THE GHOSTLY T.O.E.

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A Theory Of Everything (T.O.E.) is desired which can show that every natural force (electromagnetism, the strong and weak nuclear forces, and gravitation) is actually a variation on the theme of a single force. Physicists are reasonably sure that a Grand Unification is possible; electromagnetism and the weak nuclear force have been successfully Unified. One vital idea which helps the goal is that each force may be individually described in a similar way, using "exchange particles". Two particles experiencing a force in-between themselves are said to be emitting at each other -- and absorbing -- a third particle. A rigorous description of such an exchange, employing the smallest possible quantities of each type of particle, is a "quantum theory". The T.O.E. is expected to be a quantum theory. In this essay I wish to describe some general properties of exchange particles, and some surprising logical consequences.

Beginning that explanation means digressing at once into the topic of the Laws of Conservation. Physicists have noticed that various fundamental things seem to exist/persist without being able to be created out of Nothing -- or to be utterly destroyed. The total amount of Mass and Energy in the Universe never changes; the total amount of Momentum is constant; the total amount of electric Charge (and of other kinds of Charge, such as the "color" of the strong nuclear force) is steady, and so on. One might wonder whether or not *all* fundamental things, including Space and Time, are conserved, but first one must thoroughly define what is meant by "Conservation of Space" or "Conservation of Time"....

Contrary to some preceding statements, however, apparent creations and destructions of things like Mass and Charge actually occur all the time on the small scale; it is just that on the large scale, it all balances out! Thus for every bit of mass destroyed, some energy appears in its place; for any positive

charge which appears, there also appears a negative charge (for a total of zero charge appearing), and so on. And on the smallest scale of all, at the level of the fundamental quanta of matter and energy, appearances and disappearances are occurring in as wild a manner and pace as anyone could imagine!

During the 1920s physicists noticed some inherent limits to how accurately certain events can be measured. The limits are formally described in and known as Heisenberg's Uncertainty Principle. Mathematically, the Principle multiplies uncertainties in Momentum and Position to obtain a special constant value, which is the minimum Uncertainty in measurements made of the momentum and position of anything. Either alone may be measured to an arbitrary degree of precision, but the more precisely one is measured, the less precisely the other can be measured simultaneously. The act of measuring either *changes* the value of the other....

Einstein disliked the Uncertainty Principle, and he sought to prove it to be untrue. In one attempt, he first showed that the Momentum-Position relation is mathematically equivalent to an Energy-Time relation. [If Mass is represented by (**m**), Space is (**s**), and Time is (**t**), then Momentum is (**ms**/**t**), Position is just Space, and their product is (**mss**/**t**). The description of Energy is (**mss**/**tt**), so Energy times Time is also (**mss**/**t**).] The equivalence let Einstein propose a thought-experiment in which precise measurement of something's energy-content could be made practically instantly. I don't have the details of that, but it doesn't matter, because the thought-experiment was flawed. Uncertainty always exists even in Energy-Time measurements, despite Einstein's opinion.

For physicists who accepted Uncertainty, however, Einstein's version of it was a boon. It provided a tiny and very-short-term loophole in the Law of Conservation of Energy. In effect, the energy-content of something is allowed to vary a bit over the short term (and the shorter the time, the more variance

is allowed), but over the long term it maintains a specific quantity of energy, which is all that can actually be measured. Even Nothing (a vacuum) is allowed to have a varying energy-content! Particles of matter/energy can spontaneously pop into existence, persist for a very short period of time, and then vanish. They are generally referred to as "virtual particles", because they both exist and don't-exist. (One *could* call them "ghost particles", but the other term has become standard.) The Uncertainty Principle states that we can never catch them in the act of appearing/existing/vanishing, but we can detect some side-effects of their having been there. Chief among the side-effects are the four natural forces; the exchange particles of quantum theories are all virtual particles! Thus the boon to physicists is that the particles responsible for a given force could shoot back and forth between other particles (upon which the force acts), yet those exchange particles could forever remain undetectable in the process.

Great theories which make use of literally-fleeting exchange particles, however, do not require those particles to be undetectable *all* the time. If a virtual particle is real enough to be responsible for the operation of a force, then physicists require that it be real enough to participate in at least one other crucial type of interaction. An example of such an interaction goes like this: An energetic gamma-ray-photon can, under certain conditions, suddenly become an electron and an anti-electron (which is usually called a "positron", but I will refrain from using that label). The explanation of what actually happens begins with the statement that virtual particles manifest everywhere and all the time. Any kind of particle which can possibly exist in a detectable way already exists in a virtual way. Therefore the multitudes of pervading virtual particles have to include both virtual electrons and virtual anti-electrons. (In fact, they normally appear in pairs -- one of each per pair -- because of

Conservation of Charge.) If a real gamma-ray, carrying the right amount of *real* energy, happens to meet one of those virtual electron/anti-electron pairs (under special conditions, as mentioned), then the pair might absorb the energy of the gamma-ray, and thus cease to be virtual particles. By acquiring the real energy of the gamma-ray, they must become real (meaning detectable) particles! Thus the previous statement about the kinds of virtual particles which can exist is fully reversible: Any kind of particle which exists in a virtual way must also be able to exist in a detectable way. If one starts with *any* virtual particle and pumps enough real energy into it, then it *will* become a real and detectable particle! And that is the crucial interaction required of any proposed virtual/exchange particle...because then physicists can detect the particle for real. A proposed particle which fails this interaction is tossed out on the grounds that it doesn't exist at all, not even virtually.

Having used the Uncertainty Principle to obtain (for the benefit of a future T.O.E.) the ideas that virtual particles exist, constantly appear and disappear everywhere and all the time, and can be used to explain how the various natural forces work...there is one small consequence to bring up: What is a simple name to call this phenomenon? Physicists do occasionally discuss virtual particles *en masse*, but do they make it easy for themselves? No...they use such phrases as "energy fluctuations in a vacuum" or "the vacuum self-energy". A one-word designation for this Universe-wide sea of virtual particles would be ideal, and fortunately, there *is* such a name available. It has a history which started in ancient Greece, was very popular only a century ago, and is merely waiting to be dusted off -- to be re-defined -- and thereby be made respectable again. The name is "aether". Let us use it to refer to the totality of virtual particles and virtual energy which pops into existence everywhere and all the time, each

iota of which exists for some Uncertain period of time -- and then vanishes.

In the late 1800s, as mentioned, the aether had a different definition. It was assumed to be something which permitted light (then known to be a wave-like phenomenon) to pass through the vacuum of Space -- waves are always waves *of* something...right? Well, nowadays we have the wave/particle duality, which lets a photon of light "wave itself", so to speak. Thus last century's aether is no longer needed -- in fact it was proved not to exist. If it existed, any light passing through it would have been affected in various detectable ways. Since those effects were *not* detected in many experiments, the aether was abandoned.

Just a moment, though. What of the *modern* aether -- those virtual particles in the vacuum which most Uncertainly exist -- does *it* affect light? Yes! The speed of light through a vacuum depends on the "density" of virtual particles present. As light travels along, it encounters and interacts with many many virtual particles in its path -- the aether is chock-full of them.... (There are speculations that if the spontaneous appearance of virtual particles can be suppressed in the vicinity of a space-ship, then the speed of light near the vessel will increase. The maximum possible speed of the ship is always less than light-speed, but with light-speed itself increased, so can be increased the speed of the ship...carrying its aether-suppression equipment with it!)

Keeping in mind that the speed of light depends on the number of virtual particles with which it interacts, we may wonder about the existence of any natural variations in the particle-density of the aether. And that in turn lets us forge a link between General Relativity and Quantum Mechanics! G.R says that light goes slower and its path curves in a gravitational field, and physicists are satisfied that this is true -- here is how Q.M. can say the same:

1. If a photon interacts with something, no matter how, and then continues

on its way, it cannot do so instantaneously. The process takes time, so it is obvious that the more interactions a photon experiences with aethereal/virtual particles, the slower it goes -- and vice-versa.

2. In empty Space light will only encounter a constant density of virtual particles in the aether. Thus its rate of interaction will be constant; its speed will be constant -- and its path of motion will be perfectly straight.

3. In any theory of gravitation based on Quantum Mechanics, masses will emit/exchange/absorb virtual particles called gravitons. If we place a mass in a volume of otherwise-empty Space, that Space will now be permeated by hordes of virtual gravitons, in addition to the "background density" of the aether.

4. **A**s passing photons interact with virtual gravitons (in addition to all "normal" interactions with aethereal particles), more time will be wasted -- and the photons must travel more slowly as a result. Obviously the more massive an object, the more virtual gravitons it emanates, and the more interactions can occur between them and passing photons -- and the slower the photons travel.

But as photons go slower, a new effect occurs: the Law of Refraction. Physicists have seen that whenever light encounters a change in the environment through which it passes (especially a change which affects its speed), then the path which light takes is usually bent. (How much it bends depends on the angle at which light meets the new environment, and on how much its speed changes.) Thus a description of gravity using Quantum Mechanics *can* potentially duplicate the results of General Relativity -- although details remain to be worked out.

Let us now proceed to delve into other interesting things about the aether. Physicists are quite sure it exists as I have defined it in this essay, but somehow they seldom use it as they might, to explain various odd phenomena in Quantum Mechanics...so here we go:

1. A good starting place is the wave/particle duality: An electron, for example, doesn't sit still while we talk about it. We can't point directly at it; its wave-like properties make its precise location very indefinite....

But let's pretend that an electron holds still for a moment (it *does* if the moment is short enough), while we visualize it as being surrounded by many aethereal particles (this is quite true, too). Some of them will no doubt be virtual electron/anti-electron pairs; can they interact with the real electron?

Certainly electrons can interact with *some* of the many types of virtual particles; virtual photons, for example, can travel between electrically charged particles (like electrons), causing effects which define the electromagnetic force. We may conclude from this that *while* any virtual particle exists, it is just as real as any normal particle, undetectably ghostly though it may be. And if a virtual photon can interact with an electron despite being only *temporarily* real, we have to acknowledge that any other type of virtual particle which has the potential to interact with a real electron...*must* occasionally do so!

Definitely real anti-electrons and real electrons can interact (causing mutual annihilation)...so a temporarily-real virtual anti-electron must be able to do the same. This quite simple event has many ramifications, some of which will be examined shortly. Let me first describe the event in a bit more detail:

i. Start with a real electron. Its motion won't affect the event, so let a virtual electron/anti-electron pair pop into being nearby. (Virtual particles can appear with any amount of motion possible, so any real particle can always be treated as if it was "meeting its match"....)

ii. Assume the virtual anti-electron just happens to run into the real electron; it will definitely happen every once in a while....

iii. The real electron and the temporarily-real anti-electron will

annihilate each other. *The leftover virtual electron becomes the real electron!* It absolutely must, because the original real electron is gone....

Explaining a critical idea about Existence was the goal there. If most people have trouble understanding Reality According To Quantum Mechanics, it is because nothing is Real for very long! What was described for an electron can also happen to any other real particle in the Universe, at any place and all the time, just because the aether exists! For another example, check out this wild description of what happens to protons and neutrons in atomic nuclei:

i. Start with a proton and a nearby neutron. These particles are made from two types of quarks, which may be called [*u*] and [*d*]. The "formula" for a proton is [*u*][*u*][*d*], and the formula for a neutron is [*u*][*d*][*d*].

ii. A pair of particles known as "pions" begins existing in-between the proton and neutron. A pion is made of a quark and an anti-quark; let anti-quarks be called [*u*-] and [*d*-]. One pion has a negative electric charge and it will interact with the proton; its formula is [*u*-][*d*]. The other pion, which interacts with the neutron, is positively charged, and its formula is [*u*][*d*-]. (These virtual pions are mutual opposites, like an electron/anti-electron pair.)

iii. The following interactions can now occur: The [*u*-] quark will encounter a [*u*] quark in the proton, and the [*d*-] quark will encounter a [*d*] quark in the neutron. Two mutual annihilations take place, and the total amount of virtual energy which had manifested as pions can now vanish. However, notice the types of quarks which are left behind....

iv. The proton and the neutron have each lost one quark and gained a *different* quark. More specifically, the [*d*] quark which was left behind in the proton is exactly what the neutron lost; the [*u*] quark in the neutron is just what the proton lost. The interaction simultaneously affects two quarks just as

was previously described for an electron. A "real" quark is destroyed in both proton and neutron, while a virtual quark (originally inside a virtual pion) is forced to become real at the end of the interaction. Quarks are simply swapped by the virtual-pion interaction -- but a proton and neutron have their formulas altered, so their identities also swap! (Protons can co-exist in atomic nuclei thanks to an orgy of identity-swapping, too fast for them to be expelled! And can identity-swapping stabilize a neutron? Alone, it has a 12-minute half-life, but among protons its internal "decay clock" gets re-set every 10^{-24} second.... What about physicists attempting to detect the decay of the proton? Identity-swapping might seriously interfere! Perhaps they should look for proton decays in plain hydrogen, where protons persist without the presence of neutrons....)

For electron, quark, proton, or neutron, as described, we can simply say that this happened: Its "realness" was "transpositioned". Note that such transpositioning can -- and must -- happen all the time; how might we describe the location of its realness at any given moment? The answer is statistical: *The probability-wave functions of Quantum Mechanics can be directly associated with the aethereal transpositioning of a particle's realness!* In other words, interactions with virtual particles cause any real particle to seem wave-like!

Grasping that idea may be easier if we take a another look at virtual particles and the Energy/Time Uncertainty Relation: When virtual particles pop into existence, both their duration and the distance which they can travel is dependent on their masses/energies. For example, a virtual proton has about 1836 times the mass and must vanish 1836 times quicker than a virtual electron. Thus real protons can be transpositioned at 1836 times the frequency of real electrons -- but longer-lasting virtual electrons can travel 1836 times farther than virtual protons. Transpositioned real electrons have longer "wavelengths"!

Hopping to the other side of the wave/particle duality, let's take a quick look at the photon: It is a wave with particle-like properties. The key property is its location: When a photon is absorbed its wave-ness vanishes and the location of its absorption is *the* place where the photon's realness had to have been at the moment of absorption. But so what? As a photon moves through the aether it gets absorbed and re-emitted lots of times by virtual particles in its path (thus it moves at "merely" light-speed). The distribution of all those absorptions exactly matches the photon's wave-like nature; its final absorption by a real particle can be called "just one more". This oddball view of a photon treats it more like a particle than a wave; it merely seems to be mostly wave-like because its aethereal absorption-distribution can be quite large.... (And note that a photon is its own anti-particle; virtual photons can interact with and cause real photons to be transpositioned just like other particles.)

2. With the wave/particle duality interpreted in terms of the existence of the aether, certain related phenomena may suddenly make more sense:

i. An obvious example is called "electron tunneling". Where there is a thin barrier to the free movement of an electron, and a voltage which is too small to force the electron through the barrier, the electron can sometimes manage to get through it, anyway. This phenomenon is normally attributed to the wave-like nature of the electron: Its exact position is "spread out" (and this spread is enhanced by the presence of the voltage across the barrier); there is a chance that the spread includes a location on the far side of the barrier. The probability that the electron actually ends up across the barrier (tunnels) is tied to that chance location.

But this event is just as easily explained using the aether. A single transposition of an electron moves its realness from Point A to Point B

without crossing the intervening Space. Suppose that multiple and simultaneous transpositions occur...: *In* the barrier, virtual electron/anti-electron pairs are popping into existence. The weak voltage across the barrier yields virtual photons which can interact with those virtual particles, organizing them into a row of alternate electric charges. Then a virtual anti-electron can annihilate the real electron on one side of the barrier, all the in-between particles will cancel each other out, and a virtual electron on the other side of the barrier suddenly becomes real! The probability that a long-enough organized row will form is equal to the probability that the electron will tunnel....

ii. Another problem concerns "the interference experiment", in which electrons are shot, one at a time, towards a barrier which has two small holes in it, closely spaced together. A photographic plate behind the barrier reveals where each electron finally ends up. As many electrons sequentially land on the plate, a unique pattern is slowly formed. It is an interference pattern, and it is considered proof that the electron has a wave-like aspect, for only waves can create an interference pattern. Waves do it by going through both holes at the same time, and interacting with themselves afterwards. Exactly how electrons manage it is something which has bothered physicists for decades....

By paying attention to the momentum of an electron as it moves towards the holes in the barrier, the interference pattern can be explained in terms of the aether. Since we create the beam of electrons, we can say that we know what an electron's momentum is. Therefore we are not allowed to know just where the electron is, as it approaches the two holes. Let us now *pretend* the electron passes through a particular hole -- obeying Uncertainty, we must also pretend ignorance of its momentum! Since we actually do know its momentum, how can we reconcile the pretense? Enter the aether: As the electron moves it will

interact with aethereal particles -- its momentum *must* change constantly. Thus its momentum *will* be unknown as it passes through a given hole...while aethereal particles can carry the rest of any total known momentum through the other hole! Finally, an electron *always* gets its momentum back since virtual particles must vanish -- and Momentum must be Conserved in the long run. The interactions which return momentum to the electron must be affected by the passage through the two holes, so the interference pattern appears...and any attempt to detect the electron in either hole changes its momentum and destroys the pattern!

iii. An interference experiment for photons makes a beam of light split and travel two widely separated pathways before merging them back together to create the pattern -- which even one-photon-at-a-time can do! Yet aethereal photons interacting with real photons should similarly solve the mystery....

3. Another possible result of real particles getting transpositioned in the aether concerns the electromagnetic force. Electrically charged particles are usually treated as special entities with which virtual photons can pop into existence and interact in a special way. The details are hidden by mathematical tricks designed to do two things: A given charged particle is always "real"; and virtual particles around it act as a kind of "wall" to keep a point-source of infinite-strength charge from being visible to the rest of the Universe.

But if the particle is actually interacting with its wall, its realness jumping about, then other differences follow. The infinite-charge problem may possibly never arise, simply because no particle stays permanently real!

Consider, too, that for ordinary real mass/energy, high-energy photons are often produced during matter/anti-matter annihilation. With annihilations occurring during transpositions, virtual photons should be a common by-product. Some of them might carry information about a real particle's electric charge;

others become real if there is a mis-match between the "before" and "after" energies of a transpositioned particle (real accelerations can cause that...).

4. A quantum theory makes use of exchange particles. Assuming that real photons can interact with virtual gravitons (as mentioned earlier) leads us inexorably to the conclusion that photons, massless though they are, will be required to be a *source* of virtual gravitons, just like any object having mass. This can be acceptable because General Relativity links gravitation to the total mass/energy of any object -- and the *form* in which energy can appear makes no difference at all. (For example, the gravitational field surrounding a mass is a form of energy -- which enhances the strength of that gravitational field!)

But letting photons be equal to masses, to let them exchange virtual gravitons...brings us to a crucial question: "What aspect of Quantum Mechanics can permit both massive and massless particles to be associated with virtual gravitons in direct proportion to their mass or energy?" The only phenomenon I can find which might answer that question is the wave/particle duality....

i. The wave/particle duality solidly links a rate of vibration with the mass/energy of *any* thing. Thus we *might* assume that each time something vibrates in wave-like fashion, it can emit one virtual graviton.... Or we can note the aethereal transpositioning of real particles: Each time something is transpositioned, one virtual graviton is produced. See, in General Relativity is this key idea: When Mass is destroyed (converted to Energy), gravity waves must appear. Since mass-possessing particles are quite thoroughly destroyed in matter/anti-matter reactions, it follows that gravitons should be one (rather inconspicuous) by-product. Thus the transpositions of real particles through their annihilation by virtual particles may indeed yield virtual gravitons in direct proportion to mass/energy/duality-frequency!

ii. Such a notion would yield astronomical numbers of virtual gravitons -- a visible-light photon will radiate hundreds of trillions per second; mere electrons will radiate at least 10^{20} per second....

iii. Although that may be too many exchange particles for gravitation to be described as a feeble force -- and it is indeed the most feeble of all forces -- fortunately, the notion says nothing about how frequently a particle can *absorb* a virtual graviton. Absorptions must be rare, indeed!

Backing up that assertion is the following logic:

(a) If in General Relativity a gravitational field can itself be a source of gravitation, then in Quantum Mechanics virtual gravitons must be able to emit/exchange/absorb other virtual gravitons.

(b) Consider a black hole: If virtual gravitons can interact with each other, how can they get *out* of a black hole? The simplest ideas which spring to mind are that they either travel faster than light, or they interact very rarely. (Perhaps they do *both*; if the speed of light is what it is due to its many interactions with aethereal particles, while virtual gravitons interact very rarely, then what might we conclude about the speed of gravitation? If you worry about paradoxes, what about a Law of Conservation of Time...?)

iv. Such vast numbers of virtual gravitons would make gravitation a very "smooth" force -- as light passes near a mass, it slows even if it spends time interacting with only a tiny percentage of so many virtual gravitons. Its path through a gravity field can bend as perfectly as if Space was curved!

Moving on...I invite you all to play with this Aethereal Interpretation Of Quantum Mechanics, and see if it can make sense of other problems, like those of the "spooky action at a distance" of the Einstein/Rosen/Podowsky paradox...and maybe even Shrödinger's Cat. Enjoy!