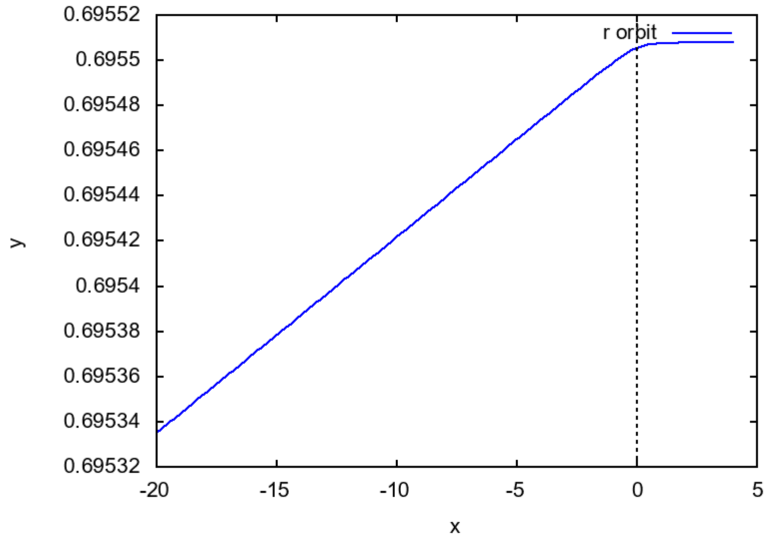

Figure 5: Orbit of light grazing the sun, $v = c$, moving from right to left (please notice the y scale).

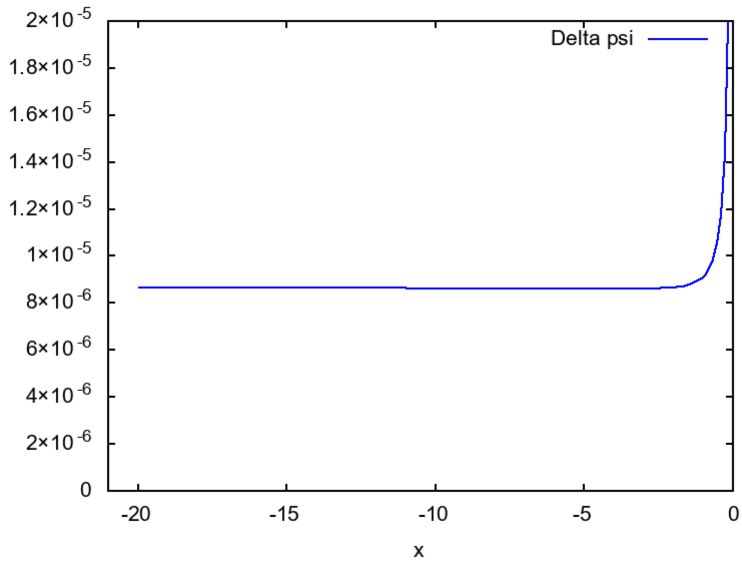

Figure 6: Deflection angle $\Delta\psi = -\Delta y/\Delta x$ of light grazing the sun, moving from right to left.