Newton's Gravity from Heisenberg's Uncertainty Principle
An In-Depth Study of the McCulloch Derivation

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Abstract

Mike McCulloch has derived Newton's gravity from Heisenberg's uncertainty principle in an innovative and interesting way. Upon deeper examination, we will claim that his work has additional important implications, when viewed from a different perspective. Based on recent developments in mathematical atomism, particularly those exploring the nature of Planck masses and their link to Heisenberg's uncertainty principle, we uncover an insight on the quantum world that leads to an even more profound interpretation of the McCulloch derivation than was put forward previously.

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

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

McCulloch has derived Newton's gravitational force from the Heisenberg uncertainty principle; see [1, 2]. At first, this might sound absurd, as Newtonian gravity not is assumed to be consistent with the quantum world and the Heisenberg principle was developed expressly for the subatomic quantum world. However, we observe that McCulloch is using the Planck mass to get his derivation and, as recent work by Haug strongly indicates that all observable gravitational phenomena are dependent on the Planck mass, which is directly linked to the Planck length.

In this paper, we will examine the McCulloch derivation, based on our understanding of the Planck masses and the link to quantum gravity. Heisenberg's uncertainty principle [3] is given by

$$\Delta p \Delta x \leq \hbar \tag{1}$$

Next McCulloch goes on to say " Now $E = pc$ so" :

$$\Delta E \Delta x \quad \leq \quad \hbar c \tag{2}$$

However, he does not mention that $E = pc$ only can hold for the Planck mass momentum. Further, we claim that it can only hold for a Planck particle. While the Planck mass, Planck length, Planck time, and Planck energy were introduced in 1899 by Max Planck himself [4, 5], the Planck particle was likely first introduced by Lloyd Motz, when he was working at the Rutherford Laboratory in 1962; see [6, 7, 8].

The momentum formula that holds for any particle is the relativistic momentum formula given by Einstein

$$p = \frac{mv}{\sqrt{1 - \frac{v^2}{c^2}}} \tag{3}$$

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 [9] relativistic principles then we must have

$$p_p = \frac{m_p c}{\sqrt{1 - \frac{v^2}{c^2}}} = m_p c \tag{4}$$

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This is only possible if $v = 0$. That is to say, the Planck mass particle must always stand still, 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. Our point is that the way McCulloch gets to his relation $\Delta E \Delta x \leq \hbar c$ likely only can be done in relation to Planck mass particles, or at least Planck masses. This is also essential for understanding gravity at a quantum level. The Planck mass particle is, in our view, the building block of all other particles (an idea first suggested by Motz). The Planck mass seems to be all to large for this to be possible, but if it only last for one Planck second this can be shown to cause no problems. In previous work, we have claimed that the Planck mass particle only lasts for one Planck second, after which it goes from mass to pure energy. Looking at this scenario, we also get a hint about the Planck acceleration, $a_p = \frac{c^2}{l_p} \approx 5.56092 \times 10^{51}\ m/s^2$. 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. The Planck mass can be described as

$$m_p = \frac{\hbar}{l_p}\frac{1}{c} \tag{5}$$

We naturally do not know the Planck mass exactly, just as we do not know the Planck length exactly; this is also something we will discuss later. Yet, the more precisely we know the Planck length, the more precisely we know the Planck momentum. From the union of this line of thought with Heisenberg principle, we have claimed that the Planck mass momentum collapses into a certainty principle, as recently described by Haug [10]:

$$\begin{aligned} \Delta p \Delta x &\leq \hbar \\ m_p c l_p &= \hbar \end{aligned} \tag{6}$$

Further, from equation 2 McCulloch describes

$$\Delta E x = \sum_i^N \sum_j^n \hbar c \tag{7}$$

where $\sum_i^N$ is the number of Planck masses in a smaller mass, so simply $\frac{m}{m_p}$ and $\sum_j^n$ is the mass in a larger mass $\frac{M}{m_p}$.

This gives us the equation

$$\Delta E = \frac{\hbar c m M}{m_p^2 \Delta x} \tag{8}$$

However, unlike McCulloch, we will claim that there is no uncertainty in the energy here, because the particular energy in this case is the Planck mass energy. As explained previously, we claim that the Heisenberg principle collapses at the Planck scale and this may be why McCulloch has been able to get gravity from the quantum scale. Again, McCulloch got ΔE from a momentum of the form pc, which can only apply to the Planck mass particle momentum.

Therefore, in our view we must have

$$\begin{aligned} \Delta E &= \frac{\hbar c m M}{m_p^2 \Delta x} \\ N n E_P &= \frac{\hbar c}{m_p^2}\frac{mM}{\Delta x} \\ N n m_p c^2 &= \frac{\hbar c}{m_p^2}\frac{mM}{\Delta x} \end{aligned} \tag{9}$$

This is only true if $\Delta x = l_p$. This can be linked to the Planck acceleration, $m_p a_p = \frac{m_p}{c_2 l_p}$ and based on this we have

$$
\begin{aligned}
Nnm_p a_p &= \frac{\hbar c}{m_p^2}\frac{mM}{(\Delta x)^2}\\
Nnm_p \frac{c^2}{l_p} &= \frac{\hbar c}{m_p^2}\frac{mM}{(\Delta x)^2}\\
F &= \frac{\hbar c}{m_p^2}\frac{mM}{l_p^2}
\end{aligned} \tag{10}
$$

Be aware that $\Delta x = l_p$ is the minimum position uncertainty in the Heisenberg principle, according to strong evidence given by Haug. However, this probably does not mean that we cannot put $\Delta x > l_p$. In other words, we can likely put Δx equal to the radius of the Earth, for example. Which give us

$$
F = \frac{\hbar c}{m_p^2}\frac{mM}{r^2} \tag{11}
$$

Which is the same formula that McCulloch first derived and is very similar to Newton's gravitational formula, except here we have $\frac{\hbar c}{m_p^2}$ (as first derived by McCulloch), instead of the Newtonian gravitational constant. Now pay attention to the fact that numerically

$$
\frac{\hbar c}{m_p^2} \approx 6.67384 \times 10^{-11} \tag{12}
$$

This is well inside the experimentally observed value of the gravitational constant. However, this is the gravitational constant derived from Heisenberg's uncertainty principle, which we have claimed becomes a certainty principle at the Planck scale and further, the Lorentz symmetry breaks down at the Planck scale.

The fact that gravity does not obey Lorentz symmetry is known, but seldom discussed, and quite obvious even from simple gravitational time dilation experiments. If we run a clock experiment with someone on a mountain top and someone in a valley, they will agree that the clock on the mountain top is running faster than the one in the valley. This in contrast to special relativity, where Lorentz symmetry holds all the way up to our newly-introduced maximum velocity of matter, at which point we reach the Planck scale and Lorentz symmetry is broken.

Gravity has to do with the Planck mass particle that in our view makes up all matter and energy in the universe. Gravity has to do with the very collision points of indivisible particle inside the atoms themselves. In a series of recently published papers, [11, 12, 13, 14] Haug has suggested and showed strong evidence for the idea that Newton's gravitational constant must be a composite constant of the form

$$
G = \frac{l_p^2 c^3}{\hbar} \tag{13}
$$

This has been derived from dimensional analysis [11], 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 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 not can find the Planck mass before we know the Newton gravitational constant. However, Haug [13] has shown that one easily can measure the Planck length with a Cavendish apparatus without any knowledge of the Newton gravitational constant. And if we have the Planck length then we can easily find the Planck mass. Further, Haug has shown that the standard uncertainty in the Planck length experiments must be exactly half of that of the standard uncertainty in the gravitational constant, which is likely a composite constant. See also [15].

2 Other Comments on the McCulloch Paper in Relation to Newton's Gravity Derivation

Close to equation 6 in his paper [2], McCulloch asks, "What if we assume that the sum of the kinetic energy and the energy uncertainty is conserved?" and provides the following equation

$$
\frac{1}{2}m(\Delta v)^2 + \frac{\hbar c}{m_p^2}\frac{mM}{\Delta x} = constant \tag{14}
$$

Let's examine this formulation in greater detail. In our framework, the $\frac{1}{2}$ should not be there in the first place, as Planck mass particles are unique and do not have standard kinetic energy. Instead, they have rest-mass energy that then bursts into pure energy. This is why the momentum of a Planck mass particle is mc, unlike for any other particle. Is there a way to join this view though, with the revolutionary development that comes out from atomism? The same challenge has also arisen when deriving Newton's bending of light, where some authors have used the kinetic energy formula, in spite of the fact that they are working with light that is naturally moving at the speed of light, a possible solution that gives a modified Newtonian quantum gravity theory and the right bending of light has recently been suggested by [15].

We can claim the Planck mass particle has zero kinetic energy, or alternatively and just as correct that all of its rest-mass energy is kinetic energy, which is unlike any other particle. Also, we think there should be a minus in McCulloch formula above. And that the constant in his formula simply is zero.

$$nNm_pc^2 - \frac{\hbar c}{m_p^2}\frac{mM}{l_p} = 0 \tag{15}$$

We think that McCulloch's hypothesis leads to something new and important, but that it needs further examination before it can be fully understood and adjusted if necessary. Then we can build a more solid framework around it.

Almost nothing new revolutionary has happened in gravity or theoretical physics since the time of Einstein. We think that recent breakthroughs in understanding the Planck units combined with new use of Heisenberg's uncertainty principle have just started to lift us to a new epoch of fundamental physics.

3 Conclusion

We have taken an in-depth look at McCulloch's interesting derivation of Newtonian gravity from the Heisenberg principle. We have pointed out that it is important to understand that McCulloch has done this from Planck masses and the Planck momentum without reference to a transformation that we have hypothesized in our work, namely that the Heisenberg uncertainty principle seems to collapse and becomes the certainty principle at the Planck scale. Not surprise as we just figured out that.

Another important point is that all observable gravity phenomena actually depend on the Planck mass or the Planck length (two sides of the same coin). McCulloch's theory supports our view that the gravitational constant must be a composite constant and that all gravitational phenomena depend on Planck-scale physics. However, we will claim that in its earliest stages, McCulloch might have a non-optimal interpretation of his own derivations. An alternative view worthy of consideration is that the Heisenberg principle become a certainty principle at the Planck scale and that gravity is dependent on the Planck scale, and therefore we can use the Heisenberg principle to derive Newton's gravity formula, with deeper implications for physics to come in the years ahead.

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