The Physics of Negative Mass Tachyons

Referenced Terms and Names

Tachyons, antigravity, FTL, superluminal, faster than light, faster-than-light, quarks, gluons, mesons, spin, charm, relativity, neutrinos, photons, electrons, protons, neutrons, pions, muons, leptons, hadrons, Bohr Magnetons, nucleus, chromodynamics, hyperluminal, quasar, Planck, Einstein, de Broglie, Schroedinger, Heisenberg, Dirac, Kepler, Ptolemy, Ptolemaic

Abstract

o This web page provides a summary derivation of the first and only theoretical tachyon model to agree with experiment. No other tachyon model, to date, has produced agreement with experiment. It is a unified model that produces agreement with experiment for the electron, the proton, the neutron, the light nuclei, and the mesons.

o The data that is used to verify this model is well known from the standard physics literature, especially the **Review of Particle Physics**, published by the Particle Data Group of the American Physical Society. No source that is controversial or possibly bogus is used. This model is, in short, a reinterpretation of existing particle data that is accepted by and used by the physics community.

o All attempts have been made to make the presentation as simple as possible so that even someone with a relatively modest background in physics can carry out the calculations with a simple hand calculator. Hence, it is shown just how simple basic subatomic physics can be if presented properly.

o The model is a Bohr-like revolving particle model that utilizes a negative mass tachyon in conjunction with a revolving, *but very tiney*, charged *point* particle. The tachyon, being unable to drop below the speed of light, causes the positive mass charged particle to revolve in a relatively large orbit, thus generating a magnetic moment while maintaining agreement with experiment in that the charged particle for the electron is know to be extremely small.

o Specifically, the heavier positive mass muon captures a negative mass tachyon to form an electron. The muon, in turn, consists of a positive mass pion and another negative mass tachyon. The radii of the revolving electron and the muon are determined from the cutoff energies of the well known mu -> e and the rare, direct pi -> e conversions curves. These radii determine the magnetic moments of the electron and the muon. The resulting magnetic moments are found to be the well known Bohr magnetons, identically. That is, the magnetic moments are

$$\mu = \pm \frac{e \hbar}{2 m c}.$$

These values are well known to agree with experiment. By requiring that the electron's charged particle have integral multiples of its de Broglie wavelength, its magnetic moment is improved to within 39 ppm of experiment. (Quantum electrodynamical corrections do much better in terms of accuracy, but there is nothing obvious to preclude its use as a correction factor for this model.)

o The residual energies of the conversions are 20 eV and 123 KeV for the electron and muon conversions, respectively, somewhat larger in magnitude than the experimentally estimated masses of their respective neutrinos, but more than enough to account for the neutrinos' masses.

o Based on this, it would be expected that colliding electrons and positrons would produce at least muons, pions, and gamma rays. This agrees with observation. All of this, of course, makes the pion the mother particle of the lepton family. This is quite

at odds with the standard particle model. And while indirect evidence has generally been interpreted to mean that the pion is a spin 0 particle, the implication here is that the pion has a magnetic moment, albeit extremely small.

o Similarly, a proton consists of a heavier sigma hyperon that has combined with another negative mass tachyon. Converse to the electron/muon model, the magnetic moment of the proton is used to determine its dimensions. These dimensions agree to within 3% of the with the experimental dimensions that are determined from both high and low energy scattering data.

o By adding a revolving pion-tachyon combination to the center of the proton, we form a neutron. The ground state energy of the pion is 4076 MeV, and its excitation energies are found to be

$$E = 4075/n^2 ,$$

where n ranges from 1 - 9. As shown below, the first order transitions of this bound pion, an analog of the Bohr model's Lyman series, produce the "charmed" psi mesons within 5 % of the experimental values. The second order transitions, an analog of the Bohr model's Balmer series, produce the eta through the ao(980) mesons generally to within 4 %. Theses energies are also produced by colliding electrons and positrons, so that one must conclude that the unbound pion itself resonates. Again, there is no relationship between this model and the standard model.

o Note that a negative mass particle is inherently an antigravity particle.

o And while this model agrees quite well with experiment, there is no relationship whatsoever between it and the generally accepted standard particle model. This model is described in more detail in a book, **The Physics of Tachyons**, and in the published papers provided at the end of this web page.

o As can be seen, comparing this extremely simple particle model to the extremely complex standard particle model is like comparing the extremely simple Kepler planetary model to the complex Ptolemaic planetary model that was prevalent in the middle ages. And while both particle models may agree with experiment, there is no comparison beyond that. There are no quarks, gluons, or strings here, just as there were no epicycles in the Kepler model. And here, mesons are not classified according to strangeness, or flavor. This model is even politically correct in that there is no reference to chromodynamics, or color!

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(Note: Comments are solicited.)

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The Definition of a Tachyon

Tachyons are particles whose velocity exceeds the velocity of light. While many believe that the existence of particles with hyperluminal (superluminal) velocities (FTL, or Faster-Than-Light velocities) is precluded by relativity, this is not the case if the particle is created with a velocity already exceeding the velocity of light. What relativity precludes, within the boundaries of our present technologies, is the acceleration of a subluminal particle to hyperluminal velocities. What is also not precluded is the possibility that technology might someday be developed that will permit the relativistic limitations to be overcome, and hyperluminal velocities to be achieved by subluminal objects.

The most well known tachyon model uses an imaginary mass. As interesting as that model is, mathematically speaking, an imaginary mass has no physical meaning. As a result, that model has, as yet, produced no agreement with experiment. That model and its mathematics is discussed extensively in an excellent review by Recami and Mignani in Rivista Del Nuovo Cimento **4**, 209,

(1974).

A Brief Comment on Units of Mass and Units

For those with minimal experience with subatomic particles, a few comments should be made on the mass terminology used here. For example, the mass of an electron is 9.1093896 x 10^{-28} grams. But this is a little clumsy for human beings to deal with on a daily basis, especially verbally. It is easier to express the mass in terms of electron volts, which for the electron is 0.511 MeV, where MeV is an abreviation for million electron volts. Further, the early particle accelerators, such as the Van der Graaf generator and the Cocroft-Walton machine used high voltages to accelerate the particles, and an electron volt is the amount of work done when a charged particle moves through a potential of one volt. Hence, it was natural to express the energy in terms of the voltage with which the particle was accelerated.

The equivalent mass energy relationship is obtained from the Einstein relationship, namely $E=mc^2$. To calculate E, we use the particle mass in grams along with the speed of light which is c= 2.99792458 x 10^{10} cm/sec. The resulting energy, E, is in ergs. However, from electrodynamics we know that one erg is equivalent to 6.24150636 x 10^{11} eV, where eV is the abreviation for electron volts. Hence, the calculation is quite simple, so the reader should have a try at it with his hand calculator.

Particle	Mass (gms)	Mass-Energy (MeV)	Magnetic Moment (Ergs/gauss)
electron	9.1093896x10^{-28}	0.51099906	9.2847701x10^{-21}
proton	1.6726231x10^{-24}	938.27231	1.4106076x10^{-24}
neutron	1.6748286x10^{-24}	939.56563	9.6623707x10^{-24}
muon	1.8835327x10^{-25}	105.658387e-24	4.4904514x10^{-23}
pion	2.488018x10^{-25}	139.5675	4.3x10^{-24} (No, it's not zero, spin 0 or not.)
Deuteron	3.3435860x10^{-24}	1875.61339	4.3307375x10^{-24}

In addition, the following constants will be needed:

Constant's Name	Symbol	Value	Unit
Speed of light	c	$2.99792458 \times 10^{10}$	cm/sec
Elementary Charge	e	$4.80320680 \times 10^{-10}$	statcoulombs*
Elementary Charge	e	$1.60217733 \times 10^{-19}$	coulombs
Planck's Constant	h	$6.6260755 \times 10^{-27}$	erg-sec
Planck's Constant/2pi	h_bar	$1.05457266 \times 10^{-27}$	erg-sec

Nuclear and subatomic dimensions are usually expressed in fm, which can stand for Fermis, which is10^{-13} centimeters, or femtometers, which is 10^{-15} meters. (Obviously the same length, but different units.)

The Meson Model

Because of its extreme simplicity and its excellent fit to the experimental meson data, we will present the meson portion of the model *prior to* the actual derivation of the overall model.

The first meson to be physically observed was the muon, and some 10 years later, the pion. Still later, other mesons were observed in various high energy particle collisions as interaction energies, or even as free particles. These resulted typically from pion-proton collisions, K meson-proton collisions, or electron-positron collisions. Some of the earlier and more spectacular observations were made inside hydrogen bubble chambers. Typically, these reactions produce pions as by products, although K mesons and other mesons are also produced.

From the standpoint of this model, all mesons arise from a resonating pion, whose internal binding energy is 4076 MeV. But what is so interesting is that the pion (again from the standpoint of this model) is the mother particle of the muon and the electron, so that one would expect that electron-positron collisions *must* produce at least pions, muons, and gamma rays, as well as the other meson energies. The most obvious would be the psi resonances. In fact, some of them were originally published in a table of excitation energies in a tachyon-hadron paper (see references below), but their significance was overlooked at the time.

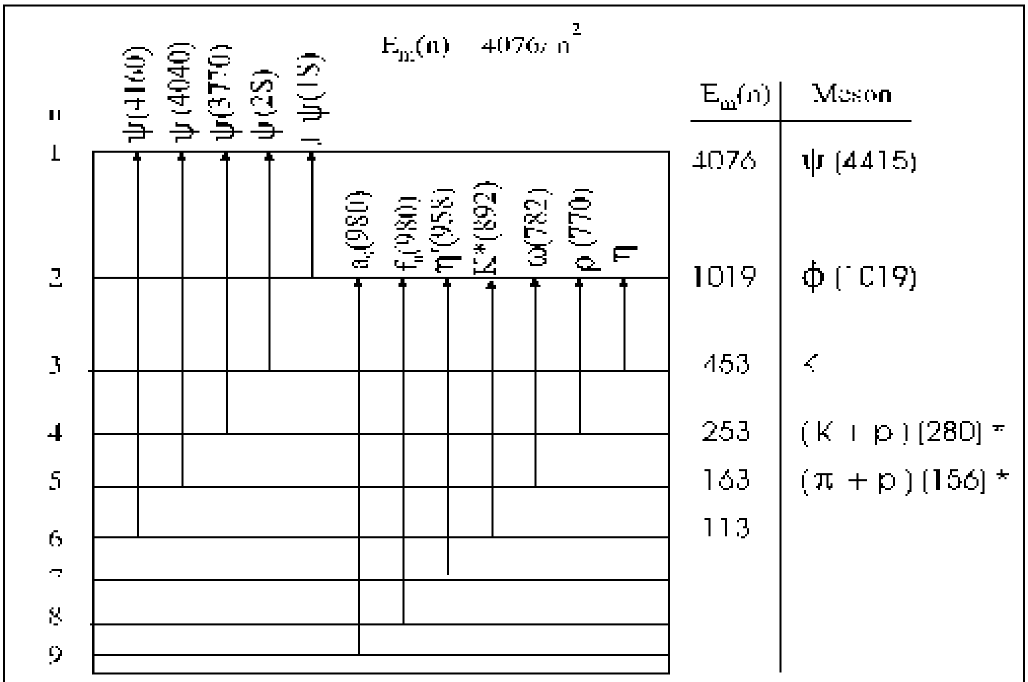
These internal pion excitation levels are given by

$$E_m(n) = 4076/n^2,$$

where the index, n, ranges from 1 through 9. To obtain the various meson energies, you may use the above equation as follows:

1. First, calculate the 9 levels of E_m using the values 1 - 9 for n.

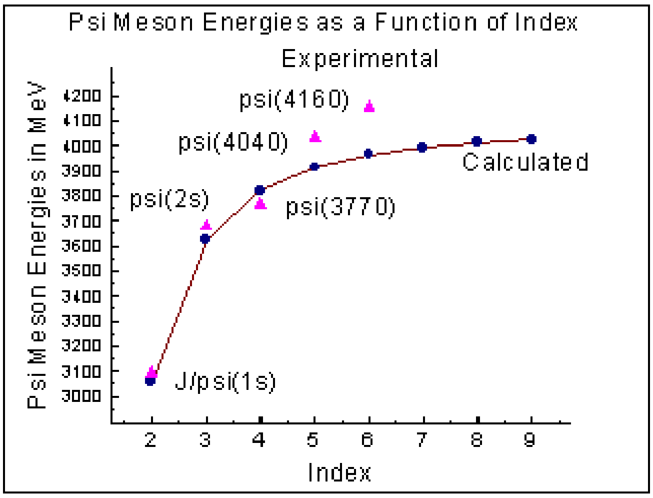
These are shown in the energy level and transition energy diagram, below. The first three levels of E_m correspond to the energy levels of the psi(4415), the phi(1020), and the K- mesons to within - 8 % to +8 %. The next two levels correspond to resonances that arise from a K- proton collision and a pi- proton collison, these resonances having energies of 280 MeV and 156 MeV, with agreements of -9.3 % and -4.3 %, respectively. These latter resonances two will be discussed in more detail in an upcoming revision of **The Physics of Tachyons**.



This is a graphical representation of the excited states of the pion. Note its similarity to the Bohr hydrogen atom's energies. The first order transitions are the "charmed" psi mesons, and the 2nd order transitions are the lighter mesons.
* These are K, pion - proton resonances.

2. Next, subtract each resulting value of E_m from the first value (for n = 1), and you will have the first order transitions, or the "charmed" psi mesons to within -1.3 % to +4.7 %. (The Bohr atom's analog is the Lyman series.) These transitions are shown in the transition diagram above, and the values are plotted in the graph below along with the corresponding experimental values where the index is the value of the energy level, n, that is differenced with the value for n=1.

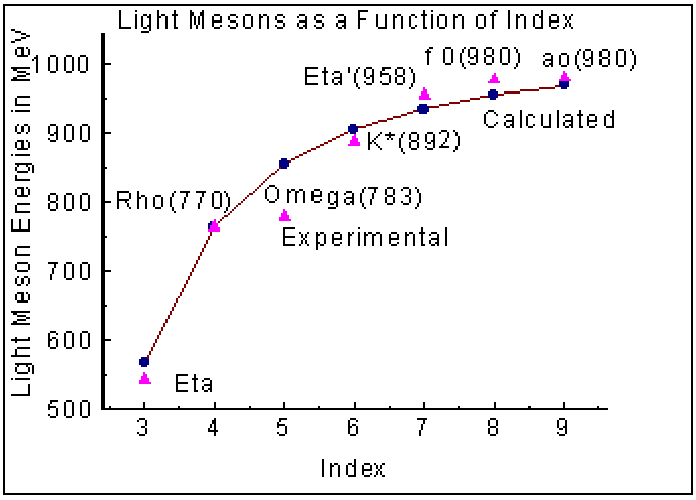
3. Finally, subtract each subsequent value from the second value (for n = 2), and you will have the second order transitions, These produce the seven light mesons, i.e., the eta through the ao(980). The agreement with experiment ranges from 0.5 % to -2.3 %, except for the omega(783), which is within +9.5 % of experiment. (The Bohr atom's analog is the Balmer series.) These are shown in the graph, below, along with their corresponding experimental values, where the index is the value n that is subtracted from the value n = 2.



These transitions, i.e., the transitions between the level for n = 1 and the lower levels correspond to the "charmed" psi mesons. The second order transitions, the transtions between the n= 2 level and the lower levels correspond to the lighter mesons from the eta through the a0(980).

4. THE READER IS INVITED TO TRY THIS WITH A SIMPLE HAND CALCULATOR.

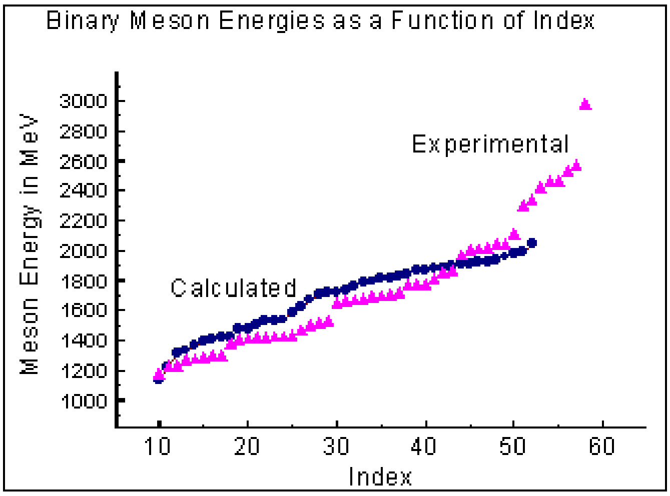
To reiterate, it is not necessary to understand quarks, gluons, etc, to achieve this systematic agreement with experiment. Nor is reference to strangeness flavor, or color needed.



The Binary Mesons

Because the many mesons studied here arise from relatively large energies that produce two or more pions, we must consider that at least some of these collision should produce energy levels that are the sum of two energy levels. Since the energies can be a combination of any two levels, we combine all possible energies of the lighter mesons (the second order transitions, above) and obtain binary energy levels of the electron-positron collisions. These binary levels are graphically shown below along with their corresponding experimental values. Here, the index n arbitrarily picks up from the value n = 9 in the graph above. Both the experimental energy levels and the summed values of the light mesons are arranged in ascending numerical order and plotted. None of the experimental mesons are named here simply because there are too many of them. They are shown in detail in **The Physics of Tachyons**.

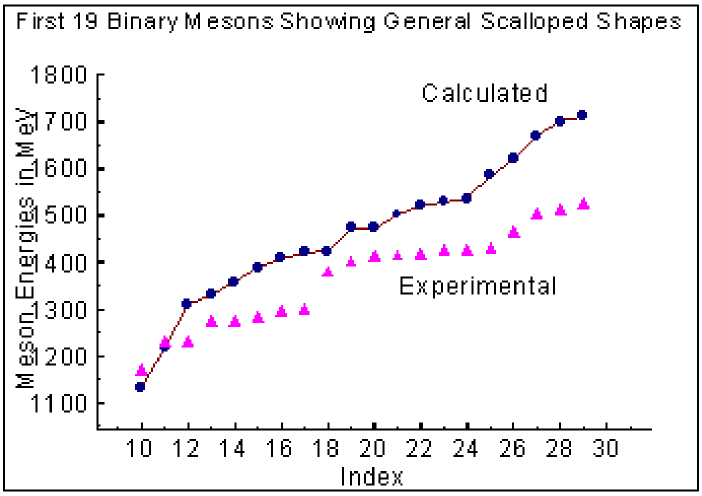
The agreement with experiment ranges from -16 % to + 12 %. While this might appear to be only crude agreement between experiment and theory, it should be noted that no attempt was made to compensate for any binding energies between the positive and negative excited pions.



Further, many of these mesons were not discovered at the time this model was originally developed, so that this model predicted more binary mesons than were know at the time.

There are, however, a number of mesons above the binary set that it does not explain. These are also shown here. No attempt has been made at to account for them at this time, although it is likely that they arise as excitations from an even more massive particle than the pion.

Note that the first 19 binary mesons have a scalloped shape that a reflection of the parabolic shape of the light mesons energy curve. The experimental values, while somewhat crude, seem to correspond to this scalloped shape. The first 20 levels are shown below in more detail to illustrate this shape.



There is no other model that produces as many mesons as this, especially when you add the binary mesons, as described below.

A Brief Comment on Magnetic Moment

The origin of the magnetic moment of particles, , is the heart of this model, so that a brief discussion of it is warranted before proceeding to the actual derivation of the magnetic moments of the electron and the muon.

In the simplest case, a wire loop with an electrical current flowing through it causes a magnetic field to be generated along its axis. A measure of the amount of torque that the loop would be subjected to when placed in a magnetic field is called the magnetic moment. It is calculated by multiplying the area of the loop by the current flowing through the wire. That is, = I x A ergs/gauss, where A is the area and I is the current. The current I is normally given by I = ne where n is the number of charges passing a point in the wire, and e is the charge per particle. For current as we normally use it, e = $1.602`7733x10^{-19}$ coulombs. However, in order to have a magnetic moment that is correct for the cgs system of units, we must use e = 4.8032068010^{-10} statcoulombs, and then that must be divided by the speed of light. I.e., I = ne/c.

The amount of torque on the loop is the T = Bcos dyne-cm, where is the angle between the axis of the magnetic moment and the direction of the magnetic field, B.

Insofar as its application to particles is concerned, the proton, electron, neutron, and the nuclei all have magnetic moments. The fact that the electron has a half-integral value of spin prevents any two electrons in an atoms from occupying the same energy/ angular momentum. This fact causes the various atoms to combine chemically in the way that they do, thus making our world the way it is. That is, without tachyons, there would be no particle spin, and so we would not exist. (Note that, here, I am not making a distinction between spin as a quantum mechanical term and magnetic moment as a physical phenomena in this simple discussion. This may enrage quantum mechanics, but is for them to worry about their blood pressure.)

The Origin of the Magnetic Moments of the Electron and the Muon

To summarize the revolving electron and muon models, a pion captures a negative mass tachyon and becomes, overall, a less massive muon. The muon captures still another negative mass tachyon, and becomes an even lighter electron. The orbital velocities of the revolving charged particles are constant at the speed of light, with only the orbital dimensions and the overall energy of the system changing during the transition from one particle system to another.

Because these transition from pion to muon and from muon to 3 electron are monopole and not dipole transitions, no radiation would be expected of them. This is observed to be the case experimentally.

Further, based on this model, *it is mandatory* that the byproducts of high energy electron-positron collisions include muons and pions and gamma rays. This is observed to be the case experimentally.

NOTE: (With apologies) At this time there is a some difficulty getting some of the Greek characters to print on the html page, so we are forced to use pi and mu for pion and muon for the moment, except in graphics or those equations that derived from the equation editor and imported from another document. This also holds for h bar, or Planck's constant divided by 2 pi.

The masses of the muon's and electron's tachyons are

$$M_{Tmu} = M_{mu} - M_{pi} = -33.9091 \text{ MeV}, \quad (1)$$

$$M_{Te} = m_e - M_{mu} = -105.147388 \text{ MeV}. \quad (2)$$

Next, we will need to utilize half of these masses as binding energies. I.e., we have

$$E_{Tmu} = - 16.9546 \text{ MeV}. \quad (3)$$

$$E_{Te} = - 52.573694. \quad (4)$$

The sum of these energies is

$$E_{Tmu} + E_{Te} = - 16.9546 - 52.573694 = - 69.5283 \text{ MeV}. \quad (5)$$

Next, examine Fig. 2. It is a composite of two particle conversion curves. The mu -> e curve on the left is well known and is contained in most particle physics books.

The right most curve, the direct pi -> e conversion curve, is less well known, the direct conversion of a pion into an electron is relatively rare, about one in 10^4 pion conversions.

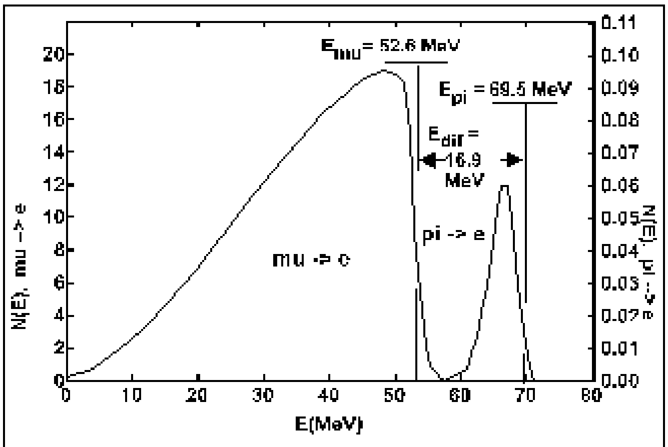


Fig 1. Spectra of Muon and Pion Conversions to Electrons.

It should be noted that accurate fits to the mu -> e curve have been produced by the V-A theory.

The generally accepted assumption is that two neutrinos are produced by the decay of an electron into a muon, and the shape of the curve is determined by the relative angles of emission of the two neutrinos. That is to say, the curves are normally considered to be decay spectra.

Neutrinos have been observed. And, the residual energies of this model are 20 eV for the electron model, and 123 MeV for the muon model, more than enough to account for the estimated masses of the neutrinos.

The interpretation used here is that the reaction during the capture of a tachyon by a muon has a residual energy whose distribution is described by the mu-> e curve. However, if the reaction energy is greater than that of the binding energy of the electron's tachyon to the charged particle, there will be no capture and hence, no electrons will be produced. The point at which this happens, 52.6 MeV, is the cutoff energy of the mu -> e curve. This compares nicely with the energy of Eq. 4.

The pi -> mu capture, on the other hand, produces monoenergetic muons at an energy 4.119 MeV, so that there is no cutoff energy. Therefore, another approach must be taken. So compare Eq. 5 with the 69.5 MeV cutoff energy of the -> e curve. The double tachyon capture implies that the total binding energy of the muon and electron's tachyons is half of sum of their masses, and hence, the binding energy of the muon's tachyon is also half of its mass energy. Note, incidentally, that the difference in the two cutoff energies is 16.9 MeV, which is half the muon's tachyon's mass energy as given in Eq. 3.

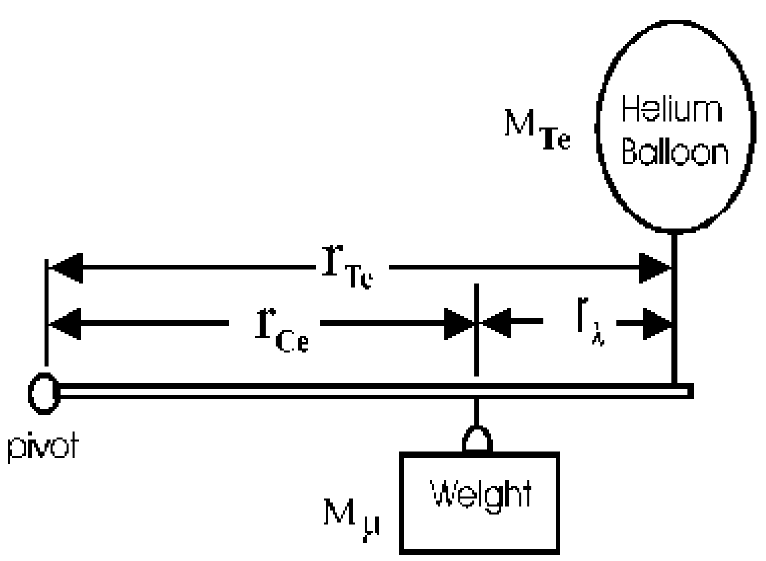


Fig. 2. The balance model for an electron, the negative mass of the tachyon being shown as a helium balloon. the positive mass muon as a simple weight. Note that the pivot is external to the line connecting the tachyon and the muon, and is the center of mass of the system.

Because of its negative mass, a revolving tachyon will have an inwardly directed force, not an outwardly directed force. This inwardly directed force of the tachyon balances the outwardly directed force of the orbiting charged particle, thus maintaining the particle systems in tightly bound orbits. The balance conditions are similar to that of a helium balloon (a negative mass analog) on one end of a massless rod balanced by a less massive weight placed between the balloon and a pivot on the other end of the rod. Because of the negative mass, the center of mass of the system is at the pivot, and is thus external to the line connecting the charged particle's orbit and the tachyon. This is shown in Fig. 2.

Based on the above, in general, the magnitude of the binding energy, which is the same as the ground state energy, is given by

$$E_T = \frac{M_T c^2}{2}. \qquad (6)$$

Considering the above, the de Broglie wavelength for the tachyon is given simply by

$$\lambda_T = \frac{h}{p} = \frac{h}{\sqrt{2 M_T E_T}}, \qquad (7)$$

where h is Planck's constant, M_T is the mass of the tachyon in grams, and E_T is the energy of the tachyon. (NOTE, again that we will be forced to sometimes use the word lambda for the wavelength.) Using Eq. 6 for the energy in Eq.7, we have

$$\lambda_T = \frac{h}{\sqrt{2M_T M_T c^2/2}}, \qquad \lambda_T = \frac{h}{M_T c}. \tag{8}$$

It could be argued that it is naive to apply this simple equation to tachyons and ignore relativity. But there is no experimental evidence one way or the other as to how they behave. Certainly it is no more naive than extending the Lorenz transformation to hyperluminal regions and concluding that tachyons have an imaginary mass as has been the accepted practice. Therefore, we will work with what we have and see how the model develops.

If we assume a single de Broglie wavelength, lambda, for the circumference of the tachyon's orbit around the charged particle, we may divide equation 8 by 2 pi. This gives us the tachyon's orbital radius, $r_{\text{lambda T}}$, as it orbits the charged particle in the charged particle's frame of reference. That is,

$$r_{\lambda T} = \frac{\hbar}{M_T c}. \tag{9}$$

Here, the subscript lambdaT refers to the de Broglie wavelength, and h_bar = h/2 pi.

While the original model used this concept, another way of looking at it is to consider that both the tachyon and charged particle revolve around the common, external center of mass. The tachyon has some 207 de Broglie wavelengths in its orbit, which is, in this case, larger than that of the charged particles orbit.

We will now explore the balance conditions for a negative mass particle that is coupled to a positive mass. This is illustrated in Fig. 2. For the electron, we define

$$R_e = \frac{M_\mu}{m_e} = 206.76826. \tag{10}$$

For the muon,

$$R_\mu = \frac{M_\pi}{M_\mu} = 1.320932. \tag{11}$$

The equation describing the balance of this system for the electron model is

$$M_{mu}r_{ce} + M_{Te}r_{Te} = 0,$$

(12)

$$M_{mu}r_{ce} + M_{Te}(r_{ce} + r_{Te}) = 0,$$

where we used the fact that $r_{Te} = r_{ce} + r_{lambda\ Te}$. Using Eq. 2 (for M_{Te}) in Eq. 12, we have that

$$M_{mu}r_{ce} + (m_e - M_{mu})(r_{ce} + r_{Te}) = 0,$$

(13)

$$M_{mu}r_{ce} + m_e r_{ce} + m_e r_{lambda\ Te} - M_{mu}r_{ce} - M_{mu}r_{lambda\ Te} = 0.$$

The $M_{mu}r_{ce}$ terms cancel, so that Eq. 13 becomes, after a little rearrangement,

$$r_{ce}m_e = (M_{mu} - m_e)r_{lambda\ Te}\ .$$

(14)

Dividing both sides of 14 by m_e, and then using Eq.10, we obtain

$$r_{ce} = (R_e - 1)r_{lambda\ Te}\ .$$

(15)

Also, rewrite Eq. 2 using Eq. 10 to obtain

$$M_{Te} = m_e - M_{mu} = (1 - R_e)m_e\ .$$

(16)

Using Eq. 9 for $r_{lambda\ Te}$, Eq. 15 becomes

$$r_{ce} = \pm (R_e - 1) \frac{\hbar}{M_{Te} c} . \qquad (17)$$

Using M_{Te} as defined by Eq. 16, we eliminate $(R_e - 1)$ and M_{Te} from Eq. 17 so that

$$r_{ce} = \pm \frac{\hbar}{m_e c} = 386.15933 \text{ fm} \qquad (18)$$

for the electron.

Using an identical approach for the muon model, the orbital radius of the muon's pion is

$$r_{c\mu} = \pm \frac{\hbar}{M_\mu c} = 1.8675947 \text{ fm}. \qquad (19)$$

The magnetic moment of a current loop is, in general,

mu = IA,

(20)

where I is the current in the loop, and A is its area. (Note that mu is not to be confused with the subscript mu representing the muon.)

Current is, in general, given by the number of charges passing a point multiplied by the charge per particle. Also, recall that in the gaussian system of units, the charge in statcoulombs divided by the speed of light is the unit of charge used to calculate the magnetic field. Hence, the current at a point caused by a single charged particle revolving about a center point is

$$I = \frac{e}{c} f , \qquad (21)$$

where f is the frequency of the particle's rotation, and for a light speed particle is given by

$$f = \frac{c}{2 \pi r_c} , \qquad (22)$$

where c is the velocity of the charged particle and r_c is its orbital radius. Hence, the magnetic moment of a single, revolving charged particle is obtained from Eqs. 20, 21, and 22, as

$$\mu = \frac{e}{c} \frac{c}{2\pi r_c} \pi r_c^{2}, \tag{23}$$

where pi*r_c^2 is used for the area, A, of the current loop of Eq. 20. Eq. 23 then becomes

$$\mu = \frac{e r_c}{2}. \tag{24}$$

Using equation 18 in Eq. 24, the magnetic moment of the electron is

$$\mu_e = \pm \frac{e\hbar}{2 m_e c}. \tag{25}$$

Using Eq. 20 in Eq.24, the magnetic moment for the muon is

$$\mu_\mu = \pm \frac{e\hbar}{2 m_\mu c}. \tag{26}$$

These are the Bohr magnetons for the electron and muon respectively. These values for the magnetic moments agree with experiment to within 0.17 % for the electron and 0.12 % for the muon. No particular significance is attached to the plus and minus versions of the magnetic moments at this time.

But to take it a step further, by requiring that the electron's charged particle have an integral number of wavelengths, the accuracy of the electron's magnetic moment is improved to within 39 parts per million. That is, the gyromagnetic ratio is g/2 = 1.0011208. (QED does better than this, but with many years and hundreds of workers, it should!)

It should be noted, for contrast, that the self-energy calculation for the electron provides the well known classical electron radius of 2.8179 fm, which is far smaller than that of the electron as given above. However, it is less than twice that of the muon. No particular significance is attached to this, however. But it is interesting to note that if we divide the electron's charged particle's radius (the reduced Compton wavelength) by the classical electron radius, the result is the fine structure constant. Again, the significance of this with respect to this model, if any, is not clear at this time.

One objection that may be raised is that the electron is much larger than the high energy scattering data indicates it is rather small. The electron's charged particle's orbit has a radius of 386.15933 fm, and the muon's charged particle's orbital radius is 1.8675947 fm. In spite of these large orbital radii, the actual scattering cross section of muons and electrons would be expected to be much smaller at high energies because the actual charged particle itself is no larger than the pion. That is, the upper most limit of its radius is 0.185 fm (2.15 Mb). This does not contradict the much lower experimental value of 5 - 30 Nb. (No lower limit is available from the model.)

Insofar as the question of a revolving charge radiating its energy away, we could, after the manner of Bohr with his hydrogen atom, merely hypothesize that its orbit is a bound, ground state orbit, and leave it with no further explanation. After all , this model uses a revolving charged particle to produce extensive agreement with experiment in spite of the radiation problem, so that obviously, conventional electrodynamics would appear not to hold here.

But to suggest two paths of investigation to address this radiation problem, first consider the significance of Eq. 27. The possibility that an electron or muon is a pseudo photon looping back on itself is one possible path of investigation. The second is to provide a detailed analysis of a light speed particle's radiation characteristics. There is no a priori reason to assume that a light speed particle should radiate in the same manner as a subluminal particle, nor is there a definite a prior reason to assume that it does not. But to reiterate, this model does produce extensive agreement with experiment in spite of this radiation question.

The Proton Model

The proton consists of a sigma hyperon and still another negative mass tachyon. However, the sigma hyperon -> proton conversion has no curve with a clearly defined cutoff energy such as there is for the electron and the muon. Therefore, an inverse approach must be used for the proton. Using the above configuration and the magnetic moment of the proton (mu_P = $1.4106076 \times 10^{-23}$ ergs/gauss) in Eq. 24, we find that the charged particle's orbital radius, r_c , is 0.58736077 fm.The masses of the proton and sigma hyperon are 938.27231 MeV and 1189.37 MeV, respectively. The result is that their mass ratio is R_P =1.2676, and the mass of the tachyon is -251.10 MeV. Using these values in Eq. 15, the radius of the tachyon's orbit is found to be 2.782 fm. High energy and low energy scattering experiments indicate that these radii agree with experiment to within 3 %.

The Neutron Model

Adding a similarly orbiting, but smaller negatively charged pion with its tachyon to the center of the proton, and we have a neutron. That is to say, it is a coaxial model with the orbits sharing the same orbital plane and revolving in the same direction. Subtracting the magnetic moment of the neutron ($mu_N = 9.6623707 \times 10^{-24}$ ergs/gauss) from that of the proton, we find that the orbiting pion's magnetic moment is $mu_{pi} = 0.4443705 \times 10^{-23}$ ergs/gauss. (Note, incidentally, that this value is within 2.5 % of the magnetic moment of the deuteron.) Using this value in Eq. 24 to calculate the radius of the orbiting pion's charged particle, we find it to be 0.18503077 fm. High energy scattering experiments have verified this value. Equating the pion's de Broglie wavelength to the circumference of its orbit, its energy level is found to be 4076 MeV. Its excited levels are found to be

$$E_m = 4076/n^2 \text{ MeV},$$

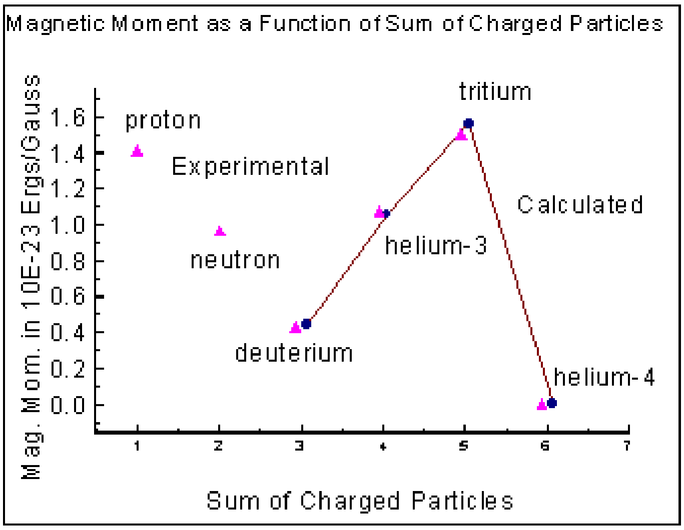
with values of the index, n, ranging from 1 through 9. This accounts for energy levels of the meson model previously shown. The first of these resonances to be discovered was a neutron resonance and was called the J particle by S. Ting. Then, the same resonance was found in ep collisions by B. Richter. Hence, it appears that the meson family consists of various states of the pion, both within the neutron and in the electron.

The Light Nuclei

Now consider the attraction of neutrons and protons to form a deuteron. If a proton approaches a neutron, its sigma hyperon will attract the neutron's pion, thus axially deforming the neutron and causing it to behave as a deformable dipole. While the sigma hyperons electrostatically repel one other, they are both attracted to the pion, thus causing this model to be somewhat similar to the Yukawa model. This produces a highly nonlinear attractive force, so that an experimental evaluation of the force would cause it to appear to have no relationship to simple electrostatic forces.

The spacing of the sigma hyperons is 1.323 fm, and their magnetic energies are 0.2276 MeV each. Using these, the sum of the calculated electrostatic and magnetostatic binding energies is 2.381 MeV, as compared with the measured deuteron's binding energy of 2.2246 MeV, a 7.0 % difference. Similarly, crude calculated values for the binding energy of tritium is 28.3 % less than the experimental value, and for the helium-three binding energy is 43 % less than the experimental value. This is discussed in detail in The Physics of Tachyons.

These values are not precise because they are based on crude estimates rather than carefully integrated algorithms. However, in spite of the lack of precision, an argument can be made that these light nuclei could be at least partially bound by electromagnetic forces, and not totally by a separate nuclear force. It is likely that with more careful calculations, better agreement will be obtained.



But if these large errors are disturbing, it should be noted that a perusal of the Physical Review will reveal many models with errors of 50 %, or worse, in those cases where the authors have the nerve to make a comparison with experiment. In many cases, they conveniently ignore that little matter of comparison with experiment, but the mathematical elegance can be impressive, even if it is useless.

The calculated magnetic moment of deuterium is within 2.5 % of experiment, the calculated magnetic moment of helium-three is within 1.7 % of experiment, and the magnetic moment of tritium is within 3.5 % of experiment.

"Space Warps"

And for those who might ask, there is no "space warp" of any kind involved in this model, nor any similarity to anything mentioned in Star Trek outside of the word "tachyon". But of course, the demonstration of the existence of tachyons might well suggest the possibility of someday breaking the light speed barrier. Obviously, that would require some advancement beyond our present technology.

How to Obtain Detailed Information on the Tachyon Model

The negative mass tachyon is described in various publications by Ernst L. Wall in the standard physics literature. It is also described in the 241 page book, The Physics of Tachyons, Ernst L. Wall, 1995, ISBN I-57485-001-6. It is published by the Hadronic Press, 35246 US 19 North #115, Palm Harbor, FL 34684, USA. Phone: (813) 934 - 9593. Special Price for Individuals, $30.

The book is also carried by:

o The International Tesla Society, PO Box 5686, Colorado Springs, CO 80931. Phone (800) 397-0137;

o Quantum Books near MIT for Boston area residents, (617) 494-5042.

Additional Publications by Ernst Wall

o "The Role of Tachyons in Electron Spin and Muon Spin", Bulletin of the American

Physical Society, 30, 729 (1985).

o "The Role of Tachyons in Proton Spin", Bulletin of the American Physical Society, 30,

729 (1985).

o Indirect Evidence for the Existence of Tachyons: A Unified Approach to the mu->e and

the pi->mu Conversion Problem", Hadronic Journal 8, 311 (1985).

o "On Tachyons and Hadrons", Hadronic Journal 9, 239 (1986).

o "Unresolved Problems of the Tachyonic Models of the Electrons and the Muon",

Hadronic Journal 9, 263 (1986)

o "Time Cancellation Hypothesis", Bulletin of the American Physical Society, 33, 1076

(1988).

o "Charm, Other Resonances, and the Tachyonic Particle Model", Bulletin of the American Physical Society, 33, 1076 (1988).

o "On Pion Resonances and Mesons, Time Cancellation, and Neutral Particles", Hadronic

Journal 12, 309 (1989).

o "Hamming Code Error Correction for Microprocessors", Chapter 3, Microprocessor Applications Handbook, edited by D. Stout. McGraw-Hill, 1981.

o "Applying the Hamming Code to Microprocessor- Based Systems", Electronics (McGraw-Hill) 52, p. 103 (1980). (Note that this was the feature (cover) article of this issue.)

o "Edge Injection Currents and Their Effects on 1/f Noise in Planar Schottky Diodes", Solid State Electronics 19, p. 389 (1976).

o E. D. Adams, G. C. Straty, and E. Wall. "Thermal Expansion Coefficient and Compressibility of Solid Helium-three", Physical Review Letters 15, p. 549 (1965)

o E. D. Adams and E. L. Wall. "Thermal Expansion Coefficient and Compressibility of Solid Helium-three", Bulletin of the American Physical Society 10, p. 519 (1965). (Note that these were the first measurements of the PVT surface of solid helium-three.)

Other Interesting Technical Web Sites

The Institute for New Energy - Click Here

Phil Gibb's Old Cyclotron Laboratory - Click Here

(More to be added later.)

APPENDIX

- **Causality** - While many physicists worry about the causality associated with the reverse time direction of tachyons, it is pointed out here that in this model, the tachyon is bound to a positive mass, charged particle in a closed system, and so the effects of causality need not be worried about, at least in the case of a first order calculation. Insofar as time travel is concerned, the random nature of atomic processes would likely preclude anyone getting younger if he achieved hyperluminal velocities. This is not to say that reverse time has no effect whatever. It might well be that there is a cancellation effect between the reverse time of the tachyon and the forward time of the charged particle, but only at the microscopic particle level. However, that possible effect has not been explored extensively, as yet. More is said about this in The Physics of Tachyons. But, consider that the Starship Enterprise, on a brief junket to the colony on Neptune, goes to warp factor 1 until it gets near Neptune, and then it drops below light speed. Have the colonists on Neptune gone backwards in time just to accommodate the Enterprise? Not likely! Have the crew members become younger? Not likely, because molecular processes will still be random processes.

- **Precedence** - This model began as an ad hoc model, and many physicists object ad hoc models. However, when it was extended to other areas than the lepton family, it produced surprisingly good results. But for those who still object, they should recall that the Kepler model was pure ad hoc, but it influenced Isaac Newton in his development of classical physics. Planck's black body radiation model was pure add hoc. Einstein described his photoelectric equation as "heuristic", i.e., one step above ad hoc. Bohr's model was ad hoc. De Broglie's thesis committee considered his thesis to be ad hoc. In fact, Einstein's recommendation was necessary in order for them to accept the thesis. Without these developments, Schroedinger's and Heisenberg's work would not have been developed, or if it had, it would have been pure ad hoc because there would have been no rationale for the development. Further, some would argue that Dirac's model was ad hoc because there was no a priori reason for his utilizing matrices the way he did. He himself said of it that "I was only looking for some pretty mathematics." So if anyone wishes to retain his intellectual "purity of essence" and not use ad hoc models or anything derived from them, then that person fobidden to utilize Newtonian mechanics and quantum mechanics.

- **Light Speed Charged Particles** - It is inherent in this model that the magnetic moment of particles arises from very tiny charged particles revolving in very much larger orbits at the speed of light. This allows the revolving charge to have sufficient area to generate a magnetic moment while remaining consistent with the experimental observations that the charged particle is extremely small. As will be shown, the radius of the electron's charged particle's orbital radius is 386.15933 fm, or the reduced Compton wave length for the electron. Likewise, the muon's charged particle's orbital radius is 1.8675947 fm, or its reduced Compton wavelength. The absolute maxim diameter of the charged particle, based on this model, is 0.185 fm, with no lower limit. (High energy scattering measurements indicate that its radius is actually of the order of 10^{-4} fm.)

This is a radical departure from conventional models. These charged particles are not accelerated to these velocities, but when the particles are created, they are created with these orbital velocities, much in the same sense that tachyons are created with hyperluminal velocities.

- **Charged Particles as Stationary Photons** - These revolving systems, such as electrons, appear to behave as stationary photons, but they are bound by the laws of relativity when they move as a system. But for the extreme skeptic, recall that there is some indication that the jets ejected from quasars appear to have light speed velocities, so that there may be some prior precedent for luminal, or even superluminal, light emitting particles. (Note also that Lucas and Bergman have a particle model that does not use a point charged particle, but uses a ring charge that revolves at light speed. It does not use tachyons to maintain the system balance. See their web site at www.cormedia.com/css/info.html.)

- **Radiating, Revolving Charged Particles** - A common objection expressed about this kind of model is that revolving charged particles would be expected to radiate their energy away. However, it is to be emphasized that this is a light speed particle, and there is no a priori reason to assume that it must radiate its energy away as would be expected for sublight speed particles. But in the simplest case, consider its orbit to be a ground state orbit. (Shades of Neils Bohr! It worked for him!!) But a more specific explanation is to be found in the fact that the revolving light speed particles appear to be stationary photons. (For more on this, see Eq. 27 and the discussion following it.) But more important, the equation that describes revolving charged particles does not hold for light speed particles. It goes to infinity at these speeds.

- **Relativity** has passed every test to which it has been subjected, but it has been tested only in the subluminal domain. While it *might be* possible that relativity is relevant to the luminal and superluminal domain, there is no a priori reason to assume that it *must* be particularly relevant to these domains. This model is concerned only with luminal and hyperluminal velocities and is, therefore, not at variance with *any measured* aspect of relativity.

- **Quantum mechanics** has been extraordinarily accurate in its description of the atom. This model utilizes only simple quantization, and it does not attempt to arrive at a wave function for the internal structure of the particle systems. However, there is little to place it in conflict with quantum mechanics as it applies to atomic structures, although its definite structure may bother some quantum theorists.

- **Neutrinos** have been detected, so therefore, they exist. However, estimates of the of the neutrino masses via Kurie measurements give upper limits of about 10 - 20 eV, so it does seem rather strange that it could be believed that the shape of the mu-> e curve (up to 52.6 MeV) can be determined by such small, non-photonic particles. Further, it should be pointed out the residual energy from the tachyonic mu-> e conversion is 19.83 eV, and the residual energy of the pi -> mu conversion is 122.97. These numbers are within range of the respective experimental estimates of the upper limits of neutrino masses. In any case, they are not needed to account for the Bohr magneton in this model.