A Modified Newtonian Quantum Gravity Theory Derived from Heisenberg's Uncertainty Principle that Predicts the Same Bending of Light as GR

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Abstract

Mike McCulloch has derived Newton's gravity from Heisenberg's uncertainty principle in a very interesting way that we think makes great sense. In our view, it also shows that gravity, even at the cosmic (macroscopic) scale, is related to the Planck scale. Inspired by McCulloch, in this paper we are using his approach to the derivation to take another step forward and show that the gravitational constant is not always the same, depending on whether we are dealing with light and matter, or matter against matter. Based on certain key concepts of the photon, combined with Heisenberg's uncertainty principle, we get a gravitational constant that is twice that of Newton's when we are working with gravity between matter and light, and we get the (normal) Newtonian gravitational constant when we are working with matter against matter. This leads to a very simple theory of quantum gravity that gives the correct prediction on bending of light, i.e. the same as the General Relativity theory does, which is a value twice that of Newton's prediction. One of the main reasons the theory of GR has surpassed Newton's theory of gravitation is because Newton's theory predicts a bending of light that is not consistent with experiments.

Key words: Heisenberg's uncertainty principle, Newtonian gravity, Planck momentum, Planck mass, Planck length, gravitational constant, Lorentz symmetry break down.

1 The Rest-mass of Light Particles and Introduction to Gravitational Bending of Light

The mainstream view in modern physics is that light has no rest-mass. However, to calculate Newton's bending of light predictions, we must assume that light has a hypothetical rest-mass. This is normally obtained by taking the light energy and dividing by c^2. The Newton bending of light was first derived by Soldner in 1881 and 1884, [1, 2])

$$\delta_S = \frac{2Gm}{c^2 r} \tag{1}$$

In 1911, Einstein obtained the same formula for the bending of light when he derived it from Newtonian gravitation; see [3]. The angle of deflection in Einstein's general relativity theory [4] is twice what one gets from Newtonian gravity

$$\delta_{GR} = \frac{4Gm}{c^2 r} \tag{2}$$

The solar eclipse experiment of Dyson, Eddington, and Davidson performed in 1919 confirmed [5] the idea that the deflection of light was very close to that predicted by Einstein's general relativity theory. In other words, the deflection was twice what was predicted by Newton's formula.

First of all, it must be clear that Newton never derived a mathematical value for his gravitational constant. It is a constant that needs to be calibrated to gravitational observations to make the theory work. The gravitational constant was first indirectly measured by Cavendish [6] in 1798 using a so-called Cavendish set-up. Bear in mind, however, that the Cavendish set-up included only traditional masses and no light; in short it consisted of four lead balls.

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Over the last years Haug has derived an extensive mathematical theory from atomism that gives all the same mathematical end results as Einstein's special relativity theory. However, Haug's work develops ideas around upper boundary conditions that are linked to the Planck length and the Planck mass. In this theory, all matter and mass are built from indivisible particles and empty space. This indivisible particle has a diameter equal to the Planck length. The indivisible particle always moves at the speed of light and has no rest-mass when it is moving. Only when colliding with another indivisible particle, does it stand still for one Planck second. This collision point is what we call "mass." The concept that photons interacting with other photons can create matter in so-called photon collisions has long been predicted, but not definitely proven in experiments yet. However, the idea that photon-to-photon collisions will create mass has recently received increased attention in the science community; see [7, 8], for example.

This collision point between two indivisible particles (light particles) is, in our theory, the Planck mass. However, this Planck mass only lasts for one Planck second. And again, this mass consists of two indivisible particles, so each indivisible particle has a rest-mass (at collision) of half the Planck mass. We also get a hint about the lifetime of a Planck particle from the Planck acceleration, $a_p = \frac{c^2}{l_p} \approx 5.56092 \times 10^{51}\ m/s^2$. The Planck acceleration is assumed to be the maximum possible acceleration by several physicists; see [9, 10], for example. The velocity of a particle that undergoes Planck acceleration will actually reach the speed of light within one Planck second: $a_p t_p = \frac{c^2}{l_p}\frac{l_p}{c} = c$. However, we know that nothing with rest-mass can travel at the speed of light, so no "normal" particle can undergo Planck acceleration if the shortest possible acceleration time interval is the Planck second. The solution is simple. The Planck acceleration is an internal acceleration inside the Planck particle that within one Planck second turns the Planck mass particle into pure energy. This also explains why the Planck momentum is so special, namely always $m_p c$, unlike for any other particles, which can take a wide range of velocities and therefore a wide range of momentums.

We can write the mass of any elementary particle in the form

$$m = \frac{\hbar}{\bar{\lambda}}\frac{1}{c} \tag{3}$$

However, we rarely see discussions on why elementary masses are dependent on the speed of light? The fact that their journey from energy to mass and from mass to energy is dependent on the speed of light speed is well-known, of course, but why elementary masses can be written as a function of the speed of light has not been discussed in depth. Under atomism, the speed of light in the elementary particle formula is related to the concept that any normal mass is assumed to consist of a minimum of two light particles, that is to say, two indivisible particles. These particles are each moving back and forth over the distance of the reduced Compton wavelength of the particle at the speed of light. Each indivisible particle is massless when moving and will attain half of the Planck mass for one Planck second when colliding with another indivisible particle. If electrons ultimately consist of light, we suggest that such collisions happen internally inside the electron an tremendous number of times per second, namely

$$\frac{c}{\bar{\lambda}_e} \approx 7.76344 \times 10^{20} \tag{4}$$

Each of these events is comprised of a Planck mass times one Planck second, which is the mass gap in the atomism theory, and this gives an electron mass of

$$\frac{c}{\bar{\lambda}_e} \times 1.17337 \times 10^{-51} \approx 9.10938 \times 10^{-31}\ \text{kg} \tag{5}$$

This means all elementary particles have a Planck mass element to them and it also explains why modern physics sometimes uses the formula $m = \frac{\hbar}{\bar{\lambda}}\frac{1}{c}$ to describe elementary masses. This also indicates why the speed of light appears in the elementary mass formula. The Planck mass is considered large and there has been a significant amount of speculation on where and how the Planck mass particle came into being: did it only exist at the beginning of the Big Bang, or it is hidden away somewhere as a micro black hole? The answers are not clear yet, but we claim the the Planck mass particle is directly linked to the Planck second, which is a very natural progression. This could explain why the Planck mass particle is basically everywhere inside normal matter, but so hard to measure.

2 Heisenberg's Uncertainty Principle, Newton's Theory of Gravitation, and McCulloch's Derivation

In this section we will follow the approach that McCulloch has used to derive Newtonian gravity [11] relying on Planck masses, and the Heisenberg uncertainty principle; see [12, 13]. However, we will assume that light particles are linked to half the Planck mass (half the mass gap), while matter (because it consists of minimum two light particles) is linked to the Planck mass (the mass gap). Heisenberg's uncertainty principle [14] is given by

$$\Delta p \Delta x \geq \hbar \tag{6}$$

Next McCulloch goes from momentum to energy simply by multiplying p with c and gets

$$\Delta E \Delta x \geq \hbar c \tag{7}$$

As recently pointed out by Haug, this approach is actually only valid as long as the momentum is related to the Planck mass particle. This is a key point. While the Planck mass, Planck length, Planck time, and Planck energy were introduced in 1899 by Max Planck himself [15, 16], the Planck mass particle was likely first introduced by Lloyd Motz, when he was working at the Rutherford Laboratory in 1962; see [17, 18, 19].

Modern physics states, often without arguing exactly why, that mc can be applied to light, but then light is assumed to be mass-less, so it should not apply. However, we think we have a sound explanation. The momentum formula that holds for any particle is the relativistic momentum formula given by Einstein

$$p = \frac{mv}{\sqrt{1-\frac{v^2}{c^2}}} \tag{8}$$

Multiplying this by c clearly does not give us the kinetic energy formula, or the rest-mass energy formula. So how does the Planck momentum fit in here? If it also follows Einstein's [20] relativistic principles, then we must have

$$p_p = \frac{m_p c}{\sqrt{1-\frac{v^2}{c^2}}} = m_p c \tag{9}$$

This is only possible if $v = 0$. That is to say, the Planck mass particle must always stand still as pointed out by Haug in a series of papers [21], even as observed across different reference frames. In other words, this indicates that there is a breakdown of Lorentz symmetry at the Planck scale, something that several quantum gravity theories also claim [22]. Our point is that the way McCulloch gets to his relation $\Delta E \Delta x \geq \hbar c$ likely only can be done in relation to Planck mass particles, or at least Planck masses. Next, just as McCulloch does, we will use the following relationship

$$\Delta E \Delta x = \sum_i^N \sum_j^n (\hbar c)_{i,j} \tag{10}$$

where m_i is the potential rest-mass of photons given by its energy divided by c^2; this is the traditional way of finding a hypothetical photon mass. And $\sum_i^N$ is the number of half Planck masses in the light beam $\frac{m_i}{\frac{1}{2}m_p}$. This is due to our hypothesis that light is linked to the Planck mass particle (the mass-gap) the way described in the introduction section, and it is the only difference with the McCulloch derivation, but it is a very important one, as we soon will see. In addition, $\sum_j^n$ is the same as in the McCulloch derivation, namely the number of Planck masses in a larger mass $\frac{M}{m_p}$. The idea is simply that we need a minimum two light particles to collide to create mass. This gives us the equation

$$\begin{aligned} \Delta E \Delta x &= \frac{m_i}{\frac{1}{2}m_p}\frac{M}{m_p}\hbar c \\ \Delta E &= 2\frac{\hbar c}{m_p^2}\frac{m_i M}{\Delta x} \end{aligned} \tag{11}$$

Further, we can divide by Δx on both sides and this gives

$$\frac{\Delta E}{\Delta x} = F = 2\frac{\hbar c}{m_p^2}\frac{m_i M}{(\Delta x)^2} \tag{12}$$

From Haug [23], we have that $\Delta x \geq l_p$, so we think Δx can be set to any larger value, for example the radius of the Earth, or any other radius $r \geq l_p$, and this gives us

$$F = 2\frac{\hbar c}{m_p^2}\frac{m_i M}{r^2} \tag{13}$$

The formula we have derived above looks very similar to the McCulloch formula, which is identical to the Newton gravitation formula except that here we have a composite gravitational constant of $2\frac{\hbar c}{m_p^2}$ versus $\frac{\hbar c}{m_p^2}$. The numerical output from the McCulloch constant is approximately

$$\frac{\hbar c}{m_p^2} \approx 6.67 \times 10^{-11}\ m^3 \cdot kg^{-1} \cdot s^{-2} \tag{14}$$

This is basically the same as the value of the Newtonian gravitational constant, and in the same units. But when we are working with gravity between light and standard matter (such light and the Sun), we claim that light is linked to half the Planck mass (mass-gap) and that other masses are linked to the full mass gap (the Planck mass over the Planck time), based on the atomism hypothesis.

In 1979, Motz and Epstein [24] suggested that a key to understanding gravity could be linked to a half Planck mass particle and that that there could be a discontinuity in Newton's gravitational constant for special situations:

> *We believe that introducing a discontinuity in G is such an ad hoc hypothesis and that a full understanding can only come from an analysis of the physical operational meaning of the constant.*
> — Motz and Epstein 1979

Our theory is one step forward from Motz and Epstein's brilliant ad-hoc hypothesis. Here we have shown that the composite gravitational constant indeed likely is different when working with light and matter than when working only with matter against matter. Since our gravitational constant is twice of Newton when working with light and matter, versus matter and matter, we will get a light bending prediction equal to that of GR, but based on a special property of the photon rather than based on bending of space. Others are also working in this area; Sato and Sato [25], for example, have suggested that the 2 factor (double of Newton) in observed light deflection likely could be due to an unknown property of the photon, rather than the bending of space-time. This is exactly what our theory strongly indicates as well.

Consider also for a moment that it was very easy to measure light bending from the Sun or even the Earth at the time of Newton (the Earth has such a weak gravitational field that we have not even been able to do it today). Then assume that light bending was the first type of gravity experiment that had been used to find and calibrate the Newton gravitational constant to fit experiments. If that was the case, then Newton's gravitational constant would have twice the value of today[1].

There are some assumptions that are hard to test in our theory. However, at least it is a very simple quantum gravity theory that correctly predicts the bending of light and other gravity phenomena. We have not looked into the Perihelion of Mercury yet, which is supposedly another key observation supporting GR, but as pointed out by several researchers it is not completely clear that it is inconsistent with Newtonian gravity, as is often assumed; see [26, 27, 28, 29, 25], for example.

In a series of recently published papers, [30, 31, 32, 33] Haug has suggested and shown strong evidence for the idea that Newton's gravitational constant must be a composite constant of the form

$$G = \frac{l_p^2 c^3}{\hbar} \tag{15}$$

This has been derived from dimensional analysis [30], but one can also derive it directly from the Planck length formula. McCulloch's Heisenberg-derived gravitational constant $G = \frac{\hbar c}{m_p^2}$ is naturally the same as the Planck mass and is directly linked to the Planck length, $m_p = \frac{\hbar}{l_p}\frac{1}{c}$.

Many physicists will likely protest here and claim that we cannot find the Planck mass before we know Newton's gravitational constant. However, Haug [32] has shown that one easily can measure the Planck length with a Cavendish apparatus and thereby know the Planck mass without any knowledge of the Newton gravitational constant. Further, Haug has shown that the standard measurement uncertainty in the Planck length experiments must be exactly half of that of the standard uncertainty in the gravitational constant, which is very likely a composite constant. See also [34].

3 Summary

In this section we will summarize our theory in bullet point style:

- We suggest that the minimum ordinary mass is linked to the collision of a minimum of two photons, so-called photon-to-photon collisions that recently have received increased attention by the physics community. From this we claim that a minimum mass can be created (the mass-gap) that is linked to the Planck mass and lasts for one Planck second. Since this requires a minimum of two photons, it means that the building blocks of photons only have half of that as a potential rest-mass that only will be realized at collision with other matter or photons. That is the rest-mass of photons are linked to half the Planck mass (over one Planck second), so an incredibly small, mass, and the half mass can never be observed, only the mass-gap that is the collision of two photons.
- McCulloch has already a gravity theory that output-wise is the same as that of Newton, but indirectly suggests that Newton's gravitational constant is a composite constant. McCulloch has been relying on Planck masses and Planck momentum to arrive at this theory.

[1] There are some additional challenges here, i.e. that one first would have to know the mass of the Sun before one could find the big G, for example, but for illustrative purposes we can disregard that for now.

- When combining ordinary matter with light, we get a gravitational constant with twice the value of the ordinary Newton formula, and this therefore gives an extended quantum Newtonian formula that gives the correct bending of light, the same as GR, but based on much simpler principles.
- Our theory simply is a Newtonian quantum gravity theory derived from Heisenberg's uncertainty principle where the gravitational constant takes two different values, one value when working with standard matter against matter, and twice the normal value when working with light against matter.
- The composite gravitational constant is of the form $G_h = \frac{l_p^2 c^3}{\hbar} = G$ when dealing with matter against matter and $G_h = 2\frac{l_p^2 c^3}{\hbar} = 2G$ when dealing with light against matter. The Planck length and thereby the Planck mass can be measured with no knowledge of the Newtonian gravitational constant using a Cavendish apparatus.

One could claim this is a simple attempt to fudge the Heisenberg principle into becoming compatible with gravity. However, we think it is much more than that. Even before he started to work with gravity, Haug has claimed that light must be linked to a half Planck mass particle. Previously, researchers like Motz and Epstein have also suggested that a half Planck mass particle likely was essential to understanding gravity from a quantum perspective and they suggested that the gravitational constant had to be discontinuous for special situations. Light against matter is precisely such a special situation and by combining key concepts from Planck and Heisenberg principle with our hypothesis about light versus matter, we seem to get a simple theory of quantum gravity that is consistent with experiments.

4 Conclusion

By combining the McCulloch Heisenberg derivation of gravity with key ideas on matter from atomism we have derived a new quantum gravity theory that is the same as Newton when working with matter against matter, but gives twice the value of Newton's gravitational constant when working with light and matter. Our quantum Newtonian gravity should give the same light bending as general relativity theory, which is also twice of that of Newton. The gravity in this theory is quantized. It seems to be a much simpler gravity theory than Einstein's theory of general relativity theory, and yet it predicts similar results to those of GR, while also appearing to be compatible with McCulloch's new and promising concept of Quantized Inertia. If so, it deserves further consideration as a gravity theory that is consistent with galaxy rotations [35], without the need to resort to concepts like dark matter to explain what we observe.

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