THE m THEORY OF THE STRONG NUCLEAR FORCE AND LOW ENERGY NUCLEAR REACTIONS (LENR).

by

M. W. Evans and H. Eckardt

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

ABSTRACT

The m theory of the strong nuclear force is developed by equating the attractive force from m space inside the nucleus to the well known Woods Saxon (WS) model of the attractive strong nuclear force between protons and neutrons. The WS model parameters are interpreted in terms of the m function and its derivative with respect to r. The low energy nuclear reaction of two particles such as p and ^{64}Ni outside the nucleus is made possible under the condition in which the attractive m force between goes to infinity and exceeds the Coulombic repulsion (the Coulomb barrier). The resulting ^{64}Ni:p complex is unstable and decomposes to ^{63}Cu and mega electron volts of energy, with other product particles.

Keywords, ECE unified field theory, m theory of the strong nuclear force and LENR.

4FT431

1. INTRODUCTION

In immediately preceding papers of this series {1 - 41}, classical and quantum mechanics have been developed in the most general spherically symmetric space, denoted m space, resulting in many important advances (UFT415 - UFT430). This theory has been named "m theory". In Section 2 the m theory is applied to the nuclear strong force that binds together the protons and neutrons of a nucleus, and which exceeds the repulsive force between protons in a stable nucleus. The m theory is also applied to the low energy nuclear reaction between a proton and a ^{64}Ni nucleus. In the vicinity of the nucleus the ubiquitous and attractive m force can go to infinity under circumstances defined in immediately preceding papers, and overwhelms the Coulomb barrier. The resulting ^{64}Ni p complex is unstable and transmutes to ^{63}Cu, mega electron volts of energy and other products. The energy appears in the form of heat and intense visible / ultra violet radiation, the broad band emission spectrum of ^{64}Ni vapour. In Section 3 the main results are developed with computer algebra and graphics.

This paper is a short synopsis of extensive calculations given in its accompanying notes. Note 431(1) develops the wave particle dualism of the energy equation of m theory and expresses m (r) in terms of the well known ECE wave equation. Note 431(2) develops a new expression for m space energy. Notes 431(3) to 431(5) develop the m theory of low energy nuclear reactions, using the entirely new concept of the attractive force of m theory and its ability to become infinite under well defined conditions. This tuning of the m force is achieved by experimentation, by designing the conditions under which LENR can take place. Finally Note 431(6) develops the m theory of the attractive strong nuclear force between protons and neutrons by equating the attractive m force with the Woods Saxon (WS) model of the attractive nuclear strong force.

2. THE ATTRACTIVE FORCE DUE TO m SPACE

This generally covariant force is entirely new to physics and is a discovery of the ECE generally covariant unified field theory {1 - 41}. It was shown in UFT427 that it is:

$$F = -\frac{dm(r)}{dr}\left(\frac{m(r)}{2m(r) - r\frac{dm(r)}{dr}}\right)^{1/2} E \quad -(1)$$

where E is the energy of m space, defined by:

$$E^2 = c^2 p^2 + m(r) m^2 c^4 . \quad -(2)$$

Here m (r) is defined by the infinitesimal line element of the most general spherically symmetric space. In the Minkowski space of special relativity it is unity, in which case Eq. (2) reduces to the well known Einstein energy equation:

$$E^2 = c^2 p^2 + m^2 c^4 . \quad -(3)$$

Here $\underline{p}$ is the relativistic momentum. As shown in Note 431(1), Schroedinger quantization of Eq. (2):

$$E = i\hbar\frac{\partial}{\partial t}, \quad \underline{p} = -i\hbar\underline{\nabla} \quad -(4)$$

leads to the d'Alembert wave equation:

$$\left(\Box + m(r)\left(\frac{mc}{\hbar}\right)^2\right)\phi = 0 \quad -(5)$$

and comparison with the ECE wave equation {1 - 41} shows that:

$$m(r) = -\frac{\hbar}{mc} q_a^{\nu} \partial^{\mu}\left(\omega^a_{\mu\nu} - \Gamma^a_{\mu\nu}\right). \quad -(6)$$

where q_a^{ν} is the inverse tetrad, $\omega^a_{\mu\nu}$ is the Cartan spin connection and $\Gamma^a_{\mu\nu}$ is the gamma connection. Therefore $m(r)$ is a property of geometry.

If the particle of mass m is at rest then:

$$E_0 = m(r)^{1/2} mc^2 \quad -(7)$$

and the attractive force due to m space is:

$$F_0 = -\frac{dm(r)}{dr}\left(\frac{m(r)^{1/2}}{2m(r) - r\frac{dm(r)}{dr}}\right)E_0 \quad -(8)$$

Under the condition:

$$r\frac{dm(r)}{dr} = 2m(r) \quad -(9)$$

this becomes infinite as discussed UFT417 and UFT430. From Eq. (7) the mass of all the elementary particles can be expressed as:

$$\frac{m_1}{m} = m(r)^{1/2} \quad -(10)$$

where m is a fundamental scaling mass whose existence is implied by unit analysis.

A low energy nuclear reaction can be explained by using the new m force of physics. Without this m force there is no explanation of why a proton can overcome the Coulomb barrier with ^{64}Ni in a mixture of nickel powder and hydrogen. Such a mixture produces a well known low energy nuclear reaction (LENR) with release of heat and intense visible frequency light. The total force between the proton p and ^{64}Ni separated by a distance r is:

$$F = -\frac{dm(r)}{dr}\left(\frac{m(r)^{1/2}}{2m(r) - r\frac{dm(r)}{dr}}\right)E + \frac{Z_1 Z_2 e^2}{r^2} \quad -(10)$$

where Z_1 and Z_2 are the atomic numbers of p and ^{64}Ni. Under the condition:

$$r\frac{dm(r)}{dr} = 2m(r) \quad -(11)$$

the attractive m force overwhelms the repulsive Coulomb barrier and p and ^{64}Ni form a complex that is unstable and which transmutes to ^{63}Cu, mega electron volts of energy, and other products of the transmutation. The great amount of energy released is due to the decrease in mass between reactants and products:

$$\Delta E = \Delta m c^2 \quad -(12)$$

and the energy is released in the form of heat and intense visible frequency light. LENR is well established, and is a reproducible and repeatable process. The U. S. and other Governments, and many companies, have been awarded LENR patents.

Without the m force, however, there is no explanation for it in the old physics, because the strong nuclear force is confined to the nucleus and does not exist outside the nucleus. In the old physics there was just a Coulomb barrier. It is well known that this was first overcome by Cockcroft and Walton in 1932 using protons accelerated with 750,000 volts.

Inside the nucleus the net potential (UFT226 ff) is:

$$U = Z_1 Z_2 \frac{e^2}{R} \left(3 - \left(\frac{r}{R}\right)^2\right) + m \text{ potential.} \quad -(13)$$

In the standard model the nuclear strong force binds the nucleus together and can be modelled with the well Woods Saxon potential (UFT226 ff.):

$$U = - \frac{U_0}{1 + \exp\left(\frac{r - R_0}{a_N}\right)} \quad -(14)$$

which produces the Woods Saxon attractive strong nuclear force:

$$F = - \frac{U_0}{a_N} \frac{\exp\left(\frac{r - R}{a_N}\right)}{\left(1 + \exp\left(\frac{r - R}{a_N}\right)\right)^2} \quad -(15)$$

Here R is the radius of the nucleus, U_0 is the potential well depth, and a_N the surface thickness of the nucleus. The surface of the nucleus is made up of neutrons, inside of which thee is a mixture of neutrons and protons. Therefore inside the nucleus the m force can be identified with the Woods Saxon force, resulting in the equation:

$$\frac{dm(r)}{dr}\frac{m(r)}{2m(r)-r\frac{dm(r)}{dr}} = \frac{U_0}{a_N mc^2} f(r) \quad -(16)$$

where

$$f(r) = \frac{\exp\left(\frac{r-R}{a_N}\right)}{\left(1+\exp\left(\frac{r-R}{a_N}\right)\right)^2} \quad -(17)$$

This is a differential equation for m (r) and its r derivative. This equation can be solved in principle using computer algebra. Inside the nucleus the resonance condition:

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

means

$$a_N \rightarrow 0 \quad -(19)$$

from Eq. (16). This means an infinitely tightly bound nucleus with an infinitely thin surface shell. At the point:

$$r = R \quad -(20)$$

the differential equation (16) simplifies to:

$$m(r)\frac{dm(r)}{dr} = \left(2m(r) - R\frac{dm(r)}{dr}\right)\frac{U_0}{4a_N mc^2} \quad -(21)$$

As can be seen from the graphics of Section 3, the Woods Saxon force (or nuclear strong force) is very short ranged and does not exist outside the nucleus. Therefore the balance of forces (10) outside the nucleus determines whether or not a low energy nuclear reaction can take place. Inside the nucleus, Eq. (16) gives the m theory of the nuclear strong force. The m force (1) is deduced in UFT427 by comparing the m force given by the Euler Lagrange development of UFT417 with the Hamilton development of UFT427. The existence of the m force is a theoretical explanation for low energy nuclear reactions of all kinds.

The m theory of the strong nuclear force and low energy nuclear reactions (LENR)

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)

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3 Computation and discussion

3.1 Comparison of m space force and Coulomb force

First we compare the force of m theory with the Coulomb force. We used femtometers (10^{-15}m) as length units. This requires a re-scaling of formulas which is a bit tricky. For example in $d\mathrm{m}(r)/dr$, $\mathrm{m}(r)$ can be defined on a fm scale but differentiation produces a factor of 10^{15} in SI units. A similar problem occurred for the Coulomb potential. The radius of the Ni atom (3.78 fm) has been marked in the graphs.

Fig. 1 shows the total relativistic energy of a ^{64}Ni nucleus in m space, using p=0 (stationary atom, see Eq. (7)). The atomic mass of this isotope is 63.927967 a.m.u. The energy is constant outside the nuclear radius, starts decreasing near to the radius and goes to zero at the centre according to the m function. This means that the relativistic energy is not constant but impacted by m space.

Fig. 2 compares the force F of m theory, Eq. (15), with the Coulomb force of a point charge at $r = 0$. It is seen that F outperforms the Coulomb force by a multiple at the nuclear radius. Inside the nucleus, we should have a different Coulomb force, this picture is only for demonstrating the size relations. The same graphs are shown in Fig. 3 with different scaling. In addition, the Coulomb force of m space,

$$F_1(r) = \mathrm{m}(r)\frac{28\,e^2}{4\pi\epsilon_0 r^2}, \tag{22}$$

has been graphed, using

$$\mathrm{m}(r) = 2 - \exp\left(\log(2)\exp(-\frac{r}{R})\right) \tag{23}$$

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

as in previous papers. It is seen that the m function reduces the Coulomb force but this is by far not enough to bring the Coulomb barrier at the nuclear radius to zero (observe the different exponential scale factors in this graph).

3.2 Resonant m force and Woods-Saxon force

The nuclear Woods-Saxon potential, Eq. (14), is graphed in Fig. 4, together with the resulting force, Eq. (15). The parameters were chosen as $R = r_{Ni}$, $a_N = r_{Ni}/20$ and U_0 was set to unity or scaled to other curves, respectively. The Woods-Saxon force only appears in the surface region of the nucleus whose thickness is defined by a_N. We used three different forms of the m function to model a resonant behaviour of the m force:

$$\mathrm{m}_1(r) = 2 - \exp\left(\log(2)\exp(-\frac{r}{R})\right), \tag{24}$$

$$\mathrm{m}_2(r) = 1 - \frac{1}{\exp\left(\frac{r-R}{a_N}\right) + 1}, \tag{25}$$

$$\mathrm{m}_3(r) = \begin{cases} \frac{r^2}{2R^2} & \text{for } r < R, \\ 1 - \frac{R}{4\left(r-\frac{R}{2}\right)} & \text{for } r \geq R. \end{cases} \tag{26}$$

The first m function is the usual model we used so far and not resonant. The second is an adaptation of the Woods-Saxon potential and the third is a form already introduced in UFT 417. It was found that $\mathrm{m}(r) \propto r^2$ leads to an infinite force. All three functions are graphed in Fig. 5. The three forces arising from these functions via Eq. (8):

$$F(r) = -\frac{d\mathrm{m}_i(r)}{dr} \frac{\mathrm{m}_i(r)}{2\mathrm{m}_i(r) - r\frac{d\mathrm{m}_i(r)}{dr}} mc^2 \tag{27}$$

are graphed in Fig. 6. F_1 is the m force of Fig. 2 which - although not resonant - is already sufficient to outperform the Coulomb barrier as discussed above. F_2 makes up a pole so has a resonance near to the nuclear radius. To shift the pole to the radius, the parameter R would have to be modified to a value different from the nuclear radius. This type of resonance does the job outside the nucleus. The unsteady jump of the force may be a hint that the model is somewhat simplistic. A high positive force just below the radius could result in an unstable transition when a proton passes the Coulomb barrier.

The third alternative form $\mathrm{m}_3(r)$ gives resonance enhancement at the correct radial position. The force is infinite in the internal region by construction but could be modified to give a constant or vanishing force in the interior.

As explained in section 2, equating the force of m theory with the Woods-Saxon force leads to a differential equation for $\mathrm{m}(r)$, see Eq. (16). This equation is quite complicated and has no analytical solution. One can restrict consideration to the region $r \approx R$ which leads to the simplified equation (21). For this equation, computer algebra delivers a quasi-solution

$$-\frac{4a_N m\, c^2\ \mathrm{m}(r) - U_0 r}{2a_N\sqrt{\mathrm{m}(r)}} = C \tag{28}$$

where C is an integration constant with dimension of an energy. Developing this equation leads to a quadratic equation for $\mathrm{m}(r)$. The two solutions are (with $C = U_1$):

$$\mathrm{m}(r) = \frac{1}{8a_N m^2 c^4}\left(2U_0 r m c^2 - U_1^2 a_N \pm \sqrt{4U_0 a_N m c^2 r + U_1{}^2 a_N{}^2}\right). \quad (29)$$

This is an equation of type

$$\mathrm{m}(r) = ar \pm \sqrt{br}. \quad (30)$$

This function is nearly linear, at least for the parameter sets we have tested. An example is graphed in Fig. 7. By definition this approach is only valid in the region $r \approx R$.

3.3 Solutions of the wave equation

The d'Alembert wave equation was derived in Eq. (5). This is the quantized form of the Einstein energy equation (2). In the static case the wave equation reads:

$$\nabla^2\psi(\mathrm{r}) + \left(\frac{m\,c}{\hbar}\right)^2 \mathrm{m}(r)\,\psi(\mathrm{r}) = 0. \quad (31)$$

For $\mathrm{m}(r)$=const. we obtain the well known oscillatory solutions. Assuming spherical symmetry, this equation can be reduced to the radial part of the Laplace operator:

$$\frac{\partial^2\psi(r)}{\partial r^2} + \frac{2}{r}\frac{\partial\psi(r)}{\partial r} + \left(\frac{m\,c}{\hbar}\right)^2 \mathrm{m}(r)\,\psi(r) = 0. \quad (32)$$

Now we transform the radial coordinate r to another coordinate x by using the constant k as an abbreviation:

$$k = \frac{m\,c}{\hbar}, \quad (33)$$

$$x = k\,r. \quad (34)$$

This lets us get rid of the squared factor in (32):

$$\frac{\partial^2\psi(x)}{\partial x^2} + \frac{2}{x}\frac{\partial\psi(x)}{\partial x} + \mathrm{m}(x)\,\psi(x) = 0. \quad (35)$$

For the m function we choose the approximation

$$\mathrm{m}(r) = 1 - \frac{r_0^2}{r^2}. \quad (36)$$

By introducing the new constant

$$x_0 = k\,r_0 \quad (37)$$

$\mathrm{m}(r)$ can be transformed to the form

$$\mathrm{m}(x) = 1 - \frac{x_0^2}{x^2}, \quad (38)$$

so the wave equation can finally be written in the simple form

$$\frac{\partial^2\psi(x)}{\partial x^2}+\frac{2}{x}\frac{\partial\psi(x)}{\partial x}+\left(1-\frac{x_0^2}{x^2}\right)\psi(x)=0. \tag{39}$$

This equation is nearly identical to the Bessel differential equation:

$$\frac{\partial^2\psi(x)}{\partial x^2}+\frac{1}{x}\frac{\partial\psi(x)}{\partial x}+\left(1-\frac{x_0^2}{x^2}\right)\psi(x)=0. \tag{40}$$

The only difference is the factor $1/x$ instead of $2/x$ which cannot be transformed away. Therefore the solutions of the wave equation are expected to be very similar to the well known Bessel functions which are the solutions of the original Bessel differential equation. The constant x_0 determines the degree of the solution, i.e. the zeros and the positions of maxima. Since x_0 depends on the particle mass m, this equation contains the mass spectrum of elementary particles, and the particle radius is also defined by x_0. This is a first step to computing mass and internal mass density of elementary particles. The equation has to be solved numerically.

We did an exemplary solution for the wave equation and the original Bessel equation with the same initial conditions. The results are graphed in Fig. 8. It is seen that the zero crossings are slightly shifted and the decay is more rapid for the solution of the wave equation. Concerning particle properties, it has to be decided for example how to interpret the border of the particle (fist zero crossing?) and if a horizontal tangent is required at $r = 0$.

Inserting a series expansion for $\psi(x)$ will presumably lead to an eigenvalue problem from which the mass spectrum is obtained as a eigenvalues with associated wave functions as eigen functions. This procedure is in full analogy to quantum chemical calculations and can be developed by known methods of numerical mathematics.

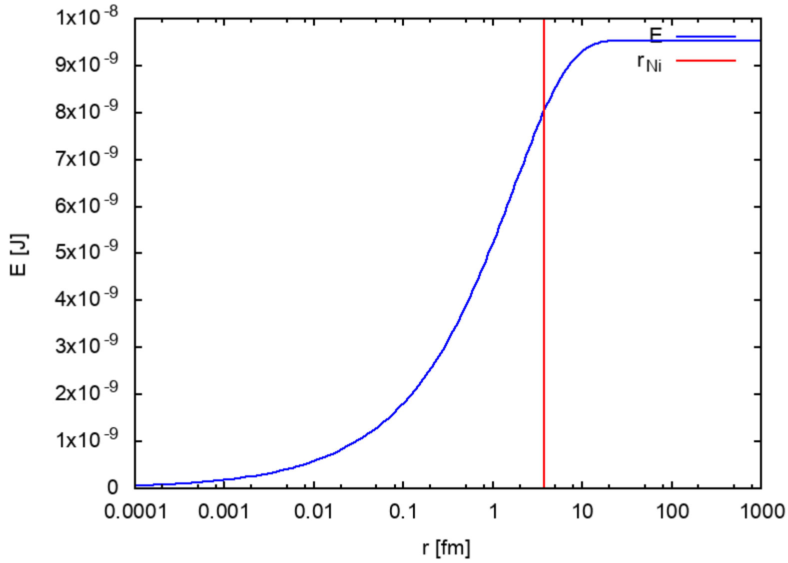

Figure 1: Relativistic energy of ^{64}Ni nucleus.

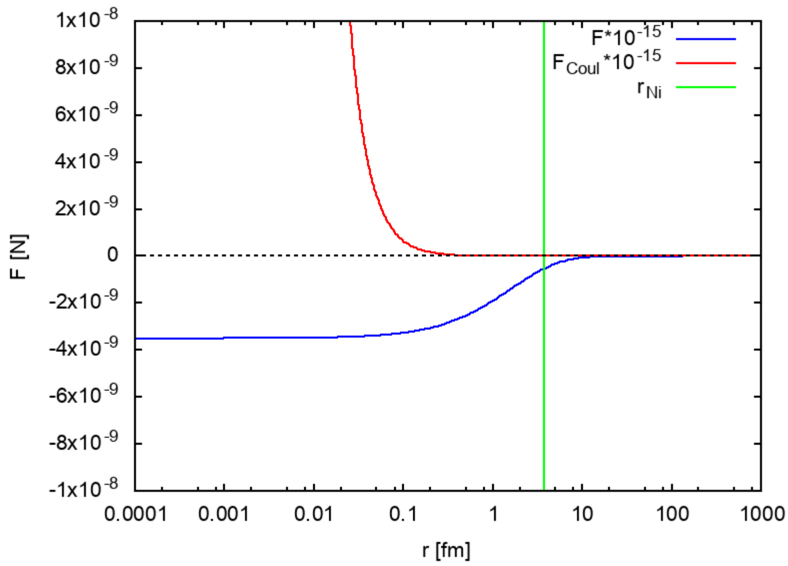

Figure 2: Force of m theory and Coulomb force.

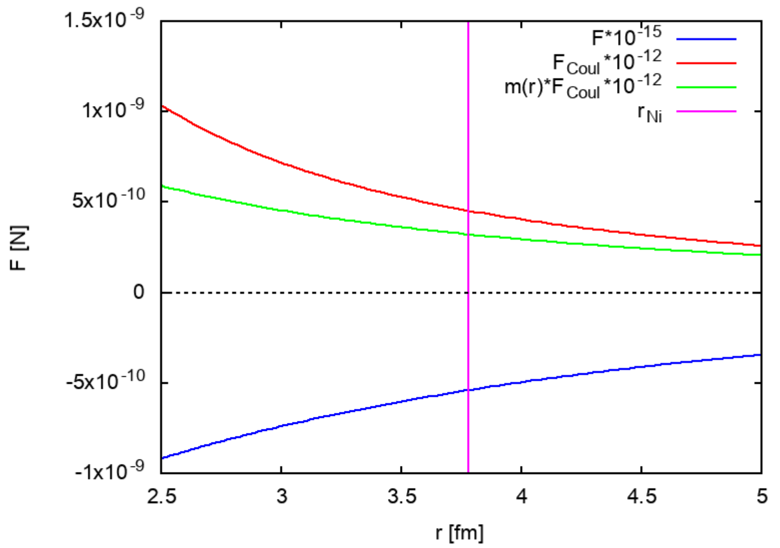

Figure 3: Force of m theory and Coulomb force, smaller radial scale. Observe the exponential factors when comparing.

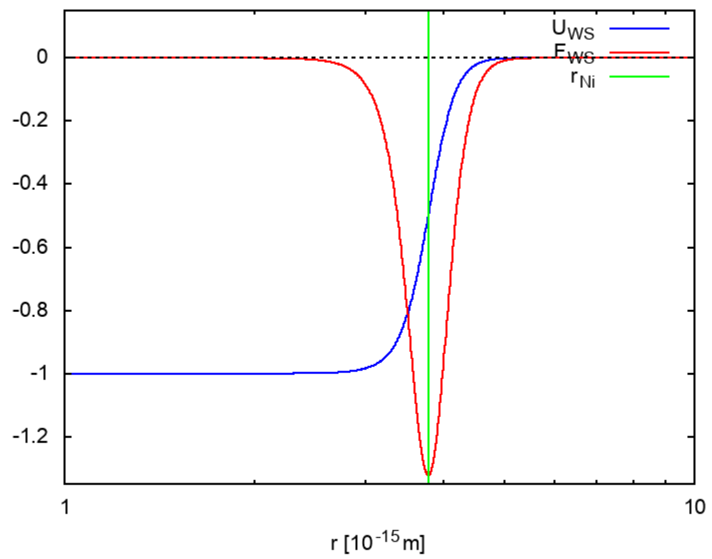

Figure 4: Woods-Saxon potential and corresponding force.

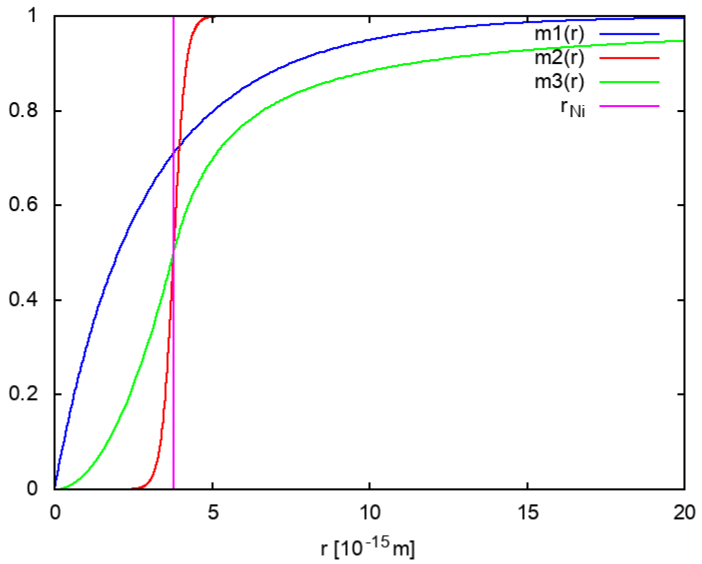

Figure 5: Three models of m functions.

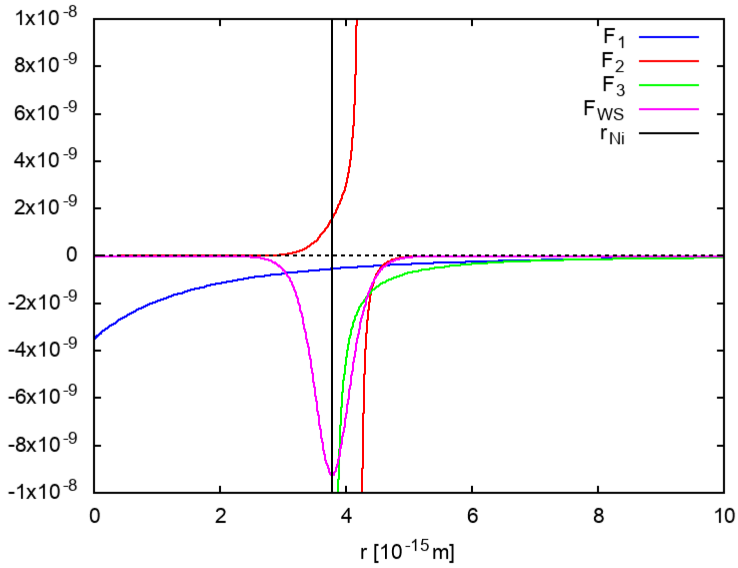

Figure 6: Resonance solutions for m space force.

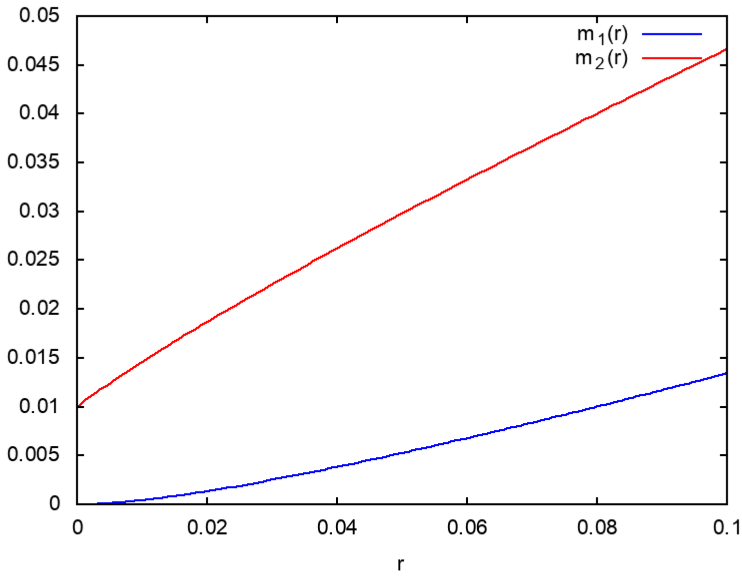

Figure 7: Solutions of m(r) for the approach $r \approx R$.

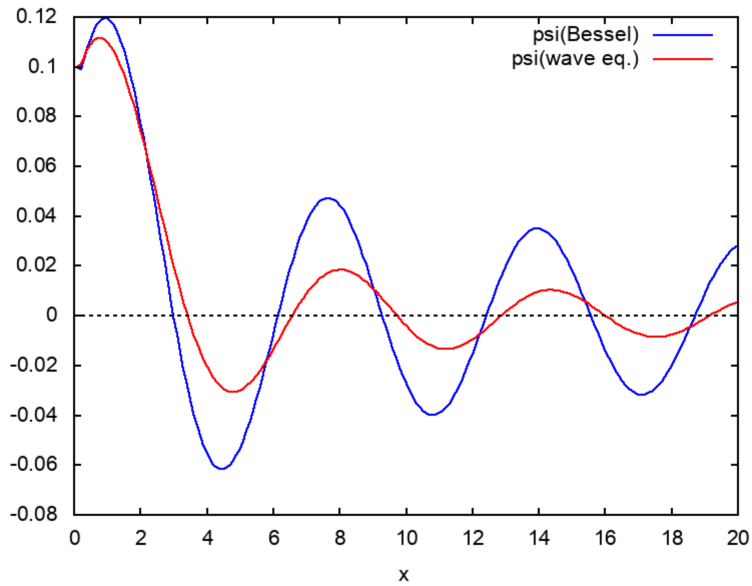

Figure 8: Solution of Bessel equation and wave equation for particles.

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