Heisenberg Probabilistic Quantum Gravity that Holds at the Subatomic and the Macroscopic Scale

Espen Gaarder Haug*
Norwegian University of Life Sciences

March 24, 2018

Abstract

Here we will present a probabilistic quantum gravity theory derived from Heisenberg's uncertainty principle. Surprisingly, this theory is fully deterministic when operating with masses that are exactly divisible by the Planck mass. For masses or mass parts less than one Planck mass, we find that probabilistic effects play an important role. Most macroscopic masses will have both a deterministic gravity part and a probabilistic gravity part.

In 2014, McCulloch derived Newtonian gravity from Heisenberg's uncertainty principle. McCulloch himself pointed out that his theory only seems to hold as long as one operates with whole Planck masses. For those who have studied his interesting theory, there may seem to be a mystery around how a theory rooted in Heisenberg's principle, which was developed to understand quantum uncertainty, can give rise to a Newtonian gravity theory that works at the cosmic scale (which is basically deterministic). However, the deeper investigation introduced here shows that the McCulloch method is very likely correct and can be extended to hold for masses that are not divisible by the Planck mass, a feature that we describe in more detail here.

Our extended quantum gravity theory also points out, in general directions, how we can approach the set up of experiments to measure the gravitational constant more accurately.

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

1 Heisenberg's Uncertainty Principle and McCulloch's Derivation

In 2014, McCulloch [1] derived Newton's gravitational force [2] from Heisenberg's uncertainty principle. We will partly repeat that derivation here, but we also develop some important new insights. Heisenberg's uncertainty principle [3] is given by

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

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

$$\Delta E \Delta x \geq \hbar c \tag{2}$$

This assumption should only hold for the Planck momentum $E = pc = m_p cc$. It is implied indirectly in the McCulloch derivation that the Planck mass somehow plays an essential role in gravity. The Planck mass was first introduced by Max Planck in 1899 [4, 5] from what he considered to be the most important universal constants, Newton's gravitational constant, the speed of light, and the Planck constant. So based on the work by Max Planck we already have a hint about a possible connection between gravity and his natural units: The Planck mass, the Planck length, and the Planck time. Further, from equation 2, McCulloch goes on to suggest that

$$\Delta E = \frac{1}{\Delta x} \sum_i^n \sum_j^N (\hbar c)_{i,j} \tag{3}$$

*e-mail espenhaug@mac.com. Thanks to Victoria Terces for helping me edit this manuscript, and also thanks to Doug Danforth for finding an important typo.

where $\sum_i^n$ is the number of Planck masses in a smaller mass m we are working with, $\sum_i^N$ corresponds to the the number of Planck masses in the larger mass. McCulloch then gives the equation

$$\Delta E = \frac{\hbar c m M}{m_p^2 \Delta x} \tag{4}$$

and if we divide by Δx on both sides, we get the force

$$\frac{\Delta E}{\Delta x} = \Delta F = \frac{\hbar c}{m_p^2} \frac{mM}{(\Delta x)^2} \tag{5}$$

McCulloch also replaces Δx with the radius, something we will get back to later. Further, he correctly points out that

$$G = \frac{\hbar c}{m_p^2} \tag{6}$$

which basically gives the Newton gravity formula

$$F = G\frac{mM}{r^2} \tag{7}$$

Still, there are several challenges that McCulloch has not yet resolved to arrive at a "complete" theory of quantum gravity. There are also several natural questions that arise about this theory. One example revolves around the question of big G – in some perspectives it may be said that we need to know big G in order to find the Planck mass, so the Heisenberg method cannot be used to get Newton gravity without already knowing Newton gravity. However, Haug [6] has recently shown that the Planck length and thereby the Planck mass can be measured using a Cavendish apparatus without any knowledge of big G, so on that basis, this point may be resolved.

A second challenge to developing a more complete theory of quantum gravity is related to a point mentioned by McCulloch in his 2014 paper

> *In the above derivation, the correct value for the gravitational constant G is only obtained when it is assumed that the gravitational interaction occurs between whole multiples of the Planck mass.* – Mike McCulloch

Is it truly the case that a theory of quantum gravity theory derived from Heisenberg's uncertainty principle should only hold for Planck masses and not for smaller than Planck masses? The Planck mass (approx. 2.17×10^{-5} gram) is larger than any observed subatomic particle and has approximately the same mass as a flea egg. This means that the Planck mass is somewhere on the borderline between microscopic and macroscopic masses. Heisenberg's uncertainty principle itself is rooted in the subatomic scale. One might, therefore, mistakenly think that McCulloch's method cannot be valid, since it only works with Planck masses, and simply applies mathematical gymnastics to make the Heisenberg principle somehow produce Newtonian gravity.

We agree with McCulloch that his theory, as it currently stands, only holds for Planck masses. However, we are also interested to see if we can extend the theory to hold for masses below the Planck mass, as well as larger masses that not are exactly divisible by the Planck mass. Let us assume that the mass simply consists of two proton masses. At first sight, the McCulloch method will not work, at least not without an extension in our interpretation apparatus. It is well-known that any subatomic mass can be written as

$$m = \frac{\hbar}{\bar{\lambda}} \frac{1}{c} \tag{8}$$

where $\bar{\lambda}$ is the reduced Compton wavelength of the particle in question. While the Planck mass as a function of G was given by Planck in 1899, the relationship $m = \frac{l_p}{\bar{\lambda}} m_p$ was possibly first pointed out by Hoyle, Burbidge, and Narlikar in 1994; see [7]. For a proton we have[1]

$$m_{\mathbf{P}} = \frac{\hbar}{\bar{\lambda}_{\mathbf{P}}} \frac{1}{c} \approx 1.67262 \times 10^{-27} \text{ kg} \tag{9}$$

However, based on the equation above, the proton mass can also be written as

$$m_{\mathbf{P}} = \frac{\hbar}{l_p} \frac{1}{c} \frac{l_p}{\bar{\lambda}_{\mathbf{P}}} = m_p \frac{l_p}{\bar{\lambda}_{\mathbf{P}}} \tag{10}$$

where l_p is the Planck length, m_p is the Planck mass, and $\bar{\lambda}_{\mathbf{P}}$ is the reduced Compton wavelength of the proton. This means we can write the gravitational formula derived from Heisenberg's principle for two proton masses as

[1] Because the proton likely not is an elementary particle it does not necessary have a measurable reduced Compton wavelength in the same way as the electron, but this is not important here, what is important is that the proton can be mathematically expressed in this way.

$$F=\frac{\hbar c}{m_p^2}\frac{m_pm_p}{r^2}\frac{l_p}{\bar{\lambda}_{\mathbf{P}}}\frac{l_p}{\bar{\lambda}_{\mathbf{P}}} \tag{11}$$

That is to say, even when we are working with only one proton mass in the mass m and one proton mass in mass M, we can still argue that the number of Planck masses in each instance are one. So we can use McCulloch's approach in formula 3. However, we now suddenly find the term $\frac{l_p}{\bar{\lambda}_{\mathbf{P}}}\frac{l_p}{\bar{\lambda}_{\mathbf{P}}}$ attached. We will claim that $\frac{l_p}{\bar{\lambda}_{\mathbf{P}}}\frac{l_p}{\bar{\lambda}_{\mathbf{P}}}$ should be interpreted as a probability factor, as suggested by Haug recently in a slightly different context; see [8, 9]. The fact that we are working with probabilities is not so strange, when we take into account that we are working with Heisenberg's uncertainty principle, that essentially tells us that the subatomic world is uncertain.

In recent work, Haug has introduced the idea of $\frac{l_p}{\bar{\lambda}_{\mathbf{P}}}\frac{l_p}{\bar{\lambda}_{\mathbf{P}}}$ being a probability factor simply by decomposing the formulas of Newton and Einstein into their deeper constitutes, based on the idea that the gravitational constant is a composite constant. The concept that the gravitational constant is a composite constant is also evident from the McCulloch derivation, where he has $G=\frac{\hbar c}{m_p^2}$. These separate pieces start to fall into place when combining Haug's ideas of a probability factor for masses smaller than a Planck mass with the McCulloch Heisenberg gravitational approach.

Assume we have two masses each containing $\frac{m_p}{m_{\mathbf{P}}}$ number of protons. Then the formula 11 can be written as

$$F=\frac{\hbar c}{m_p^2}\frac{m_pm_p}{r^2}\frac{l_p}{\bar{\lambda}_{\mathbf{P}}}\frac{m_p}{m_{\mathbf{P}}}\frac{l_p}{\bar{\lambda}_{\mathbf{P}}}\frac{m_p}{m_{\mathbf{P}}}=\frac{\hbar c}{m_p^2}\frac{m_pm_p}{r^2} \tag{12}$$

That is for $\frac{m_p}{m_{\mathbf{P}}}$ number of protons, the probability factor becomes one and we are suddenly left just with Planck masses and no probability factor. This indicates that all uncertainty disappears when we are working with Planck masses. This also means that we get a quantum gravity theory that is probabilistic below the Planck mass size and fully deterministic at the Planck mass size. For masses that add up to some Planck masses and an additional mass that does not add up to a full Planck mass, we will have a deterministic part and a probabilistic part in the gravity force.

This also explains why the McCulloch derivation is valid in particular at the cosmic scale, when working with large masses, for which the Newton formula is meant. McCulloch's model is a very good approximation for large masses. However, it needs this probabilistic modification to work for masses below the Planck mass size and even for masses that are not exactly divisible by the Planck masses, where there is a small probabilistic term.

In general, assume there are $N-1$ and $n-1$ full Planck masses and a rest part of the mass $m-(n-1)m_p$ and $M-(N-1)m_p$ that not is a full Planck mass. Based on this we get the general formula

$$\Delta F=\frac{1}{(\Delta x)^2}\sum_i^N\sum_j^n(\hbar c)_{i,j}=\frac{\hbar c}{m_p^2}\frac{(N-1)m_p(n-1)m_p}{(\Delta x)^2}+\frac{\hbar c}{m_p^2}\frac{m_pm_p}{(\Delta x)^2}\frac{m-(n-1)m_p}{m_{\mathbf{P}}}\frac{l_p}{\bar{\lambda}_{\mathbf{P}}}\frac{M-(N-1)m_p}{m_{\mathbf{P}}}\frac{l_p}{\bar{\lambda}_{\mathbf{P}}} \tag{13}$$

if we call $m_E=m-(n-1)m_p$ and $M_E=m-(n-1)m_p$ we get a little cleaner notation. Now m_E and M_E are the excess part of the mass m and M that are not exactly divisible by a Planck mass. Based on this we can write the formula above as

$$\Delta F=\frac{1}{(\Delta x)^2}\sum_i^N\sum_j^n(\hbar c)_{i,j}=\frac{\hbar c}{m_p^2}\frac{(N-1)m_p(n-1)m_p}{(\Delta x)^2}+\frac{\hbar c}{m_p^2}\frac{m_pm_p}{(\Delta x)^2}\frac{m_E}{m_{\mathbf{P}}}\frac{l_p}{\bar{\lambda}_{\mathbf{P}}}\frac{M_E}{m_{\mathbf{P}}}\frac{l_p}{\bar{\lambda}_{\mathbf{P}}} \tag{14}$$

That is gravity for a mass larger than a Planck mass consists of a deterministic known part and a probabilistic part

$$\text{Gravity Force}=F+E[F]=\frac{\hbar c}{m_p^2}\frac{(N-1)m_p(n-1)m_p}{r^2}+\frac{\hbar c}{m_p^2}\frac{m_pm_p}{r^2}\frac{m_E}{m_{\mathbf{P}}}\frac{l_p}{\bar{\lambda}_{\mathbf{P}}}\frac{M_E}{m_{\mathbf{P}}}\frac{l_p}{\bar{\lambda}_{\mathbf{P}}} \tag{15}$$

And what if the last mass is also adding exactly up to a full Planck mass? The formula above then simplifies to the McCulloch Heisenberg Newtonian formula. That is to say, the Newtonian limit is only holding for masses exactly divisible by the Planck mass

$$F=\sum_i^N\sum_j^n(\hbar c)_{i,j}=\frac{\hbar c}{m_p^2}\frac{nm_pNm_p}{r^2}=\frac{\hbar c}{m_p^2}\frac{mM}{r^2}=G\frac{mM}{r^2} \tag{16}$$

We have deliberately removed the Δ in front of the gravity force here, as all probabilistic effects will be gone if we are operating with masses exactly divisible by the Planck mass. One could then mistakenly think that since there is no uncertainty here, then a Heisenberg derivation cannot hold. However, this would be a misinterpretation. This simply means that we have used an amount of matter where all of the part probabilities exactly add up to 1, that is the Planck mass is the "magic" mass where probabilities disappear. It has recently also been predicted by Haug that the Heisenberg principle breaks down at the Planck scale, and Planck masses we predict are related to the Planck scale. Still, we have to be careful here, if we have a mass slightly above one Planck mass, then the Planck mass excess part is still affected by probability and the total gravity will then consist of the sum of a deterministic part and a probabilistic part. This suggests that gravity can only be measured accurately for large objects, or at least that only for large masses where we can easily measure gravity without taking into account probabilistic quantum effects. That is when the excess part (whose exact size is often unknown, as we do not know the Planck mass size to a fine degree of accuracy) is very small compared to the total mass.

To show how simple the new gravity formula is, let's look at an example where the small mass m consists of one Planck mass plus one proton mass, and the large mass M consists of ten Planck masses plus one proton mass. This gives

$$F = \frac{1}{r^2}\sum_{i}^{2}\sum_{j}^{11}(\hbar c)_{i,j} = \frac{\hbar c}{m_p^2}\frac{m_p(n-1)m_p(N-1)}{r^2} + \frac{\hbar c}{m_p^2}\frac{m_p m_p}{r^2}\frac{l_p}{\bar{\lambda}_{\mathbf{P}}}\frac{l_p}{\bar{\lambda}_{\mathbf{P}}} = G\frac{m_p 10 m_p}{r^2} + G\frac{m_p m_p}{r^2}\frac{l_p}{\bar{\lambda}_{\mathbf{P}}}\frac{l_p}{\bar{\lambda}_{\mathbf{P}}} \tag{17}$$

We will exclude electrons, which will also have an impact here. In general, if we are not working on masses of exactly divisible by the Planck mass, the probabilistic part will be smaller and smaller as we increase the masses used for the experiment. For example, if we want to measure gravity accurately with a Cavendish [23] type apparatus, we should use the largest lead balls possible.

In addition, we will suggest that the observational time window could play an essential role. The probability factor $\frac{l_p}{\bar{\lambda}_{\mathbf{P}}}$ should be interpreted for a observational time window of just one Planck second. If the observational time window for the gravity is exactly $\frac{\bar{\lambda}_{\mathbf{P}}}{l_p} \times \frac{\bar{\lambda}_{\mathbf{P}}}{c}$, then the uncertainty in the part that is in excess of whole Planck mass is actually certain. For a time window above this, there seems to be uncertainty again for non Planck masses. The uncertainty oscillates with different sizes of time windows for the probabilistic part of the gravity.

2 The Gravity Constant

In a series of recently published papers, [6, 9, 10, 11] Haug has suggested and shown strong evidence for the idea that Newton's gravitational constant must be a composite constant of the form

$$G = \frac{l_p^2 c^3}{\hbar} \tag{18}$$

This has been derived from dimensional analysis [10], 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 the Newton gravitational constant. However, Haug [6] has shown that one easily can measure the Planck length with a Cavendish apparatus without any knowledge of Newton's 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.

Haug has recently also recently worked on extending on the McCulloch Heisenberg principle and has suggested, based on properties of the photon, that the gravitational constant can take two values, one when working with matter against matter, and one value when working with matter against light [12]. This approach gives the same light bending prediction as GR.

3 Practical Implications

NIST CODATA (2014) tells us that the gravitational constant is $6.67408 \times 10^{-11} m^3 \cdot kg^{-1} \cdot s^{-2}$, but with a standard relative uncertainty of 4.7×10^{-5}; this is very large uncertainty compared to the fine structure constant, for example, where CODATA operates with a standard uncertainty of only 2.3×10^{-10} and the standard uncertainty in the Planck constant is considered to be 1.2×10^{-8} by CODATA. Despite large resources and many clever research teams working in this, it is still partly a mystery why it is so hard to measure the gravitational constant more acutely. Experimentally, some progress has been made in recent years based on various methods. See, for example, [13, 14, 15, 16, 17], but there is still a great deal of uncertainty in the gravity constant. Part of the reason is "blamed" on the idea that gravity is such a weak force, and yet it is the force that holds the entire solar system together. It seems that the Heisenberg Probabilistic Quantum Gravity theory presented here may give us some hints on how to measure the gravity constant, the Planck mass, the Planck length, and the Planck time more accurately.

In particular, based on our approach, one way to obtain more accurate gravity measurements is to increase the mass as well as the observational time period during which we are measuring the gravity. The drawback with increasing the time window is that Earth is moving, as are all of the other objects in the solar system, so this will make the measurements more prone to other influences that are not necessarily easy to take into account with great precision. The challenge is basically this: Ideally, one would have masses that were perfectly divisible by whole Planck masses. In order to work this way, we need to know the Planck mass, and measuring big G is actually a measurement of the Planck mass (or the Planck length). In practice this means that we will typically always have an excess mass that is not divisible by a Planck mass. This also means that the gravity measurement will be affected by probability. However, to minimize the influence of the probability component we will need to use as large a mass as possible. The maximum influence of the probabilistic terms in percent is simply $\frac{m_p}{M}$. So by making M very large compared to the Planck mass, the probabilistic effect is minimized.

Hypothetically this points towards building a massive gravity measure apparatus, for example one in the Cavendish style. Such a massive gravity apparatus we imagine could be very costly, but could be could be worth the effort as it potentially could increase the accuracy of big G considerably and thereby also confirm or dispute this promising approach to quantum gravity theory, thereby also taking a big step towards a unified theory. The probabilistic approach should also be studied further to understand measurements in microgravity better, in particular when combined with closely monitoring of short and long observational time windows. In particular, in the case of optical clocks where we can reduce down to much shorter observational time windows; this could open up new avenues directly related to the theory presented here.

Whether this research can lead to anything practical or confirm what already has been observed with respect to various experiments and their different uncertainties in big G, we leave up to others to investigate further.

4 The Strong Force Versus Weak Gravity Could be Linked to Probabilistic Gravity

The Newton gravity force is extremely strong for Planck masses when working at a radius equal to the Planck length; it is

$$F = G\frac{m_p m_p}{l_p^2} \approx 1.21034 \times 10^{44} \text{ N} \tag{19}$$

where m_p is the Planck mass, and l_p is the Planck length. However, for proton masses the gravity is very weak. Yet if we look at the proton mass gravity in the following way, we possibly get new insight on why this is so

$$F = G\frac{m_{\mathbf{P}} m_{\mathbf{P}}}{r^2} = G\frac{m_p m_p}{r^2}\frac{l_p^2}{\bar{\lambda}_{\mathbf{P}}^2} \tag{20}$$

again, pay attention to the difference between the proton mass notation $m_{\mathbf{P}}$ and m_p, where again we claim $\frac{l_p^2}{\bar{\lambda}_{\mathbf{P}}^2}$ could be interpreted as a probability factor over an observational time interval of one Planck second. The proton mass gravity is very strong when it happens, actually it is Planck gravity, but this only happens one time per reduced Compton time of the proton. In other words, the strong force and the gravity force could possibly be related. Physicists Stenger [18], just before he passed away, had an interesting popular science piece where he questioned what he called the "Myths of Physics: Gravity Is Much Weaker Than Electromagnetism.“ He did not claim to have the answer, but pointed out that there is something we do not understand with gravity theory.

The Planck gravity is about $\frac{\bar{\lambda}_{\mathbf{P}}^2}{l_p^2} \approx 1.69327 \times 10^{38}$ times the proton gravity (when working at the same radius. This is the same as the difference between the strong force and the assumed much weaker gravity force. We think the difference simply could have to do with the fact that the gravity in a proton is not constant, but is fluctuating rapidly. We predict that the Planck gravity in a proton happens $\frac{c}{\bar{\lambda}_{\mathbf{P}}} \approx 1.42549 \times 10^{24}$ times per second. Each gravity event is strong, but only lasts for a Planck second. This means when doing observations over the Compton time or longer, very strong gravity will appear smoothed out, an idea not so different than suggested by Motz and Epstein in 1979 [19]. At a deeper level we predict that gravity is fully quantized, and for a observational window of only one Planck second the probability for a Planck gravity event to happen has extremely low probability to happen. One mistakenly gets the impression that gravity is very weak when observed over a time window like the Compton time. The gravity in this theory is actually binary at the deepest level.

5 Future Research

In recent years, McCulloch has developed what he calls "Quantized Inertia theory (QI)" [20]. He has used QI to explain such things as galaxy rotation without the use of dark matter and more [21, 22]. His Heisenberg-derived Newtonian gravity plays a role here as well. Further investigation in needed to see if the extended Probabilistic Heisenberg Quantum Gravity presented here is compatible and has implications for quantified inertia mathematically and in interpretation.

The theory presented here may also be studied in relation to recent ideas around mathematical atomism, as presented in a series of recent papers by Haug.

6 Summary

The probabilistic quantum gravity theory consistent and basically derived from the Heisenberg uncertainty principle, as well as from key insights in mathematical atomism, gives us the following gravity formula

$$\text{Gravity Force} = F + E[F] = G_m \frac{(N-1)m_p(n-1)m_p}{r^2} + G_m \frac{m_p m_p}{r^2} \frac{m_E}{m_{\mathbf{P}}} \frac{l_p}{\bar{\lambda}_{\mathbf{P}}} \frac{M_E}{m_{\mathbf{P}}} \frac{l_p}{\bar{\lambda}_{\mathbf{P}}} \tag{21}$$

where $n-1$ and $N-1$ are the number of full Planck masses in the two masses m and M that we are working with. And m_E and M_E are the mass parts that do not add up to a full Planck mass, but still can be seen as a Planck mass multiplied by a probabilistic term. The first part of formula 21 is fully deterministic. The second part is probabilistic. Further, $G_m = \frac{l_p^2 c^3}{\hbar} = G$ when working with matter against matter, and it is $G_m = \frac{2 l_p^2 c^3}{\hbar} = 2G$ when working with matter against light, an idea argued for by [12].

In the special case of the two masses m and M are fully divisible by the Planck mass, the formula above simplifies to the McCulloch-derived Newton formula[2]

$$F = G_m \frac{mM}{r^2} \tag{22}$$

And in the other special case, when both mass m and M are smaller than the Planck mass, we have

$$E[F] = G_m \frac{m_p m_p}{r^2} \frac{m_E}{m_{\mathbf{P}}} \frac{l_p}{\bar{\lambda}_{\mathbf{P}}} \frac{M_E}{m_{\mathbf{P}}} \frac{l_p}{\bar{\lambda}_{\mathbf{P}}} \tag{23}$$

where m_E and M_E simply indicates the mass is a mass smaller than the Planck mass. Further, be aware that m_p stands for the Planck mass and $m_{\mathbf{P}}$ the proton mass. We assume here that we are operating with masses that come in proton mass quanta; we can easily extend our theory to also hold, simply by replacing $m_{\mathbf{P}}$ with the mass of other subatomic particles we are working with, even electrons, for example. The key point is that for masses smaller than a Planck mass, we have a probabilistic expected gravity. For masses, exactly equal to a Planck mass, we have a certain deterministic gravity. In practice we are almost always operating with a mass that can be divided into many Planck masses and on the top of that a small part with a mass that is less than the Planck mass. That is at macroscopic scale the deterministic part will typically dominate strongly over the probabilistic part. Further, the larger the mass object we work with, the less significant is the probabilistic part.

However, the gravity force is to my knowledge never observed directly only such things as gravitational acceleration, orbital velocity, gravitational time-dilation, which are observed directly. Our Heisenberg gravitational acceleration field is given by

$$g = G_m \frac{(N-1)m_p}{r^2} + G_m \frac{m_p}{r^2} \frac{M_E}{m_{\mathbf{P}}} \frac{l_p}{\bar{\lambda}_{\mathbf{P}}} \tag{24}$$

Again, the first part is deterministic and the second part is the probabilistic. The probabilistic part becomes insignificant when we are working with larger masses, but even at a few grams the probabilistic part still play a little role.

The orbital velocity must be given by

$$V_o = \sqrt{G_m \frac{(N-1)m_p}{r} + G_m \frac{m_p}{r} \frac{M_E}{m_{\mathbf{P}}} \frac{l_p}{\bar{\lambda}_{\mathbf{P}}}} \tag{25}$$

when it comes to gravitational bending of light we will claim we must have

$$\delta = \frac{2G_m(N-1)m_p}{c^2 r} + \frac{2G_m m_p}{c^2 r} \frac{M_E}{m_{\mathbf{P}}} \frac{l_p}{\bar{\lambda}_{\mathbf{P}}} = \frac{4G(N-1)m_p}{c^2 r} + \frac{4G m_p}{c^2 r} \frac{M_E}{m_{\mathbf{P}}} \frac{l_p}{\bar{\lambda}_{\mathbf{P}}} \tag{26}$$

In the end, we will highlight the most important findings in this paper:

- The McCulloch derivation of Newton gravity from the Heisenberg principle seems to be fully valid. His theory as predicted by himself only holds for masses fully divisible by Planck mass. For masses not fully divisible by a Planck mass, his theory will be an approximation, but it will be an extremely good approximation when $\frac{m_p}{M}$ is very small, as it is for any cosmological and for most macroscopic objects.
- We have here extended on the McCulloch idea, combined it with the probabilistic idea of gravity at sub-Planck mass scale, and shown that even macroscopic masses consist of a probabilistic part in addition to a deterministic part. The McCulloch part is the deterministic part (that comes out from "adding" probabilities) and a probabilistic part for the mass part that does not add up to a full Planck mass.

[2] I say Haug, because of the G_m factor that is G when working with matter against matter and $2G$ when working with matter against light

- Masses that are exactly divisible by the Planck mass lead to a fully deterministic Newton gravity, and masses below the Planck mass are more and more ruled by probability the smaller they get and the shorter time interval during which they are observed. For gravity at the Planck time scale for masses smaller then a Planck mass, it looks like gravity must even be binary ? that is Planck gravity (lasting for one Planck second) or no gravity.
- The theory presented here may have practical implications and offers general guidance on how to measure the Planck mass, the Planck length, the Planck time, and the gravitational constant more accurately. The theory indicates that apparatuses with large masses potentially can be used to measure the gravitational constant more accurately than we can today; alternatively, we need to try to take probabilistic effects in to account more accurately.

7 Conclusion

We have extended and further explored the McCulloch Heisenberg-derived gravity and combined it with an idea from Haug that a gravity probability is involved for less than Planck mass size objects. In this way, many pieces of the quantum gravity puzzle seem to fall into place. This leads to the idea that probability is dominating for masses much smaller than the Planck mass, but for large masses the probability factor is negligible. This indicates that we need a gravitational apparatus with massive objects to measure the gravitational constant, which basically is a measure of the Planck length (Planck mass), as accurately as possible. In addition, if we choose to measure the gravity over a longer time window, this should improve the gravitational precision if it is done properly.

References

[1] M. E. McCulloch. Gravity from the uncertainty principle. *Astrophysics and Space Science*, 349(2), 2014.

[2] I. Newton. *Philosophiae Naturalis Principia Mathematica*. London, 1686.

[3] W. Heisenberg. Über den anschaulichen inhalt der quantentheoretischen kinematik und mechanik. *Zeitschrift für Physik*, (43):172–198, 1927.

[4] M. Planck. *Naturlische Masseinheiten*. Der Königlich Preussischen Akademie Der Wissenschaften, p . 479., 1899.

[5] M. Planck. *Vorlesungen über die Theorie der Wärmestrahlung*. Leipzig: J.A. Barth, p. 163, see also the English translation "The Theory of Radiation" (1959) Dover, 1906.

[6] E. G. Haug. Can the Planck length be found independent of big G ? *Applied Physics Research*, 9(6), 2017.

[7] F. Hoyle, G. Burbidge, and J. Nsrlikar. The basic theory underlying the quasi-steady state cosmology. *Working paper, Inter-University Center for Astronomy and Astrophysics*, 1994.

[8] E. G. Haug. The mass gap, kg, the Planck constant, and the gravity gap. *Working paper Norwegian University of Life Sciences*, 2017.

[9] E. G. Haug. Newton and Einstein's gravity in a new perspective for Planck masses and smaller sized objects. *International Journal of Astronomy and Astrophysics*, 2018.

[10] E. G. Haug. The gravitational constant and the Planck units: A simplification of the quantum realm. *Physics Essays Vol 29, No 4*, 2016.

[11] E. G. Haug. Planck quantization of Newton and Einstein gravitation. *International Journal of Astronomy and Astrophysics*, 6(2), 2016.

[12] E. G. Haug. A modified Newtonian quantum gravity theory derived from Heisenberg's uncertainty principle that predicts the same bending of light as GR. *viXra:1803.0079*, 2018.

[13] G. S. Bisnovatyi-Kogan. Checking the variability of the gravitational constant with binary pulsars. *International Journal of Modern Physics D*, 15(07), 2006.

[14] B. Fixler, G. T. Foster, J. M. McGuirk, and M. A. Kasevich. Atom interferometer measurement of the Newtonian constant of gravity. *Science*, 315, 2007.

[15] S. Galli, A. Melchiorri, G. F. Smoot, and O. Zahn. From Cavendish to Planck: Constraining Newton's gravitational constant with CMB temperature and polarization anisotropy. *Physical Review D*, 80, 2009.

[16] G. Rosi, F. Sorrentino, L. Cacciapuoti, M. Prevedelli, and G. M. Tino. Precision measurement of the Newtonian gravitational constant using cold atoms. *Nature*, 510, 2014.

[17] F. Scholkmann. Indications for a diurnal and annual variation in the anisotropy of diffusion patterns in a reanalysis of data presented by J. Dai (2014, Nat. Sci.). *Progress in Physics*, 10, 2014.

[18] V. Stenger. Myths of physics: 2. Gravity is much weaker than electromagnetism. *Huffington Post, Blog by Victor Stenger*, 2014.

[19] L. Motz and J. Epstein. The gravitational charge $1/2\sqrt{\hbar c}$ as a unifying principle in physics. *Il Nuovo Cimento*, 51(1), 1979.

[20] M. E. McCulloch. Quantised inertia from relativity and the uncertainty principle. *EPL (Europhysics Letters)*, 115(6), 2016.

[21] M. E. McCulloch. Low-acceleration dwarf galaxies as tests of quantised inertia. *Astrophysics and Space Science*, 362(52), 2017.

[22] M. E. McCulloch. Galaxy rotations from quantised inertia and visible matter only. *Astrophys Space Science*, 362, 2017.

[23] H. Cavendish. Experiments to determine the density of the Earth. *Philosophical Transactions of the Royal Society of London, (part II)*, 88, 1798.

[24] E. G. Haug. A simple Newtonian quantum gravity theory that predicts the same light bending as GR. And also a new gravitational prediction that can be tested! *www.viXra.org 1802.0169*, 2018.