

DEVELOPMENT OF m THEORY PART ONE: RELATIVISTIC KINETIC ENERGY,
EINSTEIN ENERGY EQUATION, AND POTENTIAL ENERGY DUE TO $m(r)$.

by

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ABSTRACT

The systematic development is initiated of classical dynamics in the most general spherically symmetric spacetime (m space). The Einstein energy equation, the rest energy, the relativistic kinetic energy and the potential energy due to $m(r)$ (the energy due to spacetime, vacuum or aether) are derived systematically. Rigorous self consistency of concepts and methods is demonstrated.

Keywords: Development of m theory, relativistic kinetic energy, Einstein energy equation, rest energy, potential energy from $m(r)$.

UFT 418

1. INTRODUCTION

In the immediately preceding paper (UFT417) of this series {1 - 41}, the natural philosophy (m theory) was initiated of the most general spherically symmetric spacetime (m space). It was shown that in that type of naturally philosophy or physics, superluminal signalling, infinite energy from m space, and counter gravitation are rigorously possible. In Section 2 of this paper the m theory is developed systematically in classical dynamics to derive the relativistic kinetic energy the Einstein energy equation, the rest energy, and potential energy from m (r). The latter is defined by the infinitesimal line element of m space. The rigorous self consistency of concepts and methods is demonstrated in several complementary ways.

This paper is a brief synopsis of extensive calculations found in the notes accompanying UFT418 on www.aias.us. Note 418(1) defines the classical limit of the hamiltonian and lagrangian of m theory, which is part of the ECE and ECE2 generally covariant unified field theory. Note 418(2) is a demonstration of the rigorous self consistency of the Hamiltonian and Lagrangian methods used in m theory. Note 418(3) the flat spacetime limit, the work integral and begins the derivation of the relativistic kinetic energy in m space. Note 418(4) derives the relativistic kinetic energy of m space from the work integral over the relativistic momentum of m space. Note 418(5) is a convenient summary of m space classical dynamics, a demonstration of the rigorous self consistency of the Lagrangian method used in m space, a derivation of the ECE2 spin connection from m theory and initial development of a concept unique to m theory: the potential energy of m space. This is the rigorous definition of “energy from spacetime”, “vacuum energy”, or “aether energy”. Note 418(6) derives the Einstein energy equation of m space from its relativistic linear momentum. This method also derives the rest energy of m space. Notes 418(7) and 418(8) give a rigorously self consistence derivation of the important potential energy due to m space (“the energy of the vacuum”).

In Section 3, the calculations and concepts of Section 2 are analysed numerically and graphically, so that the meaning of the complicated mathematics becomes clear.

2. FUNDAMENTAL CONCEPTS

The frame of reference used in m theory is $(\underline{r}_1, \dot{\phi})$, which is a self consistent development of the plane polar coordinates $(\underline{r}, \dot{\phi})$. Here:

$$\underline{r}_1 = \frac{\underline{r}}{m(r)^{1/2}} \quad - (1)$$

where the $m(r)$ function is defined by the infinitesimal line element of the most general spherically symmetric spacetime:

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

Here τ is the proper time and c the speed of light in vacuo, taken to be a universal constant. The hamiltonian of m theory is:

$$H = \gamma m(r_1) mc^2 - \frac{mM\Gamma}{r_1} \quad - (3)$$

where the potential energy of interaction of a mass m orbiting a mass M is:

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

Here

$$\gamma = \left(m(r_1) - \frac{\underline{r}_1 \cdot \dot{\underline{r}}_1}{c^2} \right)^{-1/2} \quad - (5)$$

is the Lorentz factor in m space {1 - 41}. The lagrangian of m space is:

$$\mathcal{L} = -mc^2 \left(m(r_1) - \frac{1}{c^2} \frac{\dot{\underline{r}}_1 \cdot \dot{\underline{r}}_1}{1} \right)^{1/2} + \frac{mM\Gamma}{r_1} \quad - (6)$$

It is shown in Note 418(2) and 418(5) that the vector Euler Lagrange equation:

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

is rigorously equivalent to the scalar Euler Lagrange equations:

$$\frac{d}{dt} \frac{\partial \mathcal{L}}{\partial \dot{r}_1} = \frac{\partial \mathcal{L}}{\partial r_1} \quad - (8)$$

and

$$\frac{d}{dt} \frac{\partial \mathcal{L}}{\partial \dot{\phi}} = \frac{\partial \mathcal{L}}{\partial \phi} \quad - (9)$$

where:

$$\underline{\dot{r}}_1 \cdot \underline{\dot{r}}_1 = \dot{r}_1^2 + r_1^2 \dot{\phi}^2 \quad - (10)$$

Eq. (9) gives the conserved angular momentum of m theory:

$$L = \frac{\partial \mathcal{L}}{\partial \dot{\phi}} = \gamma_m r_1^2 \dot{\phi} \quad - (11)$$

so that:

$$\frac{dL}{dt} = 0 \quad - (12)$$

The hamiltonian of m theory is conserved, so:

$$\frac{dH}{dt} = 0 \quad - (13)$$

The equations of motion of m theory are therefore:

$$\frac{dH}{dt} = 0 \quad - (14)$$

and

$$\frac{dL}{dt} = 0 \quad - (15)$$

These are rigorously consistent with the equations of motion from the lagrangian of m theory. In the preceding paper (UFT417) it was shown that the hamiltonian, lagrangian and equations of motion give forward and retrograde precession of orbits, shrinking orbits, the possibility of expanding orbits and counter gravitation, superluminal signalling and infinite potential energy from $m(r)$. These are major advances in classical dynamics.

The relativistic kinetic energy of m theory is evaluated from the work integral:

$$W_{12} = T_2 - T_1 = \int_1^2 \underline{F}_1 \cdot d\underline{r} \quad - (16)$$

from state 1 to state 2. The force in m theory is:

$$\underline{F}_1 = \frac{d\underline{p}_1}{dt} = \frac{d}{dt} (\gamma m \dot{\underline{r}}_1) \quad - (17)$$

where γ is the Lorentz factor of m theory, first derived in immediately preceding papers.

If the initial state is for a particle at rest, and the final state for a particle with velocity v_1 ,

the relativistic kinetic energy of m theory is:

$$W = T = \int \frac{d}{dt} (\gamma m \dot{\underline{r}}_1) \cdot \underline{r}_1 dt = m \int_0^{v_1} \gamma v_1 d(\gamma v_1) \quad - (18)$$

Integrating by parts:

$$\int_0^{v_1} \gamma v_1 d(\gamma v_1) = \gamma v_1^2 - \int_0^{v_1} \gamma v_1 dv_1 \quad - (19)$$

where

$$\gamma = \left(m(r_1) - \frac{v_1^2}{c^2} \right)^{-1/2} \quad - (20)$$

It follows that:

$$m \int_0^{v_1} \gamma_{v_1} dv_1 = -mc^2 \left(m(r_1) - \frac{v_1^2}{c^2} \right)^{1/2} \Big|_0^{v_1} \quad (21)$$

because:

$$\frac{d}{dv_1} \left(m(r_1) - \frac{v_1^2}{c^2} \right)^{1/2} = -\frac{v_1}{c^2} \left(m(r_1) - \frac{v_1^2}{c^2} \right)^{-1/2} \quad (22)$$

It has been assumed that:

$$\frac{dm(r_1)}{dv_1} = 0 \quad (23)$$

The reason for this is that the general spherically symmetric spacetime is:

$$ds^2 = g_{aa}(a,b) da^2 + g_{ab}(a,b) (da db + db da) + g_{bb}(a,b) db^2 + r^2(a,b) d\Omega^2 \quad (24)$$

in spherical polar coordinates. Here a and b are coordinates and $r^2(a,b)$ is an

undetermined function. The coordinate function $m(r_1)$ therefore does not depend on the

velocity v_1 of a particle, and Eq. (22) follows.

From Eq. (21):

$$m \int_0^{v_1} \gamma_{v_1} dv_1 = m \gamma_{v_1} + mc^2 \left(m(r_1) - \frac{v_1^2}{c^2} \right)^{1/2} \Big|_0^{v_1} \quad (25)$$

Therefore the relativistic kinetic energy of m space is:

$$T = \gamma m v_1^2 + \frac{mc^2}{\gamma} - m(r_1)^{1/2} mc^2 \quad (26)$$

From the generalized Lorentz factor (20):

$$v_1^2 = c^2 \left(m(r_1) - \frac{1}{\gamma^2} \right) \quad (27)$$

so:

$$T = \gamma mc^2 \left(m(r_i) - \frac{1}{\gamma^2} \right) + \frac{mc^2}{\gamma} - m(r_i)^{1/2} mc^2$$

$$= m(r_i) \gamma mc^2 - m(r_i)^{1/2} mc^2 \quad (28)$$

From the infinitesimal line element (2) the total relativistic energy in m space is:

$$E = m(r_i) \gamma mc^2 \quad (29)$$

Therefore the relativistic kinetic energy in m space is:

$$T = E - m(r_i)^{1/2} mc^2 \quad (30)$$

The Einstein energy equation in m space is found from the relativistic linear momentum in m space:

$$\underline{p}_i = \gamma m \underline{v}_i = \gamma m \underline{\dot{r}}_i \quad (31)$$

From Eq. (31):

$$p_i^2 c^2 = \gamma^2 m^2 v_i^2 c^2 = \gamma^2 m^2 c^4 \frac{v_i^2}{c^2} \quad (32)$$

where

$$\frac{v_i^2}{c^2} = m(r_i)^2 - \frac{1}{\gamma^2} \quad (33)$$

from the Lorentz factor of m space, Eq. (20). It follows that:

$$p_i^2 c^2 = \gamma^2 m^2 c^4 \left(m(r_i)^2 - \frac{1}{\gamma^2} \right) \quad (34)$$

and:

$$E^2 = p_1^2 c^2 + E_0^2 \quad - (35)$$

which is the Einstein energy equation in m space, Q. E. D. Here

$$E_0 = mc^2 \quad - (36)$$

is the rest energy in m space. Defining the four momentum:

$$p_1^\mu = \left(\frac{E}{c}, \underline{p}_1 \right) \quad - (37)$$

the Einstein energy equation in m space becomes:

$$p_1^\mu p_{1\mu} = m^2 c^4 \quad - (38)$$

This is an equation of ECE and ECE2 generally covariant unified field theory and can be quantized to a wave equation and related to the tetrad postulate of Cartan geometry.

The classical dynamics of m space can be developed using the force equation:

$$\underline{F}_1 = \frac{dp_1}{dt} = - \left(\frac{mc^2}{2} \gamma \frac{dm(r_1)}{dr_1} - \frac{mM\gamma}{r_1^2} \right) \underline{e}_r \quad - (39)$$

which is the direct result of the Euler Lagrange equation (7) with the m space lagrangian

(6). This contains the new force term:

$$\underline{F} = - \frac{mc^2}{2} \gamma \frac{dm(r_1)}{dr_1} \underline{e}_r \quad - (40)$$

which in UFT417 was defined as the vacuum force. In the (r, ϕ) coordinate system:

$$\underline{F} = mc^2 \left(\frac{\gamma m(r) \frac{3}{2}}{r \frac{dm(r)}{dr} - 2m(r)} \right) \frac{dm(r)}{dr} \underline{e}_r \quad - (41)$$

and the vacuum force goes to infinity when:

$$r \frac{dm(r)}{dr} = 2m(r). \quad - (42)$$

Using the work theorem:

$$T_2 - T_1 = U_1 - U_2 = -\frac{mc^2}{2} \int_1^2 \gamma \frac{dm(r_i)}{dr_i} dr_i \quad - (43)$$

as usual in classical dynamics. Here:

$$\Delta U = U_1 - U_2 \quad - (44)$$

is the change in potential energy. In flat spacetime:

$$\frac{dm(r_i)}{dr_i} = 0 \quad - (45)$$

so:

$$\Delta U = 0 \quad - (46)$$

From Eq. (43), total energy is conserved:

$$T_1 + U_1 = T_2 + U_2. \quad - (47)$$

The change in potential energy due to the vacuum force is therefore:

$$\Delta U = -\frac{mc^2}{2} \int_1^2 \gamma dm(r_i) = -\frac{mc^2}{\gamma} \Big|_1^2 \quad - (48)$$

If it is assumed that the initial state is that of a particle at rest:

$$v_1 = 0 \quad - (49)$$

then:

$$\Delta U = -mc^2 \left(\left(m(r_1) - \frac{v_1^2}{c^2} \right)^{1/2} - m(r_1) \right) - (50)$$

Note carefully that this is non-zero if and only if:

$$\frac{dm(r_1)}{dr_1} \neq 0. \quad - (51)$$

In the classical limit:

$$v_1 \ll c \quad - (52)$$

the change in potential energy due to $m(r_1)$ is:

$$\Delta U = -mc^2 m(r_1)^{1/2} \left(\left(\frac{1 - v_1^2}{m(r_1)c^2} \right)^{1/2} - 1 \right) \rightarrow \frac{1}{2} \frac{m v_1^2}{m(r_1)^{1/2}} \quad - (53)$$

and in the limit of flat spacetime:

$$T = \Delta U \rightarrow \frac{1}{2} m v^2 \quad - (54)$$

in the usual (r, ϕ) coordinate system.

The velocity v can be thought of as that of a vacuum particle, and is imparted to the material particle of mass m by the fact that:

$$dm(r_1)/dr_1 \neq 0. \quad - (55)$$

Integrating by parts as in Note 418(8):

$$\int \gamma \frac{dm(r_1)}{dr_1} dr_1 = \gamma m(r_1) - \int m(r_1) d\gamma. \quad - (56)$$

The function $dm(r_1)/dr_1$ becomes infinite at:

$$r \frac{dm(r)}{dr} = 2m(r). \quad - (57)$$

Self consistently from Eq. (56), in the flat spacetime limit of:

$$\frac{dm(r_1)}{dr_1} = 0 \quad - (58)$$

it follows that:

$$r \rightarrow \infty \quad - (59)$$

From Eq. (56), the condition (59) can be satisfied by:

$$m(r_1) = \frac{r_1^2}{c^2} \quad - (60)$$

i. e.

$$m(r) = \frac{r^2}{c^2} \cdot \frac{1}{m(r)} \quad - (61)$$

In the (r, ϕ) coordinate system this means:

$$m(r) = \frac{r}{c} \quad - (62)$$

3. NUMERICAL ANALYSIS AND GRAPHICS

Development of m theory part one: relativistic kinetic energy, Einstein energy equation, and potential energy due to $m(r)$

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3 Numerical analysis and graphics

3.1 Possibility for negative $m(r)$

First we consider an extension of the m function to negative values. In UFT 417, Fig. 9, the dependence of the generalized γ factor on the m function was shown for a positive range of $m(r)$. The ratio v/c had been taken as a parameter. The γ factor diverges for $m(r) \rightarrow 0$ as found in the dynamics calculations. The point of divergence depends on the ratio v/c , and superluminal motion is possible.

In this paper we show that the generalized γ factor

$$\gamma = \frac{1}{\sqrt{m(r) - \frac{v^2}{m(r)c^2}}} \quad (63)$$

is not restricted to positive m values. Only the total argument of the square root must be positive, the summands below the square root are allowed to have any sign. This allows for negative m values in a certain range. As can be seen from Fig. 1, there are limits of m in dependence of v/c . Again superluminal motion is possible, and γ may take values smaller than unity.

3.2 Non-relativistic m theory

We derive the equations of motion based on m space in extension of the computer algebra work of UFT 415. The velocity of an orbiting object in observer space is

$$v^2 = \dot{r}^2 + r^2\dot{\phi}^2. \quad (64)$$

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According to note 418(1), the laws of motion can be formulated with m theory in a non-relativistic context, i.e. for $v \ll c$. the kinetic energy then is

$$T = \frac{1}{2} m \frac{v^2}{m(r)^{\frac{3}{2}}} \quad (65)$$

and the potential energy is

$$U = -\sqrt{m(r)} \frac{mMG}{r}. \quad (66)$$

Therefore the non-relativistic Lagrangian is

$$\mathcal{L} = \frac{m \left(\dot{r}^2 + \dot{\phi}^2 r^2 \right)}{2m(r)^{\frac{3}{2}}} + \sqrt{m(r)} \frac{mMG}{r}. \quad (67)$$

The resulting Euler-Lagrange equations are

$$\ddot{\phi} = \dot{r} \dot{\phi} \left(\frac{3}{2m(r)} \frac{dm(r)}{dr} - \frac{1}{r} \right), \quad (68)$$

$$\begin{aligned} \ddot{r} = & \frac{dm(r)}{dr} \left(\frac{3}{4m(r)} \left(\dot{r}^2 - r^2 \dot{\phi}^2 \right) + m(r) \frac{GM}{2r} \right) \\ & + r \dot{\phi}^2 - m(r)^2 \frac{GM}{r^2}. \end{aligned} \quad (69)$$

These contain corrections to the non-relativistic terms. The corrections depend on $m(r)$ and its derivative. As a numerical example we calculated the trajectories for the exponential m function

$$m(r) = 2 - \exp \left(\log(2) \exp \left(-\frac{r}{R} \right) \right), \quad (70)$$

see Fig. 3. The resulting orbit is a precessing ellipse (Fig. 3), that means that an m function effects precessing of the Newtonian ellipse, similar to other disturbances of a classical orbit. Accordingly, the angular momentum differs from the classical Newtonian value near to the centre (Fig. 4) and the same holds for the total energy (Fig. 5). Compared to the fully relativistic theory (Eqs. (53, 54) of UFT 416), quite large terms in the equations of motion have been neglected in non-relativistic m theory. Therefore it is doubtful if this is a meaningful approach. m theory is connected with relativity and should not be applied without this.

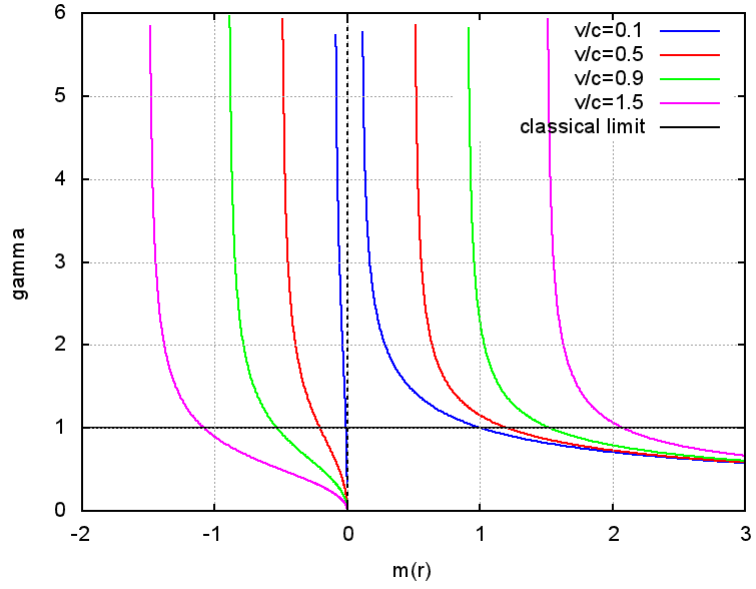


Figure 1: Generalized gamma factor in dependence of $m(r)$ for some values of v/c .

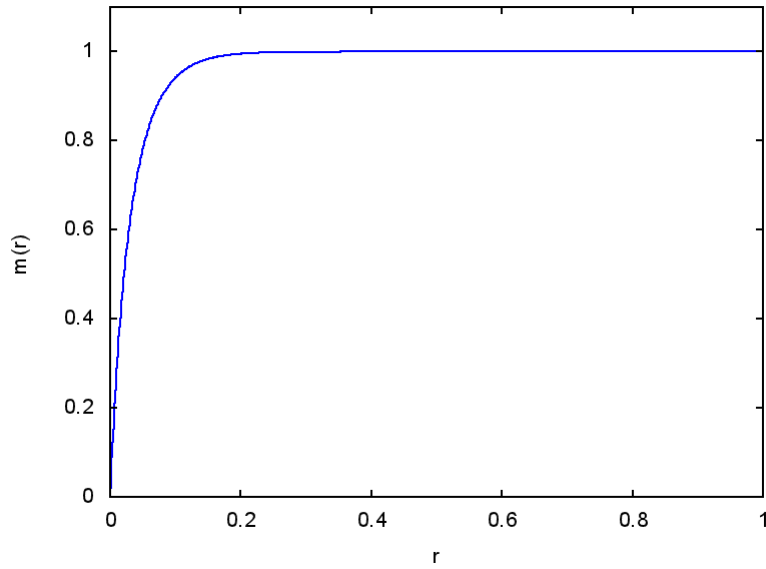


Figure 2: m function of the numerical model system.

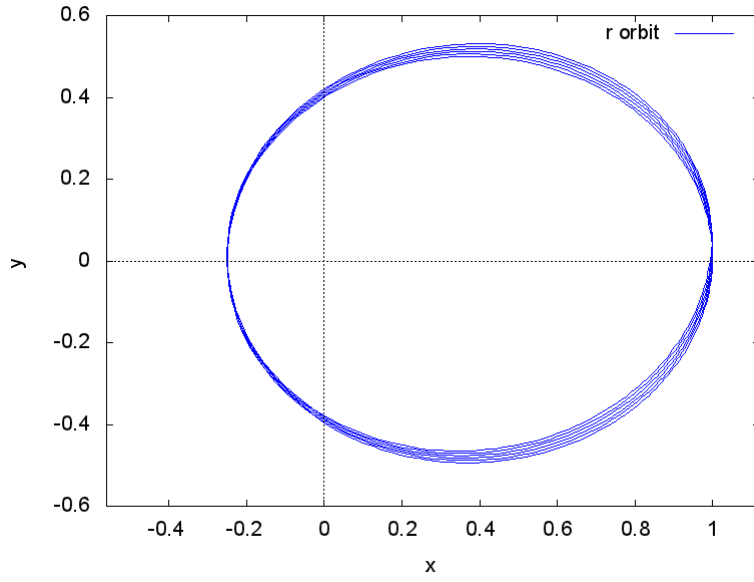


Figure 3: Classical orbit with exponential m function.

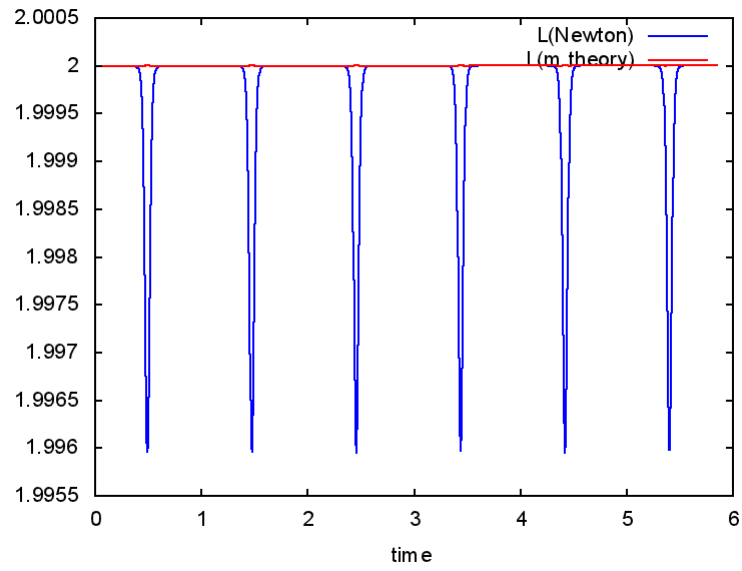


Figure 4: Angular momentum of classical orbit with m function.

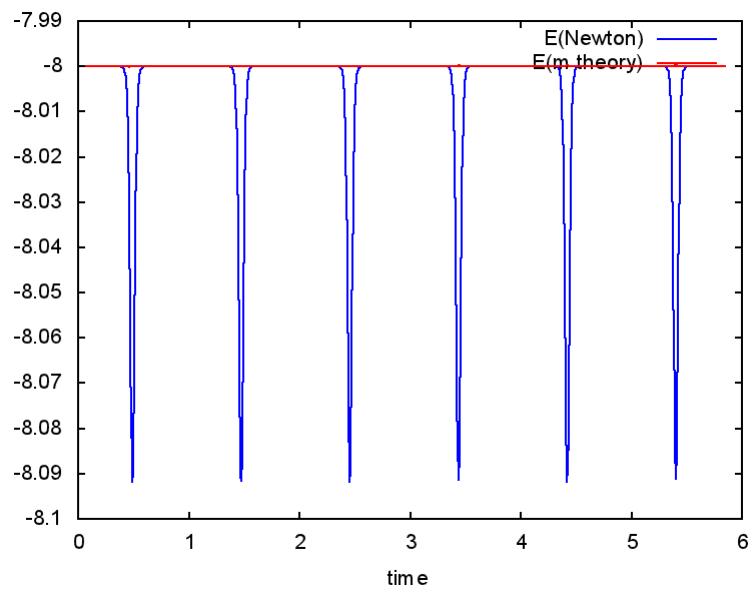


Figure 5: Total energy of classical orbit with m function.

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