THE BALANCED T.O.E.

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**A** Theory of Everything (T.O.E.) is desired which will describe how all the basic natural forces (electromagnetism, the strong and weak nuclear forces, and gravity) operate. The more things the four forces have in common, the easier the task will be...but what about things which they *almost* have in common? For example, simple observation leads us to think that various fundamental things tend to exist in pairs of opposites: left and right; plus and minus; forwards and reverse; etc. Three major groups of "symmetrical" phenomena are recognized: (1) Parity, in which the mirror image of an event is an equally-likely event; (2) Charge-Conjugation, in which interactions among particles of matter can be duplicated among equivalent particles of anti-matter; and (3) Time-Reversal, which states that if a recording of an event is played backwards, the event-in-reverse is a possible distinct event -- especially for events among subatomic particles. Anyway, the idea of Symmetry provides a useful guide to what to expect when a new phenomenon is encountered (it will probably be one-half of a Symmetry)...but the Weak Force has not cooperated very much! In this essay I wish to describe some of that unaesthetic non-symmetry, what physicists have done -- and might yet do -- about it, and various related notions.

**B**ut first, if observation leads us to think that fundamental things tend to exist in pairs of opposites, then can the idea be applied to *every* fundamental thing? A List of Fundamental Things in Physics is not very long: (1) Space; (2) Time; (3) Mass/Energy; (4) Momentum; and (5) the four natural forces. Now compare the list to the three recognized rules of Symmetry: It is easy to see that Parity is matched with Space, and Time-Reversal is matched with Time. The third Symmetry, Charge-Conjugation, can be tied to three of the four forces, but most obviously with Electromagnetism. (Yet that Force has been Unified with the

Weak Nuclear Force, and the Strong Force features particles which possess "color charges" -- which in turn can be balanced with "anti-colors", much like opposite electric charges.) Now what about Mass/Energy or Momentum or Gravity?

**C**onveniently with respect to Momentum, while it is quite important enough to be on the List, its very definition (which encompasses Space and Time and Mass) automatically matches Momentum with both Parity and Time-Reversal. For Mass/ Energy, there have been occasional speculations that anti-matter (from Charge-Conjugation Symmetry) would have "negative mass"(1) -- which would automatically match Mass/Energy with that Symmetry. However, a simple look at known facts makes this particular match impossible. Consider the equation $\mathbf{E}=\mathbf{mc}^2$; negative mass must be associated with negative energy: $(-\mathbf{E})=(-\mathbf{m})\mathbf{c}^2$. If anti-matter possessed negative mass, it would have to be made from negative energy -- but in actual fact physicists make particles of anti-matter all the time from only *ordinary* energy. Therefore anti-matter must have only ordinary mass.

**D**ivorcing the fundamental thing which is Mass/Energy from the three primary rules of Symmetry, however, means either that Mass/Energy must forever remain an asymmetrical phenomenon, or that a new Symmetry is waiting to be discovered! After all, the general idea of symmetry implies that *just because* ordinary mass and energy actually exist, so also should exist negative mass and negative energy. We can even be more specific, and associate Gravity, too: If Mass/ Energy can be linked to something which we might call "gravitational charge", then by Charge-Conjugation, negative mass/energy *should* exist! Yet one ought to be wary of such simplistic reasoning; it would be better if negative Mass/Energy can fit into Physics by solving some tough problems. (Finding and identifying some negative mass or energy would be nice, also!) As it happens, I know of a few problems which may benefit from the existence of negative mass/energy:

**1. A**t one time Symmetry seemed more important to Physics than appears to be the case nowadays. When it was first discovered that the Weak Force could violate Parity, there was a rush of head-scratching to find a way to put some symmetry back in the situation. Eventually it was shown that if a given event among ordinary-matter particles had a preferred direction or "handedness" (which is the definition of a Parity violation), then among particles of anti-matter the equivalent event would have a preference for the opposite direction. This is a symmetry rule which combines both Charge-Conjugation and Parity, and is usually called "CP-Symmetry". At the time it seemed that there was a possible use for the new rule: Suppose the Universe consisted of equal amounts of matter and anti-matter; if we encountered an alien civilization, how could we be sure that its substance was the same type of matter as ours? Just ask the aliens to observe a Parity violation, and note which direction is preferred....

**B**ut physicists in our civilization have since learned that the question is moot: The Weak Force could sometimes violate even the CP-Symmetry rule, and as a result our Universe probably contains no large amounts of anti-matter! So an even greater symmetry rule was proposed, which included Time-Reversal; it is called CPT-Symmetry. Imagine a Universe which is composed almost entirely of anti-matter: *If* Time in that Universe flowed in reverse, relative to our Universe, then perhaps that Universe would be Symmetrical....

**C**ontinuing its weirdness, the Weak Force has in recent years revealed an ability to violate even CPT-Symmetry. What now? There aren't any more major rules of symmetry! Unless we create one.... Suppose a Mass Symmetry rule is proclaimed, and then immediately meshed with the other rules to create a grand CPTM-Symmetry. This allows close examination of the properties of negative mass and negative energy; it is easy to start with the assumption that they are very symmetrical with respect to normal mass/energy:

**i.** If some negative energy was condensed into matter, particles created might well be the negative-mass equivalents of the ordinary electron and the ordinary anti-electron. A label such as "negative-mass electron-equivalent" seems worth simplifying: Let us call negative-mass particles "negma-particles", and negative-mass anti-particles "negmant-particles" (e.g., negma-electrons and negmant-electrons). Negma-matter and negmant-matter are obvious terms, too; for negative mass/energy in general, how about "negma-stuff"?

**ii.** It seems reasonably easy to imagine a whole Universe of negma-matter, experiencing Time just as our ordinary-matter Universe experiences Time. And an opposite Universe of negmant-matter would be mostly Symmetrical to it, if it could experience Time backwards like the already-described normal-anti-matter Universe. Therefore any violations of CPT-Symmetry in our Universe could be balanced in the appropriate negative-mass Universe.... Yet this scenario, however pleasing it may be to one's aesthetic sense, first requires that a major new symmetry rule be proclaimed: Mass Symmetry. To become really acceptable, however, the rule should be able to solve more than just one problem....

**2. A**n intriguing problem begins with a Universe-wide phenomenon sometimes called "the energy fluctuations in the vacuum". Thanks to a fundamental rule in Quantum Mechanics known as the Uncertainty Principle, "virtual particles" are forever and everywhere spontaneously popping into existence for extremely short time-periods. They disappear so quickly that only some side-effects of their temporary existence can be detected. I will call this Universe-wide thing "the aether"...a key question is, "What is the average energy-content of the aether?"

**B**eginning with the idea that there are always, everywhere, *some* virtual particles present, the average energy-content of the aether ought to be rather greater than zero -- despite virtual particles being undetectable. When actual numbers are computed, in fact, the magnitude of that "average" energy-content is so vast that by comparison, everything else in the Universe is as nothing!

**C**onsider one side-effect of the aether's existence: Although virtual particles are undetectable, while they exist they possess real mass/energy which must be associated with gravitational fields. Since the Universe is thoroughly filled with the aether, it follows that an absolutely overwhelming amount of gravitation should be evident in the Universe as a whole....

**D**ashing the expected, the actual facts are these: Some unexplained gravitation does exist in the Universe, but *no way* is there any respectable fraction of the amount needed to match the magnitude of gravitation required by the aethereal "vacuum self-energy". These facts point out a major disagreement between Quantum Mechanics, which states that the aether must exist (as defined here), and General Relativity, which describes the Universe rather well *without any* aethereal gravitation! Thus observation and Relativity give us two reasons to seek a way to eliminate the gravitation of Quantum Mechanics' aether....

**E**asily done -- *if* we proclaim a Mass Symmetry rule. This immediately lets us deduce that negma-stuff virtual particles should exist. Indeed, there should be as many of them as there are normal virtual particles! This instantly reduces the aether's total energy-content from an amount which is astronomically different from General Relativity...to exactly zero. The net gravitational effect of that zero-magnitude aethereal energy-content will obviously also be zero. Thus does Mass Symmetry successfully solve a *major* problem in the task of making Quantum Mechanics compatible with General Relativity....

**3. A**nother pro-negative-mass argument comes from Dr. Robert Forward. Let us suppose *our* Universe contains equal quantities of normal stuff and negma-stuff: Note that our eyes and instruments are not designed to detect negative-energy photons, so any negma-objects in the Universe would be invisible! Yet astronomers *have* observed that the large-scale arrangement of galaxies in the Universe seems to be full of huge voids.... Dr. Forward proposes that negative mass occupies the observed voids, and there are two important consequences:

**i**. If half the Universe consists of negma-stuff, then its total mass is zero, and a *big* problem is solved: "How did the Big Bang circumvent the Law of Conservation of Energy, yielding only the normal mass which we see?"

**ii**. A zero-total mass also means that the future of the Universe is "Open" in the direction of eternal expansion. The *rate* of that expansion, known as "Hubble's Constant", would not have decreased at all since the Big Bang (the common assumption: Mutual attraction of all normal mass slows the Universe's expansion). That attraction is cancelled if negative mass exists, of course.

Bringing up some very recent data, astronomers are finding Hubble's Constant to be too high for the conventional Big Bang theory. (It implies an unacceptably low age for the Universe.) But if the Constant has not decreased from some ancient and higher value, then the Universe might be just the right age...problem solved! (And more on this later....)

**B**roaching two possible tests, I start with a simple one: Take all the data on the distribution of normal mass, and *invert* it. I blithely assume that negative masses gravitationally behave much like normal masses (an assumption to examine later); thus the voids would hold superclusters of negma-galaxies. Such superclusters would be sized by the voids in imitation of known superclusters, branching thread-like from the heart of one void to the hearts of its neighbors, and would arbitrarily be declared visible. All actually-observed clusters would be declared invisible.... Also, a "buffer" of *really* empty space would separate the two types of mass, and remain invisible. What would a Universal Map look like after such an inversion? If it basically looks like the Map we already have...and I suspect it will...then that would be pretty good circumstantial evidence in favor of the existence of a Mass Symmetry rule!

**C**onstruction of special hardware to directly detect photons of negative energy is obviously the best way to verify the notion. A sensor likely has to be maintained at a fixed temperature: When normal photons are absorbed by the sensor, its temperature would go up slightly; when negative-energy photons are absorbed, its temperature would go down slightly. (The sensor's natural rate of cooling is a factor which must be subtracted out.) The telescope-mirror for an array of such sensors must be chilled to nearly Absolute Zero, to reduce its ability to absorb negative-energy photons. (More Symmetry: Normal matter has a temperature above Absolute Zero because every molecule has a positive kinetic energy; negma-molecules would have negative kinetic energy and a temperature *below* Absolute Zero. Absolute Zero is the temperature where normal matter has the least amount of positive kinetic energy -- and also where negma-matter has the least amount of negative kinetic energy. Anyway, if a telescope mirror's temperature is almost at Absolute Zero, it can't go much lower, so it probably won't absorb and probably would reflect negative-energy photons.) The telescope must be placed in outer space, where particles of ordinary matter are as rare as possible -- they would absorb negative-energy photons, and ruin the telescope's view. Finally, point the telescope at the huge voids in the observed Universe. If any negative mass is out there radiating negative energy, we should find it!

**E**xtrapolating from the preceding, I think I will make a prediction about any naturally-occurring chunks of negative mass which we might someday encounter -- if, of course, such stuff actually exists. The extrapolation is as follows:

**1.** Start with the Big Bang, the birth of the Universe. Vast amounts of normal energy and negative energy appeared from Nothing. Some of it probably interacted and vanished again, but most didn't. (Momentum-Conservation yields a picture of the Big Bang as two simultaneous and congruent explosions of opposite types of energy; that same Law makes "total-vanishing-interactions" difficult, but I can't take the space to discuss details of that in this essay.[(2)])

**2. A**s time passed, energy condensed into matter and anti-matter particles, of both normal-mass and negative-mass varieties. Interactions of various types occurred, letting the Weak Force violate CP-Symmetry for both types of mass; particles of matter began to predominate over particles of anti-matter.

**B**elaboring the obvious: Without a violation of CP-Symmetry, matter and anti-matter would exist in equal quantities to this day. Now consider only the case of normal-mass material: Having all the same type of mass, matter and anti-matter would gravitationally attract each other. Annihilations would be continuing to this day, and the Universe would differ from what we observe.[(3)]

**3. A**ssume basic similarities in how ordinary and negma particles interact. A negma-electron and a negmant-electron should be able to mutually annihilate, yielding pure negative energy. But can either interact-to-destruction with the ordinary electron? (Dr. Forward has named such destruction "nullification".)

**B**y noting the electric charges of the particles, it seems that the idea is plausible: If the negma-electron is negatively charged, then the negmant-electron will be positively charged. Since charges must always appear or vanish in pairs of opposites, the ordinary electron can only mutually nullify its positively-charged negative-mass equivalent....[(4)]

**4. A**nd now the goal of this reasoning: *If* violations of CP-Symmetry had yielded preponderances of *mutually nullifiable* particles at the time of the Big

Bang, then nullifications would have had a significant effect on the evolution of the Universe! (Even assuming that the two types of mass gravitationally repel each other, consider the early period of freely-flying particles, before atoms and clumps of matter began to form.)

**B**ehold today's Universe: Just as it would be different if matter/anti-matter annihilations had occurred for ages, so would it differ if a long period of nullifications had occurred. So violations of CP-Symmetry must have yielded types of matter which are not quite opposite enough for mutual nullification. *If it exists, natural negative mass will survive encounters with normal mass!*

**F**or any who think violations of CP-Symmetry in opposite-mass regions of the Universe should have yielded opposite/mutually-nullifiable particles, why? Mass Symmetry was proposed originally to handle only violations of CPT-Symmetry.... Besides, there is a "definition problem" which I must mention, even if I have no answer for it ("opposite" might *not* mean "mutually nullifiable"!):

**1.** Electric charges appear in two types, positive and negative. The exact nature of the thing which we call "charge" is still something of a mystery.

**2.** Is there a fundamental link between Charge and Mass/Energy, such that a negative charge on a normal particle can *appear* identical to a positive charge on a negative-mass particle? (For this reason I have not tried to specify the charges which must be associated with negma- and negmant-electrons....)

**3.** If such a link is real, then violations of CP-Symmetry in opposite-mass regions of the Universe *could* have yielded particles that are *by definition* able to nullify each other, but practically speaking, still can't actually do it!

**G**etting back to something mentioned earlier, it is now time to examine my blithe assumption that the gravitation of negative mass would be Symmetrical enough (to normal mass) to form superclusters of negative-mass galaxies....

**H**ere first is the Physicists' Standard/Conservative View:

**1.** A good approximation of the gravitational force between two masses can be found from the equation $\mathbf{F} = (\mathbf{G})(\mathbf{m}_1)(\mathbf{m}_2)/\mathbf{d}^2$, where **F** is the force, $\mathbf{m}_1$ and $\mathbf{m}_2$ are the masses, **d** is the distance between them, and **G** is "the Gravitational Constant" (a special conversion factor needed to make the equation work).

**2.** Plugging various types of mass into the equation, we get a positive force between two normal masses, a positive force between two negative masses, and a negative force between a pair of opposite masses.

**3.** **A** *m*ass *a*ccelerates in response to a *f*orce according to the equation $\mathbf{F} = (\mathbf{m})(\mathbf{a})$. Here it is necessary to note that forces and accelerations have two aspects, "magnitude" and "direction"; masses only have size. Directions of forces and accelerations are always related. A "frame of reference" in which forces and accelerations can be compared is often convenient; in every such reference frame, opposite directions are labeled "positive" and "negative".

**B**efore proceeding, one final point must be made: *Every force always exists in-between and acts upon two or more things.* ("Things" can sometimes be different portions of a single object). If we now decide to label attractive forces "positive" and repulsive forces "negative", we can always get sensible results, although the consequences might seem a bit paradoxical:

**i.** Start with two normal masses, a simple straight-line reference frame, and a positive/attractive force between them.

**ii.** One mass will obviously be affected by the positive force such that it accelerates in the positive direction of the reference frame.

**iii.** The other mass, because the force is *attractive*, must accelerate in the negative reference-direction (towards the first mass), although we still call the force "positive". See, the idea of attraction is more fundamental to determining the direction of a force -- and the resulting acceleration -- than is the arbitrary definition of positive and negative in a reference frame.

**C**ontinuing with $\mathbf{F} = (\mathbf{m})(\mathbf{a})$, let's keep things simple: When a positive force is applied in a positive direction to a positive mass, we always see the mass accelerate in the same direction. Now what if a negative mass is used? To balance the equation, acceleration must be negative: $+\mathbf{F} = (-\mathbf{m})(-\mathbf{a})$. It is very easy to interpret this new equation as saying, "A negative mass will accelerate in the direction *opposite* to the direction in which the force is applied."

**4.** Having presented enough background material, we now return to -- and expand upon -- the results of the gravitational-force equation:

**i.** Two positive masses yield a positive/attractive force in-between each other, and respond to that force by accelerating towards each other.

**ii.** Two negative masses yield a positive/attractive force in-between each other, and respond to that force by accelerating away from each other.

**iii.** A pair of opposite masses yield a negative/repulsive force, and respond by accelerating in the *same* direction (the positive mass in front).

**5.** The key result is the second one; it plainly states that the influence of gravitation between negative masses will *not* allow them to accelerate towards each other, and to thereby eventually form superclusters of galaxies. So much for that aspect of Mass-Symmetry! But that's not all:

**i.** For normal electrons and protons, the Electromagnetic Force is attractive, and they accelerate towards each other to form atoms. For negma-electrons and negma-protons, atoms would *not* be possible.

**ii.** For normal quarks, the Strong Nuclear Force is attractive, and they accelerate towards each other to form such important particles as protons and neutrons. Negma-quarks *cannot* make negma-protons and negma-neutrons.

**iii**. The Weak Force already violates symmetries aplenty. With the other three natural forces violating Mass Symmetry, need we say more?

It is now my turn to offer a counter-argument:

**1**. Consider the equation **f** = (**E**)/(**h**), which describes how the *f*requency of a photon (how many cycles per second does it vibrate while moving) relates to its energy-content. Obviously the more energy, the greater its frequency. The conversion factor (**h**) is Planck's Constant, after Max Planck, who created this equation in the year 1900. That equation is at the very foundation of all of Quantum Mechanics, so Planck's Constant appears in many other equations as well. Here is the question of the moment: "What happens when the equation is used to describe a negative-energy photon?" A second minus sign is required to balance it; this leads us to either **-f** = (**-E**)/(**h**) or **f** = (**-E**)/(**-h**) ...but which? The "negative frequency" of the former means we must deal with negative Time; before pursuing that concept, let's try the latter equation. In it we note that the "dimensional units" of Planck's Constant are Energy multiplied by Time, so (**-h**) can simply mean that its Energy "dimension" is negative. This is *consistent* with the negative energy of the photon! The latter equation is thus a logical and superior choice, simpler than adding a whole new concept, negative Time.[5]

**2**. Once we accept a negative Planck's Constant in the original equation of Quantum Mechanics, being consistent requires us to replace (**h**) with (**-h**) in *all* other equations which we use to describe negma-stuff! With extra minus signs sprinkled about, it becomes quite likely that the results of those equations will differ from what they "conservatively" say about negma-stuff....

**i**. The physicists' description of the Strong Nuclear Force is called "Quantum ChromoDynamics" -- QCD for short. It explains how quarks will interact with each other by exchanging virtual particles called "gluons" -- and thereby experience a strong attractive force. For negma-quarks (which will exchange negative-energy gluons), and using (-**h**) throughout QCD, it becomes reasonable to expect the Strong Force to be repulsive. Having negative mass, the quarks would respond to that force by sticking together just like ordinary quarks. Negma-protons and negma-neutrons may exist, after all!

**ii.** The Electromagnetic Force is thoroughly described by "Quantum ElectroDynamics" -- QED for short, in which virtual photons are exchanged by charged particles. When those particles have negative mass, and the virtual photons possess negative energy, and (-**h**) is used in place of (**h**), it becomes reasonable to expect the Electromagnetic Force between like charges (and like magnetic poles) to be attractive, while the force between unlike charges and poles would be repulsive. The negma-particles would then respond to those forces: Unlike types would accelerate towards each other, and like types would accelerate apart. Negma-atoms and negma-molecules, quite Symmetrical with respect to the ones we know, should be able to exist as a result.

**iii.** The Weak Nuclear Force offers the most interesting case, because it started the whole problem of what to do about Symmetry-violations. The truly wonderful thing about changing (**h**) to (-**h**) in the equations which describe the Weak Force, whenever they are applied to negative mass/energy, is simply this: *It will be impossible for the Weak Nuclear Force to violate CPTM-Symmetry!*

**iv.** As for the Gravitational Force, this has yet to be explained very well in terms of Quantum Mechanics. But note the Gravitational Constant **G:** In Q.M., **G** will be more than merely a conversion factor; it will be no less than a compressed description of how masses emit and absorb virtual gravitons! The decompressed description will almost certainly incorporate Planck's Constant... so for gravitational interactions among negative masses, and with (-**h**) inside **G**, turning it into -**G**: The masses would accelerate towards each other; planets, stars, and superclusters of negma-galaxies *could* exist!

**J**ust a few final items remain:

**1.** One proposal for a Theory Of Everything is called "Supersymmetry". It doesn't include Mass Symmetry...*shouldn't* something that fundamental come first?

**2.** If half the Universe consists of superclusters of negma-stuff, while the other half consists of superclusters of normal matter, then perhaps the big clumps repel each other, increasing both the size of the "buffer" of empty Space separating them, and assisting the expansion of the Universe. Could Hubble's Constant have actually have *increased* over time?[(6)] (Yet if the Universe's total mass is zero, can any balanced distribution of its mass lead to a net force?)

**3. A** fascinating subatomic particle is the neutrino, which has startled physicists for more than half a century. Its very existence had to be deduced from tiny discrepancies in the energy released during radioactive decay. It interacts so rarely with other particles that it eluded direct detection for two decades. Then it turned out to exist in two (and later three) distinct types -- and the nature of that distinction is still unknown. It casts doubt on well-understood astrophysics, because the Sun seems to be radiating only a third as many neutrinos as expected. And worst of all, a number of recent experiments indicate that the neutrino has a tiny mass -- an ***imaginary*** mass, such as is mathematically described by the square-root-of-negative-one!!![(7)]

**B**y comparison, the notion that particles might exist which possess merely *negative* mass, as described in this essay, is extremely easy to accept. If more experiments eventually verify an imaginary mass for the neutrino, then physicists will have every reason to *expect* both negative mass and negative energy to exist in Nature!

ADDENDUM -- MAY 2002: The following is associated with reference-numbers that were inserted in the prior text (no other modifications were made).

(1) For the record, I was introduced to the notion of negative mass by an essay written (mid-1960s) by Isaac Asimov, "I'm Looking Over a Four-Leaf Clover". From the context of that and a couple preceding essays – see his book *Science, Numbers, and I* -- my suspicion is that Asimov is either *the* originator of the idea, or at least he independently originated the idea.

(2) The space for that is taken in "The Imaginary T.O.E."

(3) Thus observation of the Universe as a whole tends to confirm observation in particle-physics laboratories, that the Weak Force can violate CP-Symmetry.

(4) A quick assumption/simplification made only so that part of the essay can progress. The notion is examined in more detail shortly thereafter, and certain other aspects are examined in even more detail in "The Imaginary T.O.E."

(5) OK, I know that Negative Time was already introduced in terms of Symmetry. However, what I was trying to say is something like "Do we want to think that Negative Mass experiences Time in the same way as ordinary mass, or not?" If not, then *that* is "adding a whole new concept". Besides, if Negative Time has already been used to account for the behavior of ordinary anti-matter, then what could we say about Negative-Mass anti-matter? Applying Schrödinger's "wave equation" to negmant-matter will still require us to incorporate Negative Mass along with either negative frequency or negative Planck's Constant! Meanwhile, taking advantage of the factor of energy in the dimensional units of Planck's Constant (making it negative) is still a simpler consistent thing, in "meaning".

(6) Actually and truly written in 1995. Data gathered between then and 2002 has been interpreted to mean that the expansion of the Universe is indeed accelerating. This has also led to speculations about yet another Force of Nature, of a repulsive type. Personally, I seriously wonder how the cosmologists can be sure of what the original rate of expansion was – what if it was some higher value that has never changed? On the other hand, if the expansion of the Universe is indeed accelerating, is there a way to explain it without invoking a Fifth Force? What about the gravitational "repulsion" (I admit to using the term loosely just now) between ordinary and negative mass, as this essay describes? *Whether zero or plus acceleration, the expansion of the Universe is apparently not slowing, so wouldn't those observations tend to qualify as evidence in favor of the existence of Negative Mass in the Universe?*

Belaboring the possibility of accelerating expansion, well, if it really is possible that mixed/equal magnitudes of opposite masses can lead to overall repulsion--and my doubts about that were originally expressed just after the location of reference-number (6)--then here is a speculative rationale:

Contrary to the name of this essay, what are the chances that gravitational "repulsion" between ordinary and negative mass might simply be a slightly greater-magnitude thing than gravitational attraction between/within quantities of either ordinary mass or negative mass? Then all we need is a Fifth Symmetry Principle, instead of a Fifth Force! ("The Imaginary T.O.E." offers, among other things, a highly speculative basis for a Fifth Symmetry.)

"Debates" about my above-mentioned doubts have figured in my thoughts over the years. The large-scale structure of the observed Universe is kind-of sponge-like, with intersecting filaments and voids. If as the essay describes we must think about two "interpenetrated" sponges, one of ordinary mass and one being negma, then what is the overall effect? The ordinary-mass portion will try to gravitationally collapse, and the negative-mass portion will separately try to also collapse. The intersections, after all, are superclusters of galaxies. If both "sponges" repel each other, then does the Universe's original rate of expansion increase? Perhaps it can, until enough room opens up to allow the separate collapses...and in that case no Fifth Symmetry would be needed.

Even when not thinking about that, other notions occasionally came along that had to be examined. Here's one showing a possible flaw in the fundamental idea of this essay, that the "aether" consists of equal quantities of ordinary and negative virtual particles -- the notion known as the Casimir Effect:

1. If two ordinary metal plates are placed very close to each other, flats facing each other, and although uncharged and unmagnetized, they will be observed to move toward each other. (It is my understanding that the plates are placed too far apart for "van der Waals" forces to be the explanation, either.)

2. Casimir presented the concept that if the plates are close enough together, then some of the ordinarily-appearing virtual particles in the vacuum will not have enough room, between the plates, in which to come into spontaneous existence. But away from the plates all the full variety of virtual particles will continue to appear. Thus there should be a "pressure" imbalance, with more pressure outside than between the plates -- and sure enough, the plates do move toward each other, with an amount of force that may even be predictable.

From that experiment I must deal with a dilemma: If half of all virtual particles are negma-stuff, *which are assumed to cancel out each other's gravitational effects*, then do we still have a theoretical basis to assume any other kind of imbalance (like pressure) can exist? If not, then the rationale behind Casimir's Effect blows a hole in the primary tenet of this essay.

Grasping at straws, then (partly because I don't really know if I need to be writing this!), I shall present the following wild speculation:

1. Start with the idea that some plain "empty" vacuum might be full of equal quantities of ordinary and negma virtual particles.

2. Add some ordinary mass, and ask, "If this stuff repels negma-stuff, then can it inhibit the spontaneous appearance of nearby virtual negma-stuff?"

3. If so, then there will be an imbalance in the ratio of appearance of ordinary virtual particles to negma virtual particles, around all ordinary matter (and vice-versa around any actually-existing negative matter). One consequence is simply that this imbalance, in the Mass-Symmetry of virtual particles, can lead to the kind of pressure imbalance that the Casimir Effect reveals (well, *if* I need to write this, and *if* this suggested type of imbalance is significant enough), but there should be another consequence, also!

4. There should be some additional Gravitation associated with that imbalance. This will not be of the same astronomical magnitude as what was originally described/predicted by pure Quantum Mechanics (in contradiction to General Relativity), because the "imbalance ratio" described here will probably not be enormous. Perhaps it will happen to be just the right amount to explain some of the unexplained extra gravitation that allows mysteriously speedy galactic rotations. (Sure, *some* of that can now be explained by MACHOs and neutrinos, but all of it?)

(7) Later experiments are considered to be more accurate, and indicate a tiny ordinary mass for the neutrino. While this was a fun notion to contemplate (especially in "The Imaginary T.O.E."), nowhere do I claim that those early experimental results had to be accepted as fact.