DRAFT VERSION

Quantum Gravity and Neutrinos

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Abstract

Examining the relationship between solar neutrino flux and gravity finds they correlate by

$$\frac{(2\text{GM})}{\varrho_t}=c^2\,\ell_P\,t$$

where ϱ_t *are neutrinos produced per t time, c is the speed of light in a vacuum, and* ℓ_P *is Planck's length. The correlation finds a match to within 0.74% of modern standard solar models and 0.63% of solar neutrino measured values(well within the margin of error). I also consider how this simplifies the Schwarzschild radius and the ramifications of this model on gravitational time dilation. Lastly, I consider how the relation between neutrinos and gravity may help unravel the positive cosmological constant and Supernova behavior.*

1. Introduction

A reconciliation between Quantum Mechanics and Gravity has long been sought for well over a century. One early consideration I made into this question was that gravity is likened to space-time being consumed in a process and therefore gravity must result from a process within the matter - not simply from matter existing. This paper seeks to consider this idea with several candidate quantum processes. In doing so, we find unexpected correlations between neutrinos, gravity, the Schwarzschild radius and related time dilation from the Schwarzschild Metric.

2. Space-time Gravity Model

A gravity model where space-time is consumed must be built from the ground up.

Initial space volume is given by:

$$V_0=4\pi r_0^3 \quad (1)$$

Where V_0 is initial volume and r_0 is initial radius.

Then we need to find the new radius after subtracting a constant volume of Q over t time.

$$V_0-\frac{Q}{dt}=V_1 \quad (2)$$

$$r_1=\sqrt[3]{\frac{3V_1}{4\pi}} \quad (3)$$

Now we can find that as dt in eq. 2 approaches 0 the difference between r_0 and r_1 can be represented by:

$$\Delta r=\frac{Q}{4\pi r^2\,dt}=dv \quad (4)$$

It can easily be seen how this relates to the Newtonian gravity formula by:

$$g=\frac{4\pi GM}{4\pi r^2}\simeq\frac{Q}{4\pi r^2\,dt}\simeq\frac{Q}{4\pi r^2} \quad (5)$$

Therefore we can relate this by:

$$Q = 4\pi GM \quad (6)$$

We can then see that gravity relates to dv by:

$$g \simeq dv \quad (7)$$

The astute reader will note that g is an acceleration while dv is a velocity. But you may also note that dv is the rate of space-time movement while g is the affect that movement has on matter-energy found within. Consider, for a moment, the special relativity relation between space-time:

$$s^2 = (ct)^2 - x^2 - y^2 - z^2 \quad (8)$$

Since gravity is unidirectional, we can simplify this to:

$$s^2 = (ct)^2 - x^2 \quad (9)$$

For this model of gravity, we will postulate that as space-time moves a given velocity, this is conveyed as an acceleration in that direction on all matter-energy contained. This can be represented by:

$$s = dv \,;\, ct = 0 \,;\, x_1 = x_0 - s \quad (10)$$

Thereby momentum is conserved and the object accelerates at -dv/dt.

Another way to approach this is from considering the fundamental principle of conservation of momentum. Traditional xyz Cartesian systems do not inherently retain this feature. We use a function to describe what space-time does on matter(p=mv) or light(c=d/t). Xyz Cartesian systems retain position only. If space-time retains position only, then there is no inherent factor to cause a moving particle or wave to continue moving. But if space-time retains velocity(corresponding to momentum), while position is derived from velocity, then momentum is conserved. Refer to Figures 1 and 2 below:

Fig. 1: Space-time flow on velocity

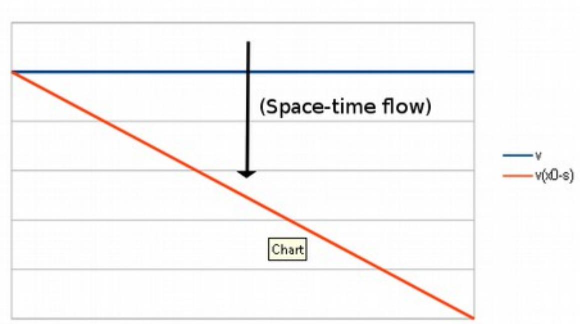
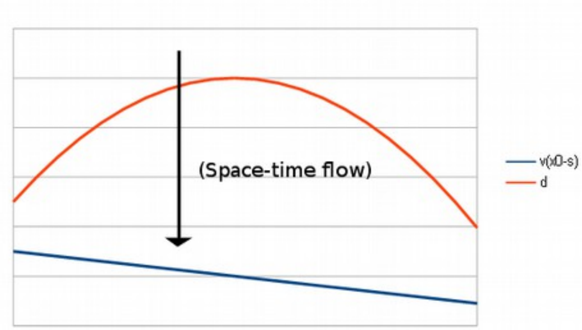


Fig. 2: Space-time flow on position



We can see in figure 1, when space-time flow is static, conservation of momentum occurs(blue line). When space-time flow is in the opposite direction of the velocity, over time the velocity's decline is linear.

When this space-time affect is applied to distance(orange line) in figure 2, we find that the path becomes parabolic. It becomes an acceleration.

Therefore, when space-time moves by a given velocity, this is conferred as an acceleration on particles and waves it is traveling through.

Another way to think of this is that space-time confers velocity while velocity confers position.

3. Candidate process parameters

A candidate process would need to meet the following:

$$Q / Q_t = k^2 \ell t \quad (11)$$

Where Q_t is the number of processes occurring per time unit(t), k is some constant taking the form of velocity, and ℓ represents some length.

This would then need to be consistent when comparing multiple examples with the same k and ℓ values.

4. Candidate process I – Luminosity

The first process I considered was:

$$E = mc^2 \quad (12)$$

That is to say that as rest matter takes the form of energy, space-time is consumed in the process, while when energy becomes matter, space-time is formed.

However, this candidate fails to pass the test when one considers the luminosity to mass relation of spectral bodies. Since luminosity closely correlates to temperature and not as much to mass [1]. When studying binary systems, one finds the standard gravitational parameter of a star and its luminosity are not directly correlated.

5. Candidate process II - Neutrinos

The second process considered was neutrino production. Challenges with this candidate is that we have had a difficult time measuring neutrinos and little is known about them. However, advances in neutrino science and the Standard Model over the last several decades has provided good information to make a correlation.

Solar Neutrinos - Several solar models have been produced based on the composition of our sun which can provide an approximate neutrino flux count.

We consider 7 models in Figure 3:

Fig. 3

Model	n/s
BP04(Yale)	1.841654E+038
BP04(Garching)	1.840949E+038
BS04	1.841603E+038
BS05(14N)	1.841854E+038
BS05(OP)	1.840187E+038
BS05(AGS,OP)	1.840334E+038
BS05(AGS,OPAL)	1.838763E+038
AVERAGE	1.840763E+038

Values derived from Bahcall-Serenelli 2005 using an Earth semi-major axis of 1.49598023 * 10^13 m. [2]

The average of the models considered is $1.840763\,E+38\,n/s$ (solar neutrinos produced per second).

The solar standard gravitational parameter(GM) is approximately given as:

$$GM = 1.32712440018\,E+20\,m^3/s^2$$

giving a Q value of:

$$Q = 1.66771370640\,E+21\,m^3/s^2$$

When calculating for $k^2 \ell$ (in eq. 11) I find that:

$$k^2 \ell = 9.0599022\text{E-}18\,m^3/s^2$$

Next, I find that if I set

$$k = c = 299{,}792{,}458\,m/s \quad \text{and} \quad \ell = 2\pi \ell_P \;,$$

where $\ell_P = 1.616229\text{E-}35\,m$ which is Planck length, then our value becomes:

$$c^2 2\pi \ell_P = 9.1269148\text{E-}18 > 9.0599022\text{E-}18$$

The difference is only ~ 0.74%.

Planck length was chosen because it is considered to be the shortest meaningful distance at the Quantum level and is defined as:

$$\ell_P = \sqrt{\frac{\hbar G}{c^3}}$$

And the speed of light is chosen for the velocity constant because it is a defining factor that correlates time-space(special and general relativity) and matter-energy(mass-energy equivalence).

And if we remove 4 pi from Q, we arrive at a simplified version of:

$$\frac{2GM}{Q_t} = c^2 \ell_P t \qquad (13)$$

We will consider the above simplified equation for future examples.

Solar models, however, have improved over the years to fall in line with the latest in neutrino detection.

Fig. 4

Type	Flux ($cm^{-2}s^{-1}$)	Error	Factor	Quantity(n/s)
pp	6.0	±0.8	1E+10	1.68737971067000E+038
pep	1.6	±0.3	1E+08	4.49967922845333E+035
hep(1)	8.23	(1)	1E+03	2.31452250313568E+031
Be	4.87	±0.24	1E+09	1.36958986516048E+037
B	5.25	±0.16	1E+06	1.47645724683625E+034
NOF(1)	3.5	(1)	1E+08	9.84304831224165E+035
			TOTAL	1.83882930190368E+038

Sources: pp [3], pep [4], Be [5], B [6]. (1) *Theoretical values provided from BS05(AGS, OPAL) due to lack of measurement data.*

The difference of the measured values and the presented model are 0.63% which is within the error threshold. I estimate the chance of these numbers being coincidental is $1/10^{109}$.

Earth Neutrinos – Earth is also a source of neutrinos. Geo-neutrinos are produced through the following decays:

- Beta Decay(1ν)
- Electron Capture(1ν)
- Positron Emission(1ν)
- Double Beta Decay(2ν)
- Double Electron Capture(2ν)
- Double Positron Emission(2ν)

In the case of geo-neutrinos, some are produced from cosmogenic origins(when cosmic rays hit matter on the surface or in the atmosphere) while others are produced from primordial isotopes(those existing when the Earth was formed).

However, neutrino detection technology thus far is unable to detect low energy neutrinos falling below an 1.806 MeV threshold. This means that only some of 238U and 232Th neutrinos can be detected while neutrinos from most other decays currently are undetectable [7]. Additionally, no known models currently exist with estimate geo-neutrino counts. Producing a meaningful model is also difficult when considering trace isotopes of more abundant elements. Take, for example, 32Si. This is a trace cosmogenic isotope which undergoes Beta Decay with a half-life of 153 years. Considering this element alone, if the isotope percentage is just 0.00003%, this would exceed the amount necessary for our above correlation to hold true. So getting more accurate trace values of elements which are of high abundance on Earth would help facilitate this estimate.

To compound the issue, many isotopes are observationally stable but are believed to undergo decay based on QE models. For example, consider 40Ca which is believed to undergo Double Electron Capture with a suspected half-life of greater than 5.9 E+21 years. If the half-life is found to be a magnitude of 10 less, this becomes a significant geo-neutrino source given the high abundance of this element.

So uncertainty in both half-lives and trace quantities can produce significant neutrino estimate variation.

And last, we are not entirely confident on the Earth's composition below the crust, although strides are being made [8]. We know much more about the Sun's composition with higher certainty than we do below our feet. Once we can fill in some of the information gaps or find more sensitive neutrino detection methods, we can then compare the values of Earth with it's standard gravitational parameter.

New innovations in neutrino detection will be necessary to make this comparison to other targets.

6. Schwarzschild radius comparison

The Schwarzschild radius is represented by:

$$r_s = \frac{2GM}{c^2} \quad (14)$$

Substituting in Q for GM with the relationship in equation (6), we would write:

$$r_s = \frac{2Q}{4\pi c^2} \quad (15)$$

When we solve for GM in equation (13) and substitute this into (14), we get:

$$r_s = \frac{2(Q_t c^2 \ell_P t)}{2c^2} \quad (16)$$

This simplifies down to:

$$r_s = Q \ell_P \quad (17)$$

In other words, if the correlation between gravity and neutrinos from equation (13) holds true, time dilation is a result of neutrino density. This was an unexpected find.

This calculates a Schwarzschild radius for the Sun of approximately 2,972 m based on measured solar neutrino values in Fig 4.

The gravitational time dilation equation could then be expressed as:

$$t_0 = t_f \sqrt{1 - \frac{Q \ell_P}{r}} \quad (18)$$

Thus, when neutrino density is greater than 1 for a sphere of Planck length radius, a theoretical event horizon occurs. However, I can conclude this as an impossible scenario due to matter never reaching the proper density to form an event horizon and black hole(BH). This is because time dilation would approach infinity as this density is approached. As time dilation increases, the amount of neutrino forming nuclear processes slow. Meanwhile, it is possible Hawking radiation, redshift, and neutrino energy loss would work to evaporate matter over infinite time [9]. At any rate, if the Universe has a finite time, the barrier of infinite time required to form such an event horizon at any point in the mass could never be passed.

It's worth noting, though, that in a collapsing star where neutrino density approaches that required for an event horizon may still exhibit some BH-like properties. Light in the main spectral frequencies would become red-shifted significantly due to gravitational time dilation. Additionally, collapsing masses approaching this density would not show signs of a "tidal disruption event" due to the collision effects being drastically time dampened [10].

Additionally noteworthy is that much of the neutrino production in our Sun is believed to be within 20-25% of the Sun's radius where core nuclear reactions occur. This would then give a time dilation for neutrino formation of 0.41% - 0.46% respectively based on this model. This time dilation may need to be considered in solar model composition predictions when determining rates of nuclear reactions, especially when modeling more massive stars where it becomes more apparent.

Lastly, it has been put forward by physicists recently that radioactive decay rates on Earth are possibly affected by neutrino density emissions from the Sun which vary periodically with the Earth's distance from the Sun [11]. This showed a wave-like shift overtime with oscillations between ±0.2% decay rates for ^{226}Ra and ^{32}Si during which distance varied by ±3% AU. If true, this would have a compound effect on solar neutrino models. Such effects need further study to find if nuclear reactions in the Sun and other stars are also affected by this. That may affect the modeling used for Sun composition and the projection of neutrino flux models applied to other stellar objects. If true, this may mean large star centers could provide more stable conditions for baryons composed of heavier quarks. Such compositions may result in a more linear neutrino flux to mass ratio while allowing luminosity to still rise exponentially.

7. Quantum Spin and Angular Momentum

After discovering the above relationships, I stumbled across an article from the late Satio Hayakawa written in 1958 titled "Neutrinos and Gravity". Satio Hayakawa was the founder of Nagoya's Institute of Plasma Physics, was president of the Institute of Fundamental Physics and served on the Japanese KEK Laboratory Board. His article also attempts to relate neutrinos and gravity but through a recoiling of the Universe due to mirror symmetry of space. At the time, he considered the theory "to be very speculative". In his theory, the neutrino carries away ½ quantum angular spin beyond the cosmological radius which causes the local space to recoil as this occurs and thus causing gravity [12]. He provides a series of equations such as follows:

$$R = b\,\hbar^2 / GM^2 m \quad (19)$$

Where b is a numerical factor, $\hbar$ is the Planck constant, G is the gravitational constant, while M(large) and m(small) are two masses. As interesting as his hypothesis was, they don't put forward any substantive claim or predictions. But it's still impressive he drew a correlation in the first place given the lack of data he had during that time about neutrino counts.

Moving along similar lines, it was Wolfgang Pauli who proposed the existence of neutrinos in the first place to account for ½ quantum spin which was seemingly lost during beta decays. If we rearrange equation 13, we find for 1 neutrino of ½ spin that:

$$\frac{GM}{\varrho} = 1/2\, c^2\, \ell_P = 7.262968\text{E-}19\, m^3/s^2$$

where $\varrho = 1$

This can also be arrived at with the following:

$$1/2\,\frac{\hbar\,\ell_P}{t_P m_P} = 7.262967\text{E-}19\, m^3/s^2$$

where $\hbar$ is the reduced Planck constant and m_P is Planck mass.

What this means is that when 1/2 spin is taken away from a quantum system by a neutrino departing at light speed(or near it), quantum angular momentum of the system becomes reduced which is translated as gravitation.

8. Supernova Explosion

It has long been known that Supernovas produce an intense flux of neutrinos. What is not known is what causes the Supernova to eject a significant amount of mass into the surrounding galactic area. If gravity and neutrinos are correlated, then it becomes quite clear what causes the explosion.

If a temporary high flux of neutrinos corresponds with an increased temporary gravity field, this could possibly cause the star to contract with high pressure during this quick burning only to have the gravity return to prior levels. The outer mass would then shoot off like a spring as the pressure stabilizes.

9. Accelerated Expansion without Dark Matter

This model may help find answers to the accelerated expansion of the Universe. If space-time is consumed during neutrino formation in dense systems, and if neutrino pairs are absorbed in photon pair production and other energy-mass conversions in intergalactic regions, space-time would form. As the space increases, more area for these reactions would allow more reactions to occur resulting in an outward acceleration.

The space between galaxies where large amounts of cosmic waves and neutrinos converge would be a prime area for matter formation. This would then result in neutrinos being used in the process and space-time being formed. Over greater distances, this may also produce gravitational lensing, especially between where galaxies more closely converge. This is because there would be a higher amount of cross sectional radiation and neutrinos density from the nearby galaxies. Recent analysis of galaxy ellipticities has found this gravitational lensing [13].

10. Testable Predictions

A theory describing why gravity occurs ought to also have testable predictions. Below, I provide three predictions that can test this theory:

Prediction I: Surface Levels Off near Abundant Neutrino Sources

If gravity is a result of neutrinos, then sources of abundant neutrinos/anti-neutrinos(i.e. nuclear reactors) should provide ideal testing conditions for examining this theory. When constructing buildings, including reactors, architects make sure that all concrete and flooring laid is level with Earth’s gravity to ensure stability. But if neutrinos produce gravity, then the buildings and surfaces near a nuclear reactor may have detectable variance in the level of their surfaces.

To determine the predicted variance, we can use equation 13.

Next, we will need to determine the number of neutrinos produced by the reactor core each second. There are several ways to achieve this. One way is by calculating the energy output from the reactor divided by its efficiency and divided by 205.5 MeV - the amount of energy released per Uranium fission reaction. Another way to determine neutrino counts is by direct detection as was done with the Laguna Verde Nuclear Power Plant [14]. Marisol and Alexis made measurements of anti-neutrino flux from 100 meters of one of the reactor cores over the course of 200 days.

Divide the antineutrino luminosity flux by the energy corresponding for each neutrino to get a neutrino flux $n/cm^2 s$. Since the measurement was performed at 100m, we should calculate the surface area of a sphere of r = 10,000cm with:

$$A_R = 4\pi r^2$$

Then multiply this by the neutrino flux $n/cm^2 s$ to get the total neutrinos per second.

$$\varrho_t = A_R * n/cm^2 s$$

We can enter this count into the above equation as ϱ_t and solve for the standard gravitational parameter(GM) of the reactor for t = 1s. Next, calculate for local g at the measurement location(which should ideally be 90° from the core):

$$g_R = GM/r^2$$

Then take the arctan of the ratio of both gravity vectors.

$$\arctan(g_R/g_E) = \theta$$

The angle θ will most likely fall somewhere between 0.05–0.10° at 100m for most reactors. The angle is a little more pronounced at 50m at somewhere between 0.17–0.35° Using a bubble level, then measure the level of surface. This can be compared with a laser level. A laser level would(for all intents and purposes) not be affected by the reactors gravity. Taking several samples from around the perimeter should produce similar results.

Prediction II: Time Dilation Near Abundant Neutrino Sources

Time dilation should be slightly more pronounced near abundant neutrino sources. For example, at 50 meters from a reactor the time dilation would result in 2–3 picoseconds lost per day.

However, recent research has implied that neutrinos may act as a catalyst in certain nuclear reactions [15,16].

This may act as a dampening effect on detecting time dilation using atomic clocks. If the neutrinos are causing the atomic clocks to tick *faster* due to this affect, atomic clocks may not be ideal for measuring this time dilation. More research will be needed to determine if this is feasible with atomic clocks or if a quantum laser clock should be employed instead [17].

Prediction III: Neutrino Counts of Jupiter

While Earth may not be an ideal place for counting neutrinos due to low energy and diversity of elements(as explored in the original article), Jupiter might make for a more ideal testing target. Jupiter's standard gravitational parameter is:

$$GM_J = 1.26686534(9) * 10^{17} m^3/s^2$$

With the neutrino/GM relation equation, I predict that Jupiter produces approximately:

$$\varrho_{Jt} = 1.74428 * 10^{35} n/s$$

Note:

If you know of anyone who works with or has access to a nuclear plant that can help me to test the first two predictions, please feel free to contact me at j.johnson.bbt@gmail.com.

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