THE IMAGINARY T.O.E.

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An imagination is a wonderful thing; it lets one burst free from the bonds of "conventional wisdom" and usher something new into the world. In recent years physicists have put a great deal of imagination into constructing what is known as a Theory Of Everything (T.O.E.). Unfortunately, there are almost as many T.O.E.s as there are physicists exercising their imaginations. Winnowing them down to a final choice is the task of the experimenters; Nature has the Last Word when the problem is to imagine things about Reality.

Before one reads this very speculative essay, there are three other essays which provide background information. They note that one task of a Theory Of Everything is to make Quantum Mechanics and General Relativity compatible with each other. In those background essays, attempts are made to show how modest changes in various fundamental ideas of Physics can lead to major increases in the compatibility of those two most important of modern theories:

1. "The Stubbed T.O.E." suggests that the idea of "potential energy" must take a consistent form, if *all* natural forces are ever to be Unified. That form is mass; if gravitational potential energy appears as mass, it is possible to extract from Quantum Mechanics the ideas that Time and Space (or lengths) are affected by a gravitational field, much as is stated in General Relativity.

2. "The Ghostly T.O.E." suggests that the most fundamental idea in Quantum Mechanics is a thing known as "energy fluctuations in the vacuum". *Everything*, every single real elementary particle, is constantly interacting with "virtual particles". Those fluctuations can cause light to go slower and take a curved path through a gravitational field, much as is stated in General Relativity.

3. "The Balanced T.O.E." suggests that something called "negative mass/ energy" should be able to exist in Nature, mostly because just about everything *else* in Nature seems to be linked to a Symmetry of one kind or another. Also, a problem with Quantum Mechanics arises if *only* ordinary mass/energy exists: The fluctuations just mentioned should have an extreme gravitational effect upon the Universe. That effect is not observed, nor does General Relativity predict it. With Symmetry and "negative-energy fluctuations", the problem is cancelled out!

Continuing with the present essay, I wish to tie up some loose ends, and to imagine things about gravitons, the key particles which Quantum Mechanics needs to explain how gravity works. Here are some ideas from the background essays:

1. One virtual-graviton is produced each time any particle vibrates due to the wave-particle duality. Thus the number of virtual-gravitons emanating from any object will always be directly proportional to its total mass/energy.

2. Virtual-gravitons may themselves be sources of other virtual-gravitons. General Relativity requires this because the gravitational field of an object is a form of energy, the existence of which enhances the total gravitational field.

3. Virtual-gravitons interact with other particles (including gravitons) very rarely. This lets Gravitation be the weakest force in Nature, allows them to escape a black hole, and possibly permits them to travel faster than light.

Delving now into the main body of this essay, let us begin by discussing the topic of negative mass for a time. Newton showed how forces and accelerations lead to an understanding of normal mass; let us try it for negative mass.... Physicists say that when a (repulsive) force is applied to a normal mass in a particular direction, the mass accelerates in that same direction. An opposite force (either attractive and applied in the original direction, or repulsive and applied in the opposite direction) causes the mass to accelerate opposite to the original direction. Using a larger force or a smaller mass results in greater acceleration (changes of magnitude, all) -- and vice versa. Suppose we apply a particular force to a series of decreasing masses: Each accelerates faster than the last. An object having no mass at all might be expected to accelerate at an infinite rate -- and photons do, indeed, instantly begin moving at light-speed upon being created. But the next object in the series, possessing negative mass, should accelerate at *more*-than-infinite rate! And what does that mean...?

Examining the equation **F** = (**m**)(**a**) provides an acceptable answer. If (**m**) is negative while **F** is positive, then (**a**) must be negative for the equation to balance. Thus a more-than-infinite acceleration in a particular direction is equivalent to a less-than-infinite acceleration in the opposite direction.

For an alternate but similar line of reasoning, consider a specific distance across Space to be traversed in a series of decreasing times: Each successive velocity at which the distance is traversed must be greater than the last. To traverse it in zero time the velocity must be infinite; to traverse it in less-than-zero time the velocity must be more-than-infinite...yet that same velocity is easily expressed as (**s**)/(-**t**) -- it is a *negative* velocity!

Going out on a temporary tangential limb, the astute reader will have noted a difference between the negative velocity in the previous paragraph and the negative acceleration in the next-previous paragraph: The negative velocity is negative due to its "Time" component, but the negative acceleration is assumed to be negative due to its "direction" (or Space) component. Is the assumption correct? Well, "acceleration" is expressed in detail as $(\mathbf{s})/(\mathbf{t}^2)$ -- if we have a negative acceleration then we either have $(-\mathbf{s})/(\mathbf{t}^2)$ or $(\mathbf{s})/(-\mathbf{t}^2)$. Negative Space has already been defined in terms of direction, while $(-\mathbf{t}^2)$ implies Time-with-an-imaginary-component (the square root of minus-one)! Obviously it is easier for physicists to stick with what they know, and to prefer the negative-Space type of negative acceleration. However, for the duration of this tangent let us speculate about an imaginary-Time-axis, distinct from the normal-Time of normal physics. The reason relates to all the types of matter which have been presented by now (including the previous T.O.E. essays):

1. Ordinary matter having ordinary mass experiences normal Time in the normal way -- this is the by-definition default.

2. Anti-matter having ordinary mass also experiences normal Time in the normal way. The assumption of CPT-Symmetry is that *IF* anti-matter experienced normal Time in the opposite way, then its behaviour would be basically the same as the behaviour of ordinary matter.

3. If neutrinos have imaginary mass, then they should experience normal Time in the opposite way. This is because imaginary-mass particles have been studied in a hypothetical way for a couple decades, and are usually referred to as "tachyons". They should also always travel faster than light-speed...which may cast some doubt as to whether neutrinos truly have imaginary mass: The explosion of Supernova 1987A was heralded by a wave of neutrinos, but they were little faster (if at all) than the main flux of photons from the blast....

4. Anti-neutrinos would have the same kind of mass and experience Time in the same way as regular neutrinos. One intriguing consequence of imaginary-mass neutrinos/anti-neutrinos regards their interactions with normal matter: A lone neutron is an unstable particle which decays into a proton, an electron, and an anti-neutrino. Where was the anti-neutrino's imaginary mass while the neutron was intact? Can so-called "normal mass" really be a "complex" thing, having both a normal component and an imaginary component? Can an imaginary component to the mass of normal matter explain such mysteries as the "spooky action at a distance" of the Einstein/Rosen/Podowsky paradox???

5. Once the notion of imaginary mass becomes acceptable, then the idea of imaginary energy immediately follows...and only a minor delay should precede the acceptance of imaginary Space, imaginary Time, and imaginary-everything on the List of Fundamental Things. For evidence see the discipline of electromagnetic engineering, where there is plenty of use of imaginary numbers. The math works, and who is to say that genuine aspects of the Universe are not being described by that math? So it may be possible, after all, to associate negative mass and imaginary Time (symmetrical to the imaginary-mass/negative-Time of tachyons!).

6. According to Symmetry, negative mass should manifest in forms which are equivalent to the particles/anti-particles of ordinary matter. Presumably there may also be neutrino-like particles possessing what can only be called "negative imaginary mass". And Symmetrical to what was described above, the "plain" negative mass would experience imaginary-Time in one direction, while the imaginary negative mass would experience imaginary-Time the other way....

Having sown a few seeds of future speculations, let us now check one more place where Quantum Mechanics and General Relativity need to be compatible. It has been suggested that a Symmetry for mass/energy leads to a negative value for Planck's Constant, which in turn affects all the equations of Quantum Mechanics when they describe negative mass/energy. A negative Gravitational Constant is also deduced, leading negative masses to accelerate towards each other under the influence of gravity. But how might we deduce a negative Gravitational Constant from General Relativity, and the "curved space" which Einstein described? The answer lies in the realm of multidimensional geometry:

1. A mathematician's line possesses length as its only dimension. For a line of finite length, one can always declare the central point on the line to be the "origin" -- for an infinite line, which has no center, any point can be declared the origin. From the origin one can move along the line in either of two directions; most lines are inherently Symmetrical.

2. The mathematician's plane has two dimensions only. Each dimension is associated with a line, and the two lines cross each other to form four angles all alike ("right angles"). By definition the origin of the plane is the point where the lines intersect. The neat thing about a plane is that it can contain curved lines -- and there are two possible directions of curvature: clockwise and counterclockwise.

3. To deal with Space, the mathematician places a third dimension-line at right angles to both key lines in the plane, intersecting the plane's origin. Curved planes, such as the surface of a hemisphere, become possible when there are three dimensions. And just like curved lines, planes can curve in either of two directions: Think of bumps and potholes in a road, for example.

4. At the next level, in order to begin talking about curved Space at all, a fourth dimension-line must be invoked. This line will have to be oriented at right angles to the three dimension-lines of Space, and mathematicians have no problem dealing with such a notion. Multidimensional geometry is *consistent* -- and this means that there are two directions automatically associated with that fourth dimension-line. Therefore if Space can be curved at all, then it can be curved in either of two directions....

By looking at General Relativity from this viewpoint, it is clear that the gravitation of ordinary masses uses only *one* of the two possible directions of Space-curvature! Therefore we may freely associate negative masses with the opposite direction of Space-curvature, and consider the consequences:

i. Ordinary Gravitation can be explained in terms of curved Space something like this: Two ordinary masses each cause Space to curve in the same particular direction. Think of the total amount of curved Space caused by the two separate masses. Now suppose they were together, and think about the total amount of curved Space caused by their combined mass. The second total is less than the first; Gravitation causes ordinary masses to accelerate towards each other *because* the total curvature of Space will thereby become minimized!

ii. For two negative masses, each causing Space to curve opposite to the normal direction, the general description of Gravity can be the same. The total amount of curved Space when they are together will be less than when they are apart; therefore negative masses should accelerate towards each other. In this overall explanation the Gravitational Constant has to carry information about the direction of Space-curvature: It must be (**G**) for normal masses and (**-G**) for negative masses...a Symmetry which is compatible with the previous explanation based on a negative Planck's Constant.

It appears that my attempts to explain how General Relativity and Quantum Mechanics can be compatible with each other...must tie up another loose end. A previously mentioned point was that in Quantum Mechanics virtual gravitons should themselves be sources of more virtual gravitons. But this sounds like the start of an endless chain: Virtual gravitons emit more virtual gravitons which emit more virtual gravitons which...leads to infinite Gravitation!

1. To break that chain we should examine the Uncertainty Principle in some detail. The original expression of it went like this: $(\Delta \mathbf{p})(\Delta \mathbf{s}) = (\mathbf{h})/2\pi$ where $(\Delta \mathbf{p})$ is the Uncertainty in the measurement of a particle's momentum, $(\Delta \mathbf{s})$ is the measurement-Uncertainty of its location in Space, (**h**) is Planck's Constant, and π is pi, the numerical constant 3.14159.... Einstein's form of the Uncertainty Principle (connecting Energy and Time) looks like this: $(\Delta \mathbf{E})(\Delta \mathbf{t}) = (\mathbf{h})/2\pi$, and there are several other Uncertainty relations known to physicists.

2. Note how the Energy-Time relation describes virtual particles: The longer such particles exist, the less energy they can have. Now recall the notion that each time an ordinary real particle vibrates in wave-like fashion, it emits a virtual graviton. Thus the moment it is emitted, a virtual graviton may possess quite a bit of energy, but as it propagates across Space (and thus experiences the passage of Time) it must lose energy. (The energy will simply vanish; its original existence was a violation of Energy-Conservation.) If you wish to see a graph of the rate of energy-loss, the curve is essentially like that of the function 1/**x**, with Energy on the Y-axis and Time on the X-axis.

3. Despite their diminishing energy, virtual gravitons are supposed to be sources of more virtual gravitons. Therefore an appropriate question is: "In its lifetime, how many wave-like vibrations can a virtual graviton experience?" To answer that we must use an equation which relates energy and frequency: (**E**) = (**f**)(**h**). I am going to plug this into Uncertainty's Energy-Time relation: $(\Delta\mathbf{f})(\mathbf{h})(\Delta\mathbf{t}) = (\mathbf{h})/2\pi$, which may be reduced to $(\Delta\mathbf{f})(\Delta\mathbf{t}) = 1/2\pi$, and rewritten as $(2\pi)(\Delta\mathbf{f})(\Delta\mathbf{t}) = 1$. At this time I note that when cycles of almost any type are described by mathematicians, the expression (2π) is defined as being equal to exactly *one* cycle. Therefore that final equation seems to be telling us this: During the entire lifetime of any virtual particle (not just virtual gravitons), it experiences just *one* wave-like vibration! Thus a "primary" virtual graviton (emitted by a real particle) can emit just one "secondary" virtual graviton in its lifetime. Furthermore, that entire lifetime is required for the emission of the secondary graviton -- one emission per vibration is allowed, but the entire lifetime of the primary is only one vibration! This in turn implies that the secondary virtual graviton is unable to emit a "tertiary" virtual graviton; if the secondary needs the entire lifetime of the first simply to start existing, how good an emitter can it be? And so the endless chain of virtual gravitons emitting more virtual gravitons breaks down near the start: Primaries emit secondaries, and that's about all.

Just as all these basic concepts of Physics seem to be fitting into a nicely logical framework, we now look at what happens when an ordinary mass meets an equal-magnitude negative mass. Things are about to get interesting, indeed (in the sense of the ancient Chinese curse: "May you live in interesting times!"). For starters, do we use (**G**) or (-**G**) when computing the Gravitational Force upon the masses? Do we use both, separately -- (**G**) for the force on the normal mass and (-**G**) for the force on the negative mass? Doing that would let us say, "The masses will accelerate away from each other." This would make for a simplistic but Symmetrical rule-of-thumb for Gravity: "Like masses attract; unlike masses repel." Also, if the Universe possesses equal quantities of opposite mass, its huge voids can be easily explained. But what about the description of Gravity in terms of curved Space: The two masses create equal and opposite amounts of curved Space, which could be absolutely minimized to zero if they accelerated *towards* each other, and "nullified" each other! And last but not hardly least, there is a whole new factor involved: The Law of Conservation of Momentum....

Knowing all about that Law is critical. First, momentum can be written as (**m**)(**s**)/(**t**). Since its Space component allows opposite directions, positive and negative momentum both exist. Next, when *any* force causes two normal masses to accelerate towards -- or away from -- each other, one mass moves in direction (**s**) while the other mass moves in direction (-**s**). The total momentum gained by the masses will always be zero: Momentum is Conserved. For negative masses it will be the same: Momentum is Conserved. But for forces between a normal mass and a negative mass, Conservation of Momentum leads us straight to Asymmetry!

1. If the opposite masses accelerate towards each other, then the normal mass may gain a momentum of (**m**)(**s**)/(**t**) while the momentum of the negative mass would be (**-m**)(**-s**)/(**t**). Each momentum is positive, so their sum is a greater-magnitude positive instead of being zero, and momentum would not be Conserved!

2. If the opposite masses accelerate away from each other, then the normal mass will move in the opposite direction than just mentioned, so its momentum will be (**m**)(**-s**)/(**t**), and the momentum of the negative mass will be (**-m**)(**s**)/(**t**). Now each momentum is negative, so their sum is a greater-magnitude negative and not zero -- again momentum would not be Conserved.

3. As the possibilities diminish, consider the case where opposite masses accelerate in the *same* direction in response to an applied force. The momentum of the normal mass can be (**m**)(**s**)/(**t**), and the momentum of the negative mass can be (**-m**)(**s**)/(**t**). At last we have a positive and a negative momentum which can add to yield zero! (The particular direction in which they both move -- either (**s**) or (**-s**) -- does not matter.) Thus if Conservation of Momentum is to obeyed as opposite masses interact, then such Asymmetry seems very likely!

Backing up a bit, there still remains the question (at least as far as Gravitation is concerned) of whether to use (**G**) or (**-G**) to compute the force in between the two masses. The proposal to use both leads to two separate forces (that of the normal mass upon the negative mass, and that of the negative mass upon the normal mass) -- but it also violates Momentum-Conservation. A single force between and upon the two masses Conserves Momentum (by making the masses accelerate in the same direction)...but requires a decision!

Choosing cannot be done without more information, though; (**G**) and (**-G**) make a Symmetry which we have to break *only* to satisfy Momentum-Conservation. (But physicists will break Symmetry before a Conservation Law.) Do we have any information which might lead to a correct choice? What about these notions:

i. A lesser possibility begins by noting that when we see a mass accelerating in response to a force-at-a-distance, there is always a change in the magnitude of the force upon the mass. We can thus imagine that the mass exists within a "force field gradient", and we might argue that the real reason it accelerates is because it may thereby change its position in the gradient. *Some* sort of change, after all, is responsible for converting potential-energy-in-the-form-of-mass into the kinetic-energy-of-a-mass-responding-to-a-force!

By looking at the normal mass and the negative mass from that angle, we can question their acceleration in the same direction: If the gap between them while they move changes at all, then Momentum-Conservation will be violated. However, if the gap does *not* change, then neither mass changes its position within the Gravitational force-field-gradient they create in-between themselves! So why should they accelerate at all? (And note that if they did *not* accelerate, then that would both be a Symmetrical response to the force(s) upon the masses, and Momentum would remain Conserved!)

Chances are, though, there is no easy way to modify Newton's Gravitation equation to yield zero total force (or two balanced forces) between opposite masses...because any such modification must have ordinary results when only masses of one variety are fed into the equation. This entire speculation may remain in limbo until physicists someday get a chance to play with actual negative masses, and then discover how they *really* interact with normal masses!

ii. Perhaps the craziest possibility concerns the idea, mentioned earlier, that negative masses might experience imaginary Time. A negative mass' momentum would be either (-**m**)(**s**)/(**t*i***) or (-**m**)(-**s**)/(**t*i***), where ***i*** is the imaginary number, the square-root-of-minus-one. Conservation of Momentum still works for negative masses only. But when normal and negative masses interact...*HOW*!?!? If they just ignored each other, due to experiencing utterly different Time axes, then their total Momentum stays Conserved. (Alas, imaginary-Time for negative masses makes a hash of the rest of this essay, so while I felt obliged to mention it, I choose to ignore it. On the other hand, if neutrinos let physicists give any mass an imaginary component, then opposite masses may yet interact in some complex fashion, after all -- and what follows may still make sense, albeit in a more complex form....)

iii. A very "interesting" possibility derives from the notion that normal and negative masses might "nullify" each other. Let us ignore any force between equal and opposite masses during their mutual approach at equal and opposite velocities: Their total mass is zero; their total kinetic energy is zero; their total momentum is *not* zero! **[**Approaching, if (**m**) moves at velocity (**s**)/(**t**), then (-**m**) must be moving at velocity (-**s**)/(**t**). (**m**) plus (-**m**) equals zero by definition of this event; their kinetic energies are (**m**)($\mathbf{s}^2$)/2($\mathbf{t}^2$) and (-**m**)(-$\mathbf{s}^2$)/2($\mathbf{t}^2$), which also add to a total of zero; but their momentums will be (**m**)(**s**)/(**t**) and (-**m**)(-**s**)/(**t**), which add to yield a positive non-zero amount. If we were using the opposite reference frame, in which (**m**) has velocity (-**s**)/(**t**), then the momentums will be (**m**)(-**s**)/(**t**) and (-**m**)(**s**)/(**t**), which are two negative quantities which add to yield a greater-magnitude negative, non-zero amount. I will have more to say about the reference frame later.**]**

Because momentum would be "left over" if the two masses cancel out each other's existence, we can question whether or not the very idea called "nullification" is even possible. Momentum must be Conserved! Well, one rather unlikely -- but *possible* -- event involves *four* masses, two being ordinary and two being negative. Suppose the two normal masses collide at equal and opposite velocities (say, on the X-axis of a graph), while the two negative masses also collide at equal and opposite velocities (perhaps on the Y-axis of the graph, but that is not critical). Now *if* all the velocities are of the same magnitude, and *if* all the masses are of the same magnitude, and *if* the four of them meet at exactly the same place and time, *THEN* their total momentum (and total kinetic energy) will be zero, and complete nullification can occur. (Imagine the Big Bang as having been two simultaneous and congruent explosions, one of ordinary mass/energy and one of negative mass/energy: Both varieties could persist together, to this day, because of the rarity of the just-described event.)

Conservation of Momentum can lead this speculative essay towards another idea altogether. The neutrino, after all, was originally postulated to exist because of apparent violations of Momentum-Conservation which had been noticed by physicists. Can nullification involving only two masses be associated with a new particle which carries off the otherwise-unbalanced momentum? Well, to discuss particles, we should think in terms of the sub-nuclear scale, which lets us call on the power of such laws as Time-Reversal Symmetry. Let us review the four types of particles which we may expect after accepting a Mass Symmetry rule: There are particles of ordinary matter, anti-matter, negma-matter, and negmant-matter. A pair of particles which have opposite properties, such as the electron and the anti-electron (or positron) can spontaneously appear anywhere and at any time (among the energy-fluctuations in the vacuum, or "aether"). The pair will only virtually exist unless it is lucky enough to happen to meet and absorb an appropriate amount of real energy -- then they would become real and detectable particles. But how "opposite" may opposite particles be?

Do a neutron and a negmant-neutron count as a pair of opposites which might spontaneously appear in the aether? If so, then they should appear anywhere and at any time, just like neutron/anti-neutron and negma-neutron/ negmant-neutron pairs. These two pairs of particles must absorb real ordinary energy or real negative energy in order to become real particles themselves... but what about the first pair mentioned? What must a neutron/negmant-neutron absorb in order to become real particles?

Easy enough is that question to answer: If momentum is left over after a normal mass and an equal negative mass nullify each other, then momentum is what normal-/negma- virtual-particle-pairs must absorb to become real! The Uncertainty Principle will allow the particles to possess a tiny amount of unConserved momentum for a tiny distance apart, but they will be able to go separate ways only after first absorbing some real momentum! And it is actually a quite sensible answer from another perspective: If two-particle nullification easily Conserved momentum (that is, by simply disappearing without leaving any inconvenient momentum behind), then normal-/negma- particle-pairs could directly pop into existence as real -- not virtual -- particles! They'd be everywhere! But they are *not* everywhere, thanks to Momentum-Conservation....

Further progress along this line of reasoning requires me to first make this hypothesis: If a normal particle is nullified by its negative-mass opposite and momentum is left over, then that momentum will exist as an independent entity. I will declare it to be a "quantum of momentum"; I think this can be acceptable because most items on the List of Fundamental Things in Physics are quantized! Prior to now, Momentum just hasn't been one of them... yet if physicists can discuss quanta of Mass, of Space, and even of Time, then those dimensional units of Momentum require it to be quantized, also!

Getting back to nullification, by describing it in a number of different frames of reference we can accumulate additional information about this hypothesized quantum of momentum. In the following table, the dimensional units are generic to any scale: mass-units, velocity-units, momentum-units....

Reference Frame:	I	J	K	L	M	N	O	P	Q	R	S	T	U
Mass1 Mass	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1
Mass1 Velocity	-4	-3	-2	-1	0	+1	+2	+3	+4	+5	+6	+7	+8
Mass1 Momentum	-4	-3	-2	-1	0	+1	+2	+3	+4	+5	+6	+7	+8
Mass1 KineticE	+8	+4½	+2	+½	0	+½	+2	+4½	+8	+12½	+18	+24½	+32
Mass2 Mass	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
Mass2 Velocity	-8	-7	-6	-5	-4	-3	-2	-1	0	+1	+2	+3	+4
Mass2 Momentum	+8	+7	+6	+5	+4	+3	+2	+1	0	-1	-2	-3	-4
Mass2 KineticE	-32	-24½	-18	-12½	-8	-4½	-2	-½	0	-½	-2	-4½	-8
Mass After	0	0	0	0	0	0	0	0	0	0	0	0	0
Momentum After	+4	+4	+4	+4	+4	+4	+4	+4	+4	+4	+4	+4	+4
KineticE After	-24	-20	-16	-12	-8	-4	0	+4	+8	+12	+16	+20	+24
Velocity After	-6	-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5	+6

Here the first thing to note is that Reference Frame "O" holds the original description of the masses' nullification: Only momentum remains afterwards. Second, this leftover momentum has the same magnitude in every reference frame in which the event is described! Such continuity can only help physicists accept the idea of quantized momentum! (If the reference frames are *reversed* -- say Mass1 is negative and Mass2 is positive -- then all the signs for momentum and kinetic energy will flip. The quantum of momentum will then hold -4 units -- its absolute magnitude is independent of the reference frame!) Third, in all reference frames except "O", some kinetic energy remains after nullification. I will assume the quantum of momentum can accommodate leftover kinetic energy by simply moving: Energy *can* equal Momentum times Velocity.... Thus I have placed appropriate numbers in a "Velocity After" row of the table; they are velocities for the quantum of momentum in all the reference frames. Fourth, everything about this hypothetical quantum of momentum, except for the absolute magnitude of its momentum, depends utterly upon the reference frame! Thus if quanta of momentum really exist, they are all intrinsically alike....

It is extremely important to note that the quantum of momentum does not by itself possess any energy. If it did it would be required to move at the speed of light -- energy *in* motion must always do that. Mere momentum in motion, however, would only possess the kinetic energy *of* motion, and so the velocity of a quantum of momentum need not be a specific value.

Jumping back to the previous discussion of how opposite masses might respond to any force(s) they create in-between themselves, where might a thing like quantized momentum fit? It may be stretching the possibilities to suggest this, but those interactions are so "interesting"...what if they can cause quantized momentum to be generated? Then the masses could accelerate away from or towards each other, leaving momentum-quanta behind. The momentum previously not Conserved would now be balanced! Still, it is probably best to wait for the day when physicists can test the matter experimentally....

Let me now shorten the label "quantum of momentum" to "momenton". Because normal-mass/negma-mass interactions are so "interesting", it seems to me worth wondering, "Can momentons actually exist?". Thus they will be mentioned so often in the rest of this essay that a simpler and reasonably obvious name will be desirable. And so we might think about -- that is, imagine! -- some way to create momentons, other than through nullification of opposite-mass particles. Experiments should follow. *If* momentons can be produced merely by manipulating ordinary masses appropriately, then uses for them abound!

1. A machine radiating momentons in one direction has to go the opposite way (to Conserve Momentum). It's a "rocket" with an invisible exhaust....

2. At the subnuclear scale, if we could choose virtual particles to absorb momentons, we could obtain anti-matter for powerplants -- and the negma-matter left over could *not* nullify ordinary matter (it's not opposite enough!).

3. Mix that negma-matter with normal matter, and we could make things having almost zero total mass: towers reaching outer Space, vehicles of every imaginable sort (like a winged anti-weight suit, to fly with the birds!)....

4. Other virtual particle-pairs to absorb momentons may be normal-/negma-magnetic-monopoles, or unbound quarks -- particles highly desired by physicists.

5. But while it would great if the family car was a spaceship with almost zero mass, anti-matter for power, and momenton-generators for propulsion, the first step is to figure out how to prove the hypothesis of momentons....

Manipulating only normal masses to somehow generate momentons seems like a rather tough job. However, we may be able to gain a few ideas by first invoking Time-Reversal Symmetry, and looking at absorption instead: Any mass which can expel a momenton must also be able to assimilate one! If we can understand what should happen to a mass during an absorption, then making those things happen to that mass by other means...ought to result in the production of a momenton.

Naturally we want to keep things simple, so let us begin with a lone mass sitting stationary in Space. Any momenton passing by will have a velocity which we can designate as (**V**), and a momentum we can designate as (**p**). Its kinetic energy has already been defined as (**V**)(**p**). Now if the mass absorbs a momenton, do we assume that *all* of the momenton's kinetic energy and momentum will be acquired by the mass? I think such an assumption is valid for these reasons:

1. The momenton has been defined as being a "quantum" of momentum. All through Quantum Mechanics, quanta are only created or destroyed "all at once".

2. If momentons were reasonably common and a mass could absorb only a part of one, then there should be many sightings of masses spontaneously acquiring momentum and kinetic energy! But there are no reports, so either momentons are very rare (or don't exist), or absorption is an extremely rare event. And rare absorptions are easily deduced (below) if *whole* momentons must be absorbed....

Observe Newton's descriptions of momentum and kinetic energy for a moving mass -- (**mv**) and ($\mathbf{mv}^2$)/2, respectively . We may now reason: If a mass is in motion because it absorbed a whole momenton, that momenton must previously have been carrying those exact magnitudes of momentum and kinetic energy as its (**p**) and (**V**)(**p**). Next, algebra reveals that if a resting mass (**m**) does absorb a momenton, and *exactly* gains its momentum and kinetic energy, then the momenton must have originally possessed values of (**p**) and (**V**) such that (**p**)/2(**V**) = (**m**). This relation must be as exact as Uncertainty allows (perhaps 14 decimal places of precision). Now just pick any mass and a reference frame in which it is at rest -- the average momenton passing by will probably have a relative velocity such that its momentum and kinetic energy are an *un*absorbable combination!

Perturbing the Newtonian equation (**m**) = (**p**)/2(**V**) is the fact that if we must have 14-place accuracy, then we must convert it to relativistic form! Newtonian equations are merely approximate when that degree of precision is needed, even at low velocities.... So here is what a resting mass must be for it to absorb a specified momenton: ($\mathbf{m}_o$) = [(**p**)/2(**V**)] [1-(**V**/**c**)^2]. Afterwards, the mass will move at this relativistic velocity: (**v**) = 2(**V**)/[1+(**V**/**c**)^2] -- and the Newtonian approximation is: (**v**) = 2(**V**). Please note that (**v**) is the velocity of the mass and (**V**) is the velocity of the momenton; in Newton's world a mass which happens to absorb a momenton will suddenly be moving at twice the momenton's velocity! In Einstein's world the relativistic results are "interesting": Fast-as-light momentons can only be absorbed by massless particles (which move at light-speed both before and afterwards); faster-than-light momentons can only be absorbed by *negative* masses, which afterwards will move at *less* than light-speed!

Question: Do we now have enough hypothetical information to design some kind of experiment? Well, if for merely Newtonian velocities a mass will leap into motion at twice the velocity of the momenton it absorbs...then perhaps we do: If a large, fast-moving mass was stopped very suddenly, could some small part of its momentum and kinetic energy keep moving (at half that speed)? It is an "interesting" fact that sensitive instruments tend to get smashed in this type of experiment...so I shall let the reader imagine a definitive test. If it can be shown that some momentum does "disappear" during such a test, then a new test becomes vital: detecting a momenton. *If* one can be produced, noticing it may turn out to be rather easy. I will explain that statement in due course....

Right now is a good time to diverge into the subject of virtual momentons. (It will lead us straight back to the detection problem!) Obviously if there is such a thing in Nature as a momenton, then there must also be such a thing as a virtual momenton. Let us immerse ourselves in the fluctuations of the aether:

1. Any two particles which possess opposite properties are allowed to pop into temporary being. The Energy/Time form of the Uncertainty Principle allows matter/anti-matter pairs and negma-matter/negmant-matter pairs to do this; the Momentum/Position form of Uncertainty lets matter/negmant-matter pairs and anti-matter/negma-matter pairs do it.

2. Virtual particles interact with real particles, causing their Realities to be transpositioned (see "The Ghostly T.O.E."). Let us look at interactions between ordinary/real electrons and virtual electron/negmant-electron pairs. If half the aether consists of negma-stuff, then real electrons will interact with virtual negmant-electrons just as often as they do with virtual anti-electrons!

3. Nullification may occur if a real particle meets its negmant match; momentum is left over. It is important to note that this leftover momentum is strictly associated with the "Inertial Masses" of the interacting particles. [Inertial Mass is defined as the (**m**) in Newton's equation **F** = (**m**)(**a**).]

4. When a real electron and a virtual negmant-electron interact, a virtual electron will become real -- *and* a virtual momenton will be created. Incessant transpositions of this type could yield vast numbers of virtual momentons. The correlation between transpositions and the wave/particle duality is important: For all particles, not just electrons, the rate at which virtual momentons can be produced is directly proportional to the mass/energy of the particles.

5. Virtual momentons will traverse Space and meet other particles, some of which will be real. A tiny fraction of those virtual momentons, at the moment of the encounter, will possess exactly-absorbable magnitudes of kinetic energy and momentum. Their absorption by the Inertial Masses of those real particles must have an effect, but the effect will be very feeble -- mostly due to so few virtual momentons being absorbed.

6. A very feeble effect which is directly proportional to the mass/energy of interacting objects sounds a great deal like the Gravitational Force! Since I have described it strictly in terms of Inertial Masses, it naturally follows that those Inertial Masses should be *equivalent* to Gravitational Masses...[which are the $(\mathbf{m}_1)$ and $(\mathbf{m}_2)$ in Newton's equation $\mathbf{F} = (\mathbf{G})(\mathbf{m}_1)(\mathbf{m}_2)/\mathbf{d}^2$].

So at last I have reached the end of this essay, which has turned out, after all, to be imaginations concerning the graviton. If the hypothetical quantum of momentum can also be the graviton, then I have not really been speculating about some totally new particle! All I have been doing was re-defining a particle which is essential to a Theory of Everything.... For centuries physicists have *assumed* the two aspects of Mass were equivalent (because the math works great!), but they haven't had a good fundamental reason *why* the assumption might be true. Since we want proof, first imagine: "What might happen to a mass if a momenton passes through it and *isn't* absorbed?" Thus I recommend the use of gravity-wave detectors in conjunction with those momenton-generating experiments!