Modeling the Universe as a Quantum Well

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Abstract: By modeling the Universe as a quantum well for standing waves and solving Schrodinger's equation for a particle trapped in this well, the solutions for the allowable rest-energies of all particles in the Universe are obtained, from the mass of the photon up to the mass of the Universe. The quantum numbers that predict the allowable rest-energies of all particles are also found to quantize the distance over which gravity acts, ranging from the Planck length to the radius of the universe. The potential that is derived from the quantum well model is validated for gravitational, strong, weak and electromagnetic forces by confirming the mass of the vector particle for each force.

I. The Quantum Well of the Universe

It is believed that some form of quantization of the gravitational field exists and one approach to understanding this quantization is to map the field to a quantum well and solve for all of its associated nodes. If we assume these standing waves are DeBroglie waves correspond to the particles in our Universe, then we can assign the resulting well potential for each series of quantum numbers to the rest energy of a particle. Dirac found with his Large Number Hypothesis (LNH) that there appears to be a relation between the ratio of magnitude between forces and the scale of the Universe. The quantum well model discussed in this paper shows a similar relation and provides an explanation for Dirac's LNH. Based on the model discussed, the energy in a particular DeBroglie wave is equal to the rest-energy of a particle which may be localized by its probability-density function. The effect of wave interaction within the well may be similar to Mach's principle where it can be shown that the rest-energy of any object is equivalent to the universal gravitational potential energy acting on that object [1].

We start by calculating the smallest mass that can occur in the two-dimensional plane where DeBroglie waves travel. This is done by solving Schrodinger's equation for the fundamental standing wavelength in a two-dimensional system with dimensions equal

to twice the radius of the Universe. In this process, we find all the allowable rest-energies that the particle can have based on quantum numbers for *x* and *y* as follows [2]:

$$E = [(n_x)^2 + (n_y)^2]\pi^2 h^2 / (2mL^2) \qquad (1)$$

Where n_x and n_y are the quantum numbers, m is the mass of the particle, L is the length of the box or in this case, twice the radius of the universe (with the radius being equal to 1.9×10^{26} meters), and h is Planck's constant of 6.62×10^{-34} Joules-sec. By setting n_x and n_y equal to 1, and L equal to twice the radius of the universe, we obtain the ground state energy of a particle of fundamental matter-wavelength inside the universe which we assume to be the photon, **m_p**. We then set the ground-state energy of the photon's matter-wave equal to its rest-energy,

$$2\pi^2 h^2 / (2m_p L^2) = m_p c^2 \qquad (2)$$

By substituting L = 2r where r = 1.9×10^{26} meters we find the mass of the photon to be:

$$m_p = [2\pi^2 h^2/(2(2r)^2 c^2)]^{1/2} = 1.8 \times 10^{-68} \text{ kg} \qquad (3)$$

This value for photon mass closely matches an estimate proposed by JP Vigier in his analysis of what was considered experimental error in the Michelson-Morley experiment [3]. The Michelson-Morley experiment was designed to verify the existence of the medium that electromagnetic waves travel in (what we would view as a space-time fabric and what used to be called the ether). The experiment actually yielded a small ether drift of 8 Km/sec that was much smaller than the expected 320 Km/sec and this small drift was attributed to experimental error. An analysis of the data by Morley and others however, has shown that the "error" is periodic with respect to the rotation of the Earth and its periodicity is verified in other multiple experiments. Vigier has proposed a photon mass of 10^{-68} Kg from the Einstein-DeBroglie relation that will offset the ether drift of 8 Km/sec and restore a relativistic outcome for the experiment, otherwise the ether drift indicates an absolute reference frame.

II. Quantization of Mass and the Gravitational Field

The underlying principle that is used for the above derivation of (2) and (3) is that rest-energy of the particle is equivalent to quantum well energy with the corresponding quantum numbers and it can be shown from Mach's principle that universal gravitational potential energy (UGPE) is equivalent to rest-mass energy [1], therefore quantum-well energy is then equivalent to UGPE, which allows us to quantize the Newtonian-gravitational potential as follows:

$$[(n_x)^2 + (n_y)^2] \pi^2 h^2 / (2mL^2) = mM_uG / r \qquad (4)$$

Where r = radius of known observable universe, M_u = mass of universe (1.44 x 10^{53} Kg), and m = mass of object

Notice above that the quantization is more noticeable at larger potentials, on the order of galactic clusters, for instance, than it would be at a solar system level. This is what we would expect for a transition from Newtonian to Non-Newtonian gravitational model. As the quantum numbers get larger, the potential curve will obviously take on different shapes for the strong and weak regimes of particle interaction, similar to an elasticity plot for a given material. We will show later that this allows for a relationship similar to Hooke's law to be applied to space-time. It can be seen from (2) that this is a formula for the quantization of mass which can be defined as,

$$m = [((n_x)^2 + (n_y)^2) \pi^2 h^2 / (2(2r)^2 c^2)]^{1/2} \qquad (5)$$

Where, for the photon the quantum numbers are equal to 1 as we have just shown, and for more massive, stable particles, the quantum numbers are larger. This equation assumes particles that do not decay. For the largest mass, the mass of the universe, we solve for the combination of $((n_x)^2 + (n_y)^2)$ by taking a ratio of two equations modeled after (5). By leaving the quantum numbers as variables in the numerator for the mass of the universe and setting them equal to 1 in the denominator for the mass of the photon (with all but quantum numbers cancelling on the left hand side),

$$((n_x)^2 + (n_y)^2) = M_u / m_p = 10^{121} \qquad (6)$$

Where M_u = Mass of universe (10^{53} Kg) and m_p = mass of photon = 10^{-68} Kg

And the effective quantum number (n_{eff}, the quantum number of the same order of magnitude as either n_x or n_y) is,

$$n_{eff} = [((n_x)^2 + (n_y)^2)]^{1/2} = 10^{60} \qquad (7)$$

Which is similar to the results obtained from Jordan and V. E. Shemi-Zadah [4][5].

The physical interpretation of these results is that rest-energy (and hence rest-mass, as c cancels from numerator and denominator in (6)) is quantized and can assume only certain values.

As a particle of higher mass than the photon will have a higher n_{eff}, which corresponds to a shorter DeBroglie wavelength, the standing waves in (1) will then have a wavelength given by

$$\lambda = 2L/n \qquad (8)$$

where L = 2(radius of known observable universe). This last development corresponds directly with Heisenberg's Uncertainty principle,

$$\Delta E \Delta t = h \qquad (9)$$

Where ΔE is found from (1) as,

$$\Delta E = (\Delta n_{eff})^2 \, \pi^2 h^2 / (2mL^2) \qquad (10)$$

and $\Delta t = \Delta\lambda / c \qquad (11)$

where c = speed of light and $\Delta\lambda$ is found by differentiating (8) with respect to n:

$$\Delta\lambda = -4L/(\Delta n_{eff})^2 \qquad (12)$$

Therefore, combining (10), (11) and (12) and recognizing L = 2r,

$$\Delta E \Delta t = [(\Delta n_{eff})^2 \, \pi^2 h^2/(2mL^2)][-4L/c(\Delta n_{eff})^2] \qquad (13)$$

$$= \pi^2 h^2/(mrc)$$

where m = mass of photon = 1.8×10^{-68} kg, r = radius of known observable universe = 1.9×10^{26} meters, c = speed of light and

$$\Delta E \Delta t = \pi^2 h^2/(mrc) = 6 \times 10^{-34} \text{ Jsec} = h \qquad (14)$$

This shows that an increase in energy (by increasing mass as in (10)) causes a decrease in Δt (12), which makes $\Delta E \Delta t$ constant. Therefore, Heisenberg's uncertainty principle is derived from assuming a standing wave formula for all masses (with n = 1 corresponding to λ = r) and applying Schrodinger's equation to calculate the energies in the standing waves. A photon has the lowest location resolution and the highest momentum resolution. The low-resolution of photon location (let's call it non-locality) may explain photon entanglement, where photon's initially linked by metastable quantum states are capable of non-local communication.

As an object approaches the speed of light and it's relativistic energy approaches $M_u c^2$, it's n_{eff} approaches 10^{60} and it's matter-wavelength is reduced. This may be where the Planck length is most commonly noticed – as a limiting factor on n_{eff} which in turn limits the velocity that an object can attain as it approaches the speed of light.

III. Particle Interactions in the Quantized Field

Now we examine how quantization affects the vector particles and their ranges for the four forces. The Planck length is defined as,

$$L_p = [(hG)/(2\pi c^3)]^{1/2} = 1.616 \times 10^{-35} \text{ meters} \qquad (15)$$

By knowing that the radius of the universe, R_u is 1.9×10^{26} meters and knowing that the Planck length is the minimum distance the gravitational force can act over we find that,

$$(R_u) / (L_p) = n_{eff} = 10^{61} \qquad (16)$$

Therefore, the maximum quantum number ($n_{eff} = 10^{61}$) that corresponds to the ratio of the maximum to minimum rest-masses in the universe is also equal to the ratio of maximum to minimum radii that the gravitational force acts over. By incorporating (6) and (16) together we find,

$$GM_u / R_u^2 = Gm_p / L_p^2 \qquad (17)$$

Or that the gravitational force from the mass of the universe acting on an object over the radius of the universe is equal to a photon's gravitational pull on the same object acting over the distance of the Planck length. This simply states that the electromagnetic force and its vector particle the photon has the same mass/range

relationship on its minimum scale (Planck Length) as the gravitational force has over its maximum scale (mass of universe, radius of known observable universe). It is also interesting to note that the relationship in (17) applies to the strong nuclear force as well:

$$GM_u / R_u^2 = Gm_{pi(+)\ meson} / R_{strong}^2 = Gm_{photon}/R_{Planck\_length}^2 \qquad (18)$$

Where $m_{pi-meson}$ = 139.6 MeV and R_{strong} is the distance the strong-nuclear force acts over (or maximum nuclear radius distance), which after solving (18) we find

R_{strong} = 7.88 x 10^{-15} meters,

which is the maximum known nuclear radius and the limit of the range of the strong-nuclear force. For the weak nuclear force, which has a generally accepted range of 10^{-18} meters and using the constant evaluated in (17), the estimated mass of the vector particle (which is mostly likely the electron-neutrino) is 10^{-36} Kg or 0.65 eV/c^2. In this respect, the strong and weak nuclear forces obey Newton's gravitational law at their maximum ranges as shown in (18). The gravitational force is therefore quantized at the level of the atom, with the strong and weak nuclear force exhibiting gravitational effects.

The relationship in (18) suggests Newtonian gravity works from the scale of the radius of the Universe down to the size of nuclei and even to the Planck length. A way of expressing this formula in terms of Newtonian gravitation and an elastic force law which resembles the familiar equation $F = kx$ (where k is an elastic constant for spacetime and x is the displacement of the spacetime fabric) is:

$$F = kAe^{\frac{-krA}{GM_1M_2}} \qquad (19)$$

Where k is an elastic constant for the space-time fabric, A is amplitude of the wave and the deflection of space based on the interaction of Mass1 and Mass2, such that $F = -kA$ is the deflection force (also corresponding to gravitational force) between Mass1 and Mass2. The variable r is lateral distance from the wave center corresponding the wave distance traversed on the x-axis, whereas A is the amplitude on the y-axis which is determined by the equation $0.5kA^2 = \sqrt{M_1M_2}c^2$.

Then to compute the potential, we assume a constant distance r from the wave center and that the deflection A is variable then integrate force:

$$PE = \int_0^A kAe^{\frac{-krA}{GM_1M_2}}dA = 0.5kA^2e^{\frac{-krA}{GM_1M_2}} + \frac{GM_1M_2}{r}(1 - e^{\frac{-krA}{GM_1M_2}}) \qquad (20)$$

The familiar gravitational potential of $\frac{GM_1M_2}{r}$ in (20) is evident as a far-field approximation when r approaches infinity, which is essentially what we currently measure for Newtonian gravitation. By using (20) for distance scales in which r is of the nuclear radius and Planck length, we approach the formulas in (18) and this provides a test of the theory at these distance scales.

Based on (2) where we assume that the rest-mass energy of a particle is equivalent to its quantum-well energy we formulate the conclusion that a particle can be viewed as a series of standing-wave ripples in the fabric of space-time, where the amplitude of the ripple is mc^2 and this amplitude is also the vector axis of particle motion. The cartesian-coordinates that are normal to the particle's axis of motion correspond to the DeBroglie wave vectors specified by n_x, n_y and L in (1). Also, as we have calculated a mass for the photon in (3) and assigned n = 1 to it's DeBroglie wavelength while it travels at free-space velocity, we know that it's E and H vectors are normal to its direction of propogation and therefore the E and H fields are mapped into the same plane as it's DeBroglie waves, which explains why we used a 2-dimensional model for the quantum well. The amplitude of the photon's DeBroglie waves are found to be m_pc^2 which is also equivalent to its gravitational potential as defined by (4), which allows for future derivations between the gravitational field and the electromagnetic fields.

IV.   Conclusions

The quantization of mass and gravitational fields can be interpreted by viewing these particles or fields as standing DeBroglie waves in a space-time fabric. The potential energy in this fabric is equivalent to the rest-energy of particles and the potential energy of gravitational fields. The standing DeBroglie waves of a particle are projected in two-dimensions normal to the axis of motion of the particle. The E and H vectors of electromagnetic fields are mapped into the same plane as the DeBroglie waves, with interactions occurring as energy displacement inside the space-time fabric. By applying Schrodinger's equation to this standing wave with the two-dimensional plane that it is in, the mass of particles can be interpreted from the quantized energy of the waves.

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