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Research Article

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Using Space Particle Dualism Theory to Solve the Hierarchy Problem

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Abstract

The following paper is based on an approach to quantum gravity the author has been developing since 2005 [1]. In this theory space is quantized by postulating that every particle carries its own quantum of space with it, which is a 2-sphere with two complex dimensions [2, 3]. Different from all other approaches to quantum gravity is that in this theory, which the author calls 'space particle dualism theory' the quantums of space do not all have the same size and are not inhabiting the Planck scale, but are comparatively large in size, being just below the subatomic level and having an energy dependent size.

In this theory gravity is modeled as differences in the density of elementary spaces. The density of elementary spaces in the absence of gravity determines the strength of gravity. The aim of this paper is to test whether or not this leads to the right strength (or weakness) of gravity.

This present paper is not an introduction to the theory, and therefore not all the concepts that are needed to understand it can be introduced at length.

A few equations of the theory have to be known to the reader in order to understand the paper.

Brief mathematical introduction

According to space particle dualism theory gravity is caused by differences between what is called 'granular dimensionality' [4]. Granular dimensionality is given by the rather simple equation [5]:

$$D = 2 + \left(1 - \frac{1}{\sqrt{n_E}}\right)$$

Here n_E is the number of connections from one elementary space to other elementary spaces. The value of D is always very close to 3, but it never reaches 3 entirely.

The closer the value of D is to 3 already in empty space, the smaller are the differences between the values of D in different locations in a gravitational field.

Former estimates (2016) had shown that D must be 2.999…with so many 9's that differences can show up only in the 36th digit after the comma [6]. That would explain why gravity is 10^{36} times weaker than electromagnetism. Those estimates were rather imprecise and the agreement with the observed strength of gravity was not precise. That was because they didn't account for the variable size of elementary spaces [7].

Now we also need to know the size of elementary spaces. According to space particle dualism theory that is given by [8]:

$$R_E = \frac{2\,G_E\,M}{c^2} = \frac{2\,G_E\,E}{c^4}$$

$$G_E = \frac{k_e e^2}{m_p^2} = 8.246441821 \times 10^{25}\,\mathrm{N\,m^2kg^{-2}}$$

One last thing we need to know is the energy at which the elementary space becomes larger than the wavelength of the particle. For photons that is [9]:

$$E_{crit} = \sqrt{\frac{h\,c^5}{4\,G_E}} = 2.2 \times 10^{-9}\,\mathrm{J}$$

Which corresponds to a wavelength of about 9×10^{-17} m.

For electrons the critical energy is reached at the following speed [10]:

$$v = \frac{-\frac{4\,G_E\,m_0^2}{h} + \sqrt{\frac{16\,G_E^2\,m_0^4}{h^2} + 4\,c^2}}{2}$$

$$v_{e^-{}_{crit}} = 299{,}792{,}457.8\ \mathrm{m/s}$$

Which corresponds to a wavelength of 8.862×10^{-17} m [11-13].

Higher energies and speeds are possible, but according to this theory it is not possible to measure shorter distances directly using photons or electrons.

Shorter distances can however be measured using interference, as the recent detection of gravitational waves showed [14].

We can represent the strength of the gravitational constant by the connectivity n of elementary spaces as follows [15]:

$$G_S = \frac{k_e e^2}{m_p^2} \times \frac{1}{10\sqrt{n_E}}$$

It shall be noted that this G is slightly stronger than the usual G, because in space particle dualism gravity is a side effect of hypercharge, and thus measurements of G that don't take account of mass defect, don't yield the right outcome. Accordingly the index S here represents 'strong force' [16].Gravity is seen as a side effect of mainly the strong force. All the details to that can be found in other papers of the author.
From there we know that [17]:

$$G_S = G_{|\Upsilon|} = 7.110645989 \times 10^{-11}\,\mathrm{m^3kg^{-1}s^{-2}}$$

We can use this value to compute an expected value for the granular connectivity of space (the number of connections) [18]:

$$n_E = \left(\frac{k_e e^2}{10\,G_S m_p^2}\right)^2$$

$$n_E = 1.344977701 \times 10^{70}$$

And that leads to an expected value for the granular dimensionality of:

$$D = 3 - 8.62268375 \times 10^{36}$$

It would be too lengthy for this paper to explain all these figures in detail. Giving these basics, we can now go over to examine if calculating the energy of the quantum vacuum really leads us to the above figures for the granular connectivity and granular dimensionality of the quantum vacuum, and therefore to the right strength of gravity.

Solving the hierarchy problem

We shall now look at the degree of connectivity n of elementary spaces provided by electrons and other fermions.

The formula for the tightest packing of spheres can provide us with the elementary space density required for a continuous space, and that is [19]:

$$\rho = \frac{\pi}{3\sqrt{2}}$$

We want to know how many times a volume of space can be filled up with different sized elementary spaces.

The volume of each elementary space is [20]:

$$V = \frac{32\,\pi\,G_E{}^3}{3\,c^6}\left[\frac{m_e}{\sqrt{1-\frac{v^2}{c^2}}}\right]^3$$

There are $1/V_p$ of them in a cubic meter of space and they need to arrive at the density ρ in order to fill up the cubic meter once. So the contribution from one particular relativistic mass of an electron is:

$$n_E = \frac{96\,G_E{}^3\sqrt{2}}{V_P\,3\,c^6}\left[\frac{m_e}{\sqrt{1-\frac{v^2}{c^2}}}\right]^3$$

We need to quantize the mass-energy of these virtual electrons, and therefore we must look at their wavelength [21], which is:

$$\lambda = n \times l_P = \frac{h\sqrt{1-\frac{v^2}{c^2}}}{m_e\,v}$$

Solving this for v yields:

$$\frac{\lambda\,m_e\,v}{h} = \sqrt{1-\frac{v^2}{c^2}}$$

$$\frac{\lambda^2 m_e^2 v^2}{h^2} + \frac{v^2}{c^2} = 1$$

$$v^2\left(\frac{\lambda^2 m_e^2}{h^2} + \frac{1}{c^2}\right) = 1$$

$$v^2\left(\frac{\lambda^2 m_e^2 c^2 + h^2}{h^2 c^2}\right) = 1$$

$$v^2 = \frac{h^2 c^2}{\lambda^2 m_e^2 c^2 + h^2}$$

$$v = \frac{h\,c}{\sqrt{\lambda^2 m_e^2 c^2 + h^2}}$$

Now we can substitute λ^2 by $n^2\, l_P{}^2$ and enter this term into the original equation for the number of connections n_E on elementary spaces, which yield:

$$n_E = \frac{96\,G_E{}^3\sqrt{2}}{V_P\,3\,c^6}\left[m_e : \sqrt{1 - \frac{h^2}{n^2\, l_P^2 m_e^2 c^2 + h^2}}\right]^3$$

The next step is to take the sum of all different values for n, up to the value that corresponds to the 'maximal relevant wavelength 'that was mentioned in the mathematical introduction. It corresponds to $n = 2.5\times10^{37}$, so we write:

$$\sum_{i=1}^{n=2.5\times10^{37}} n_E = \frac{96\, G_E{}^3\sqrt{2}}{V_P\, 3\, c^6}\left[m_e : \sqrt{1-\frac{h^2}{n^2\, l_P^2 m_e^2 c^2 + h^2}}\right]^3$$

For the sake of simplicity we will now replace the individual groups of constants by the factors *A*, *B*,*C* and *D*:

$$\sum_{i=1}^{n=2.5\times10^{37}} n_E = A\left[B : \sqrt{1-\frac{C}{D\, n^2 + C}}\right]^3$$

$$A = \frac{96\, G_E{}^3\sqrt{2}}{V_P\, 3\, c^6} = 8.280023422 \times 10^{118}$$

$$B = m_e = 9.1093835611 \times 10^{-31}\ \text{kg}$$

$$C = h^2 = 4.390479797 \times 10^{-67}$$

$$D = l_P^2 m_e^2 c^2 = 1.948163391 \times 10^{-113}$$

This can be further simplified into:

$$\sum_{i=1}^{n=2.5\times10^{37}} n_E = A\left[B : \sqrt{1-\frac{1}{D' n^2 + 1}}\right]^3$$

With:

$$D' = \frac{D}{C} = 4.43724486 \times 10^{-47}$$

The order of magnitude of *D* is 10^{-113}. When we divide this by *C*, we get an order of magnitude of 10^{-47}. When we square the maximal value for n, we get 6.25×10^{74}.

In the following we will use a method which only applies to $D' n^2 << 1$. The terms for which $d' n^2 >>1$ we will calculate separately.

Accordingly our first sum goes only ton$=10^{23}$, which is about the half of 47. After isolating the factors *A* and *B* and replacing the root, we get:

$$n_{E_1} = A\, B^3 \sum_{i=1}^{n=10^{23}} \left(1-\frac{1}{D' n^2 + 1}\right)^{-\frac{3}{2}}$$

In this case $D' n^2$ is much smaller than 1, and that allows the following simplification:

$$1-\frac{1}{D' n^2 + 1} \approx 1-(1-D' n^2) = D' n^2$$

Thus the sum is reduced to:

$$n_{E_1} = A\, B^3 D'^{-\frac{3}{2}} \sum_{i=1}^{n=10^{23}} n^{-3} = A\, B^3 D'^{-\frac{3}{2}} \zeta(3)$$

With ζ(3) being Apéry's constant, which has the value:

1.202056903159594285399 …

Putting the physical constants back into our equation we get:

$$n_{E_1} = \frac{96\, G_E{}^3\sqrt{2} m_e^3 (n^2\, l_P^2 m_e^2\, c)^{-\frac{3}{2}} \zeta(3)}{V_P\, 3\, c^6}$$

And that is:

$$n_{E_1} = 4.889092274 \times 10^{212}$$

This value is far higher than what we expected, namely the $n_E = 10^{70}$ mentioned in the mathematical introduction.

Estimates from 2016 didn't take account of the varying elementary space size, and thus a much lower value for n_E was obtained there, although the amount of vacuum energy that was assumed to exist was the same.

This might be a hint that vacuum fluctuations equivalent to the Planck energy in fact don't exist. Such a fluctuation would have an elementary space with the radius of ridiculous 40 meters (!).

The shorter the lifetime of a quantum fluctuation is, the more energetic it is. Shouldn't the same apply to extension in space? For particles with wavelengths larger than their own diameter that is certainly true. Fluctuations with huge energies are usually confined to smaller volumes of space. Large elementary spaces would violate this rule.

If this line of reasoning is correct, then the critical energy mentioned in the introduction should at the same time be the maximal energy of vacuum fluctuations. Particles with larger energies do exist, but presumably only as real particles, not as virtual particles in the quantum vacuum.

As we saw in the introduction, the critical energy corresponds to a wavelength of 8.862×10^{-17} m and that equals 5.483132598×10^{18} Planck lengths.

That means a new calculation should start with $n = 5\times10^{18}$ and end with $n=2\times10^{37}$.

Again we note that:

$$1-\frac{1}{1+D' n^2} < 1-\frac{1-D'^2 n^4}{1+D' n^2} = 1-(1-D' n^2) = D' n^2$$

And that this difference becomes neglect able for 'small' values of *n*, namely whenever:

$$n \ll \frac{1}{\sqrt{D'}} \approx 10^{24}$$

So whenever n is smaller than10^{24}, the whole term simplifies into $D' n^2$.

For very big values of n on the other hand, we have the simple estimate:

$$1 - \frac{1}{1 + D'n^2} < 1$$

Overall we can assess that:

$$\sum_{n=n_1}^{n_2} \left(1 - \frac{1}{1 + D'n^2}\right)^{-\frac{3}{2}} > \sum_{n=n_1}^{n_2} \left(\min(D'n^2)\right)^{-\frac{3}{2}} = \sum_{n=n_1}^{n_2} \max\left(D'^{-\frac{3}{2}}n^{-3}, 1\right)$$

Whereas

$$n_1 = 5.483132598 \times 10^{18} \ll \frac{1}{\sqrt{D'}}$$

and

$$n_2 = 2.512019674 \times 10^{37} \gg \frac{1}{\sqrt{D'}}$$

That means we have to separate the sum there. For n_1 we have:

$$\sum_{n=n_1}^{\frac{1}{\sqrt{D'}}} \max\left(D'^{-\frac{3}{2}}n^{-3}, 1\right) = D'^{-\frac{3}{2}} \sum_{n=n_1}^{\frac{1}{\sqrt{D'}}} n^{-3} \approx D'^{-\frac{3}{2}} \int_{n_1}^{\frac{1}{\sqrt{D'}}} x^{-3}\, dx$$

Adding back in A and B and solving the integral yields:

$$n_{E_1} = A\,B^3 D'^{-\frac{3}{2}} \left[-\frac{1}{2}x^{-2}\right]_{x=n_1}^{\frac{1}{\sqrt{D'}}} \approx \frac{1}{2} A\,B^3 D'^{-\frac{3}{2}} n_1^{-2}$$

$$n_{E_1} = 3.521607475 \times 10^{60}$$

And for n_2 that is simply:

$$\sum_{n=\frac{1}{\sqrt{D'}}}^{n_2} \max\left(D'^{-\frac{3}{2}}n^{-3}, 1\right) = \sum_{n=\frac{1}{\sqrt{D'}}}^{n_2} 1 \approx n_2$$

$$n_{E_2} = A\,B^3 n_2$$

$$A\,B^3 = 6.258907484 \times 10^{28}$$

$$n_{E_2} = 1.572249874 \times 10^{66}$$

Adding together the two yields:

$$n_{E_\Sigma} = n_{E_1} + n_{E_2} = 1.572253396 \times 10^{66}$$

As mentioned in the introduction, the connectivity (number of connections) of elementary spaces in empty space is:

$$n_E = \left(\frac{k_e e^2}{10\, G_S m_p^2}\right)^2$$

$$n_E = 1.344977701 \times 10^{70}$$

It is good that our result here did not exceed this value. If it did, the theory would be in serious trouble.

Now we have to calculate the contribution from massless bosons like the photon.

Out of $m = E/c^2$ and $E = h\,c / \lambda$ as well as the equation we used before for the contribution of electrons follows that:

$$n_{E_\gamma} = \frac{96\, G_E{}^3 \sqrt{2}}{V_P\, 3\, c^6} \left[\frac{h}{n\, l_P c}\right]^3$$

$$n_{E_\gamma} = \frac{1}{n^3} \times \frac{96\, G_E{}^3 \sqrt{2} h^3}{V_P\, 3\, c^9 l_P^3} = \frac{1}{n^3} \times \frac{A h^3}{c^3 l_P^3}$$

For finding the contribution from all different wavelengths we take the sum from the shortest wavelength up to the longest wavelength. For photons these correspond to:

$$n_1 = 5.572591903 \times 10^{18}$$

$$n_2 = 2.512019674 \times 10^{37}$$

Thus the photon contribution to the connectivity of elementary spaces is given by:

$$n_{E_\gamma} = \sum_{n_1}^{n_2} \frac{1}{n^3} \times \frac{96\, G_E{}^3 \sqrt{2} h^3}{V_P\, 3\, c^9 l_P^3}$$

The constant cluster on the right has the value:

$$A' = \frac{A h^3}{c^3 l_P^3} = 2.11752448 \times 10^{98}$$

We can now approach this sum using an integral:

$$A' \sum_{n=n_1}^{n=n_2} n^{-3} \approx A' \int_{n_1}^{n_2} x^{-3}\, dx$$

$$n_{E_\gamma} = A' \left[-\frac{1}{2}x^{-2}\right]_{x=n_1}^{n_2} \approx \frac{1}{2} A' n_1^{-2}$$

These yields: $n_{E_\gamma} = 3.409447167 \times 10^{60}$

This is far below the overall value of 10^{70} for the connectivity of elementary spaces in empty space. This calculation shows that rest mass particles like electrons contribute by far more to n_E than massless particles like photons.

The question now is if the diversity of particles in the quantum vacuum can explain the gap between our before calculated value of 10^{66} and the expected overall value of about 10^{70}.

In previous estimates the result was multiplied by 17, for 17 fundamental particles, and then by 1.5, to account for all the dark matter particles [22].

However, due to the 'coldness' of dark matter it is to be doubt that it really contributes significantly to the quantum vacuum [23].

Something else that was wrong with that former estimate is that it counted in only elementary particles, while in reality all subatomic particles contribute to the quantum vacuum. Including not yet observed ones that give a total of 226 baryons, 196 mesons, 6 leptons and 4 vector bosons and 1 scalar boson. That gives a total of 433 subatomic particles. Accounting for all their anti-particles we have to multiply that by 2 and arrive at 866. Two of these particles, the photon and the gluon, do not have rest mass, and do therefore contribute much less to the connectivity of granular space. That leaves us with a factor of 862, which yields:

$$n_E = 862 \times n_{E_\varepsilon} = 862 \times (1.572249874 \times 10^{66})$$

$$n_E = 1.355279391 \times 10^{69}$$

Here I didn't calculate the contribution from different rest mass particles separately. That is because we know the only thing that is different with these particles is the mass, and since mass is a side effect of charge, differences in mass are presumably only due to the running of coupling.

However, a vast majority of the particles we counted were subatomic compound particles (mesons and baryons) composed of 2 or 3 quarks.

Three quarks correspond to three elementary spaces, thus each baryon counts as three particles. This gives us a new particle count, which yields:

$$2 \times [(226 \times 3) + (196 \times 2) + 6 + 2 + 1] = 2{,}158$$

Using this particle count we arrive at:

$$n_E = 2{,}158 \times n_{E_\varepsilon}$$

$$n_E = 3.392915228 \times 10^{69}$$

Of course, on earth we have a much higher vacuum energy density due to all the force transmitting virtual particles that are emitted by all the charges and hypercharges around. However, according to space particle dualism theory this higher density is not observable, because implies a change in the strength of gravity, and a change in the value of a fundamental constant is indistinguishable from a Lorenz transformation [24].This idea was also formerly considered by Einstein himself [25, 26].

Similarly space particle dualism is explaining speed dependent time dilation and length contraction by saying that uniformly growing elementary spaces are indistinguishable from a change in the speed of light, which is effectively perceived as time dilation [27].

Even if it is impossible to measure a higher G far away from any gravitational source, the number of connections between elementary spaces must definitely be lower there, although we are not able to measure that, because it changes the way we perceive space and time.

If this line of reasoning is correct, the departure between the actual value of G and the predicted one, can tell us how much time dilation we have here on earth relative to a hypothetical observer infinitely far away from any gravitational source.

References

1. Sky Darmos (2014-2019) One core component, the similar worlds interpretation, is however older. It was first conceived in 2003. Quantum Gravity and the Role of Consciousness in Physics.
2. Sky Darmos (2014-2019) Originally different values for the complex factors a and b were considered (2005). That was rooted in the notion of *oscillating mass*. However, since August-2019 a new scheme has been introduced, in which a = b is the general assumption. The old scheme is still introduced in the present book. See chapters 3.3 and 3.5 of "Quantum Gravity and the Role of Consciousness in Physics".
3. The disadvantage of the old scheme was that it had the ungeometric distinction between source mass/energy and surface (2017) The new scheme drops this distinction; butit still has the disadvantage that it still relies on assuming a point-like particle that orbits the elementary space. This still seems to violate strict geometrism. A possible solution could be the assumption of oscillating surface. The downside of that is that it makes it harder to define geodesics in granular space in such a scheme.
4. Sky Darmos (2014-2019) An in depth introduction to granular dimensionality can be found in chapter 3.8. Quantum Gravity and the Role of Consciousness in Physics.
5. The square root was not there in the original 2005 version of the equation. It was added in 2015 in order to account for the fact that one needs to be able to access more directions in order to get a feeling of three-dimensionality in a granular space with 2-dimensional elementary spaces (2-spheres), than one would need in a granular space with 1-dimensional elementary spaces.
6. Sky Darmos (2014-2019) That first calculation can be found in chapter 3.8 (formally 3.7) of "Quantum Gravity and the Role of Consciousness in Physics". The more precise calculation can be found in chapter 3.16 and in his present paper.
7. The reason the first approximation in 2016 got somewhat close to the right result is the fact that wavelengths of more than one meter were omitted. On the other hand very energetic fluctuations up to the Planck mass were allowed, while they are not in this present calculation, as we shall see.
8. This precise value for GE was not known before 2018. In 2016 an approximated value was used, which was one order of magnitude too large. That was because it was believed that

GE would have to be a G that is scaled up to the strength of the GUT-force. Later it was found that the running of coupling makes that unnecessary, because when using the strength of the GUT-force one would have to also use the naked mass of particles, and the two effects cancel out.
9. Sky Darmos (2014-2019) Some readers probably would like to suggest that the electron mass is more fundamental and that it should be preferred when defining the strength of gravity. However, according to space particle dualism gravity is mainly caused by nuclei, not by electrons, so using the proton mass is appropriate here. According to SPD the gravity of electrons falls-off after 40 meters. See chapter 6.6 of "Quantum Gravity and the Role of Consciousness in Physics".
10. Sky Darmos (2014-2019) The derivation of this formula can be found in chapter 3.8 (formally 3.7) of "Quantum Gravity and the Role of Consciousness in Physics".
11. Ibid.
12. It is not yet clear what the close approximation of these two critical frequencies indicates. It might be suggesting some sort of deeper connection between photons and electrons; or maybe Penrose is right that the distinction between massive and massless particles vanishes at high energies (Penrose; 2010).
13. When we translate this into a mass we get $2.447830123 \times 10^{-26}$ kg, somewhat close to the mass of the W- and Z-bosons. That could be indicating a connection, or not.
14. Whitcomb SE (1995) "Precision Laser Interferometry in the LIGO Project", Proceedings of the International Symposium on Modern Problems in Laser Physics. Novosibirsk, LIGO Publication P950007-01-R.
15. Dividing through 10 is because we need to get behind the last9, in the figure for granular dimensionality, because that is where differences between the density of space between different regions show up.
16. Sky Darmos (2014-2019) In a newer connotation used since 2019, 'GS' is written as G|Y|, with |Y| standing for 'cardinal hypercharge' (read as 'absolute double-struck Y'). It is usually denoting the number of quarks nq. See chapter 6.6 of "Quantum Gravity and the Role of Consciousness in Physics".
17. Ibid.
18. Sky Darmos (2014-2019) This equation is derived in chapter 3.9 (formerly 3.8) of "Quantum Gravity and the Role of Consciousness in Physics".
19. Gauß CF (1831) Besprechung des Buchs von L. A. Seeber: Untersuchungen über die Eigenschaften der positiven ternären quadratischen Formen usw" [Discussion of L. A. Seeber's book: Studies on the characteristics of positive ternary quadratic forms etc].
20. Sky Darmos (2014-2019) This is simply based on the elementary space radius equation introduced earlier in this paper and in chapter 3.3 and 3.8 of "Quantum Gravity and the Role of Consciousness in Physics".
21. One could consider a quantization directly through the size of elementary spaces. However, the wavelength is more directly measurable and should thus be preferred.
22. Sky Darmos (2014-2019) That was done in chapter 3.8 (formerly 3.7) of "Quantum Gravity and the Role of Consciousness in Physics".
23. Sky Darmos (2014-2019) Mathematical reasons of why dark matter must be cold are given in chapter 4.9 of "Quantum Gravity and the Role of Consciousness in Physics".
24. Sky Darmos (2014-2019) Gravitational time dilation was derived in in chapter 6.3 of "Quantum Gravity and the Role of Consciousness in Physics".
25. Einstein Albert (1907) Uber das Relativitätsprinzip und die aus demselben gezogenen Folgerungen. Jahrbuch fur Radioaktivität und Elektronik 4: 411-462.
26. Einstein (1911) "Uber den Einfluß der Schwerkraft auf die Ausbreitung des Lichtes" (PDF). Annalen der Physik 35: 898-906.
27. Sky Darmos (2014-2019) Speed dependent time dilation was derived in chapter 3.13 of "Quantum Gravity and the Role of Consciousness in Physics".