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The Planck Computer Is the Quantum Gravity Computer: We Live inside a Gigantic Computer, the Hubble Sphere Computer?

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Abstract: Recent developments in the quantization of general relativity theory provide a new perspective on matter and even the whole universe. Already, in 1922, Eddington suggested that a future quantum gravity theory had to be linked to Planck length. This is today the main view among many working with quantum gravity. Recently, it has been demonstrated how Planck length, the Planck time, can be extracted from gravity observations with no knowledge of G, $\hbar$, or even c. Rooted in this, both general relativity theory and multiple other gravity theories can be quantized and linked to the Planck scale. A revelation from this is that matter seems to be ticking at the reduced Compton frequency, where each tick can be seen as one bit, and one bit corresponds to a Planck mass event. This new speculative way of looking at gravity can also potentially tell us considerably about what quantum gravity computers are and what they potentially can do. We will conjecture that that all quantum gravity and quantum gravity computers are directly linked to the Planck scale and the Compton frequency in matter, something we will discuss in this paper. Quantum gravity computers, we will see, in many ways, are nature's own designed computers with enormous capacity to 3D "print" real time. So, somewhat speculatively, we suggest we live inside a gigantic quantum gravity computer known as the Hubble sphere, and we even are quantum gravity computers. The observable universe is based on this model, basically a quantum gravity computer that calculates approximately 10^{104} bits per second (bps).

Keywords: quantum gravity; quantum gravity computers; quantization of gravity

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1. Background

There is lots of research published on quantum computers, and many firms are into developing quantum computers (see [1–4]; there is, however, little written about quantum gravity computers). A quantum gravity computer (QGC) would be a computer where quantum gravity also plays a role or, according to, for example, Hardy [5]:

> "*A quantum gravity computer is one for which the particular effects of quantum gravity are relevant.*"

There exist quantum gravity theories, such as loop quantum gravity theory (LQG) and superstring theory. However, none of these theories has been able to unify gravity with quantum mechanics in a way that makes their theory testable or widely accepted. To have hope to develop or understand quantum gravity computers, we basically need a quantum gravity theory. In this paper, we rely on a new type of quantum gravity theory rooted in general relativity theory to look into quantum gravity computers.

It was Max Planck [6,7] who, in 1899, assumed there were three important universal constants: the Newtonian gravitational constant G, the Planck constant h, and the speed of light. Based on these constants and dimensional analysis, he derived unique units, length $l_p = \sqrt{\frac{G\hbar}{c^3}}$, time $t_p = \sqrt{\frac{G\hbar}{c^5}}$, mass $m_p = \sqrt{\frac{\hbar c}{G}}$, and temperature $T_p = \frac{1}{k_b}\sqrt{\frac{\hbar c^5}{G}}$, today known as the Planck units. However, Max Planck had no clear meaning for what these units represented in the physical world, if anything.

Einstein [8] was already suggesting in 1916 that the next step in gravity theory should be a quantum gravity theory, or in his own words:

> *Because of the intra-atomic movement of electrons, the atom must radiate not only electromagnetic but also gravitational energy, if only in minute amounts. Since, in reality, this cannot be the case in nature, then it appears that the quantum theory must modify not only Maxwell's electrodynamics but also the new theory of gravitation.*—A. Einstein

Einstein worked much of his later years in the hope of coming up with such a unified quantum gravity theory, but without much success. Eddington [9], in 1918, was likely the first to suggest that the Planck length would likely play a central role in quantum gravity theory. However, this was far from obvious. Bridgman [10], who received the Nobel Prize in Physics, thought of the Planck units more as mathematical artifacts emerging from derivations, rather than something that likely could have some physical meaning.

Today, most physicists working on trying to unify gravity with quantum mechanics think the Planck scale will play an important role in the ultimate unified quantum gravity theory (see [11–13]), but there is no consensus on how. Despite the lack of consensus, we base our arguments here on recent progress that has been published along one line of quantum gravity theory.

Cahill [14,15], in 1984, suggested that the Newtonian gravitational constant could be expressed as $G = \frac{\hbar c}{m_p^2}$. However, already in 1987, Cohen [16] pointed out that this leads to a circular argument if one does not know how to find the Planck units independent of G. Recently, it has been demonstrated that one can find the Planck units, such as the Planck length, the Planck time, and the Planck mass, without any knowledge of G (see [17,18]). The ability to directly find the Planck units without any knowledge of G means that we indeed can express the gravitational constant in terms of Planck units, for example, as $G = \frac{l_p^2 c^3}{\hbar}$, and rewrite a series of gravity equations (see [18]). However, first, one must also understand that all kilogram masses can be expressed by solving the Compton wavelength formula, $\lambda = \frac{h}{mc}$, with respect to mass, which gives

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

Note that this does not need to be a physical Compton wavelength but can be an aggregate of all the Compton wavelengths of the fundamental particles in our universe when working with the mass of the universe, including energy converted into mass equivalents. The aggregation of individual Compton wavelengths that work for any mass is (see [17])

$$\bar{\lambda} = \frac{1}{\sum_i^n \frac{1}{\bar{\lambda}_i}} \tag{2}$$

This formula is fully consistent with, for example, the standard mass aggregation formula:

$$m = m_1 + m_2 + m_3 + \cdots + m_n + \frac{E_1}{c^2} \pm \frac{E_2}{c^2} \pm \frac{E_3}{c^2} \pm \cdots \pm \frac{E_N}{c^2} \tag{3}$$

This formula applies to both bound and unbound masses, treating any form of energy as mass equivalent. For atoms with multiple protons and neutrons, there is a correction for binding energy, as discussed in [19]. Binding energy can be treated as mass equivalent because of Einstein's equation $E = mc^2$. However, even if we ignore binding energy, our calculations have less than 1% error, so it is not critically important here. We can easily take it accurately into account if we wish under this method.

Some will protest here and claim it is the de Broglie [20,21] wavelength that is the matter wavelength and not the Compton wavelength. We believe this is one of the biggest mistakes made in physics, something that we have discussed in detail in [22]. There is nothing wrong with the de Broglie wavelength, but from our perspective, it is a pure mathematical derivative of the Compton wavelength, and the domain validity of the de Broglie wavelength is not as complete as the domain validity of the Compton wavelength.

This means models relying on the de Broglie wavelength will not be able to properly account for gravity, but this is outside the scope of this paper and is discussed in detail in the paper we just referred to. So, here, we ask the reader, at least for a moment, to accept these premises and focus on how this leads to an understanding of quantum gravity computers.

By simply replacing the gravity constant G with $G = \frac{l_p^2 c^3}{\hbar}$ and kilogram masses with $m = \frac{\hbar}{\bar{\lambda}}\frac{1}{c}$, we can quantize general relativity theory, as we shortly go through in the next section.

2. Quantized General Relativity Theory Linked to the Planck Scale

Haug [23,24] has recently published a quantized version of general relativity where Einstein's field equation is rewritten as

$$R_{\mu\nu} - \frac{1}{2}Rg_{\mu\nu} = \frac{8\pi l_p^2}{\hbar c}T_{\mu\nu}. \tag{4}$$

The Schwarzschild solution now is given by

$$ds^2 = -\left(1 - \frac{2l_p}{r}\frac{l_p}{\bar{\lambda}_M}\right)c^2dt^2 + \left(1 - \frac{2l_p}{r}\frac{l_p}{\bar{\lambda}_M}\right)^{-1}dr^2 + r^2d\Omega^2, \tag{5}$$

where $d\Omega^2 = (d\theta^2 + \sin^2\theta d\phi^2)$, and $\bar{\lambda}_M$ is the reduced Compton wavelength of the mass M. The term $\frac{l_p}{\bar{\lambda}_M}$ simply represents the reduced Compton frequency in the gravitational object per Planck time. The reduced Compton frequency per second is naturally $f = \frac{c}{\bar{\lambda}_M}$, and therefore, the reduced Compton frequency per Planck time is $f = \frac{c}{\bar{\lambda}_M}t_p = \frac{l_p}{\bar{\lambda}_M}$. The metric Equation (5) yields identical results to the standard Schwarzschild [25] metric:

$$ds^2 = -\left(1 - \frac{2GM}{rc^2}\right)c^2dt^2 + \left(1 - \frac{2GM}{rc^2}\right)^{-1}dr^2 + r^2d\Omega^2.$$

However, the new metric (Equation (5)) is quantized and also linked to the Planck scale. Other solutions to Einstein's field equation can also be quantized in a similar manner. For example, the extremal Reissner–Nordström [26,27] metric can be expressed in such a quantized form as follows:

$$\begin{aligned} ds^2 &= -\left(1 - \frac{2GM}{rc^2} + \frac{G^2M^2}{r^2c^4}\right)c^2dt^2 + \left(1 - \frac{2GM}{rc^2} + \frac{G^2M^2}{r^2c^4}\right)^{-1}dr^2 + r^2d\Omega^2 \\ ds^2 &= -\left(1 - \frac{2l_p}{r}\frac{l_p}{\bar{\lambda}_M} + \frac{l_p^2}{r^2}\frac{l_p^2}{\bar{\lambda}_M^2}\right)c^2dt^2 + \left(1 - \frac{2l_p}{r}\frac{l_p}{\bar{\lambda}_M} + \frac{l_p^2}{r^2}\frac{l_p^2}{\bar{\lambda}_M^2}\right)^{-1}dr^2 + r^2d\Omega^2 \end{aligned} \tag{6}$$

It should be noted that these quantized forms of writing general relativity theory do not alter any gravitational predictions, but they provide deeper insights into how gravity and matter likely operate. The quantization of matter arises because matter oscillates at a reduced Compton frequency. The reduced Compton time interval is given by $t_c = \frac{\bar{\lambda}_M}{c}$, and at the end of each Compton time interval, there is a Planck mass event, which lasts only for the Planck time.

This approach should not be directly compared with standard quantum mechanics; it leads to a modified quantum mechanical theory. Standard quantum mechanics typically deals with quantum probabilities at the atomic and subatomic scales. In quantum gravity theory, while probabilities exist, they are of a different nature compared with those in standard quantum mechanics. Both Einstein and de Broglie were critical of the interpretation and application of quantum probabilities in standard quantum mechanics. Their concern was not with probabilities per se but with the particular nebulous nature of probabilities in standard quantum mechanics, as articulated by de Broglie himself:

> *We have to come back to a theory that will be way less profoundly probabilistic. It will introduce probabilities, a bit like it used to be the case for the kinetic theory of gases if you want, but not to an extent that forces us to believe that there is no causality.*—Louis de Broglie, 1967

Also, in this new quantum form of general relativity, probabilities exist. The Planck mass has a reduced Compton wavelength equal to the Planck length: $\bar{\lambda} = \frac{\hbar}{m_p c} = l_p$. The reduced Compton frequency for the Planck mass per Planck time is therefore $f = \frac{l_p}{\bar{\lambda}_p} = \frac{l_p}{l_p} = 1$. For any mass smaller than the Planck mass, the frequency is less than one. Since events cannot be observed with a frequency less than one, this can be interpreted as a probability of frequency for masses smaller than the Planck mass. In other words, there is a probability of being in a special state that we refer to as the Planck mass state within a given observational time window of a Planck time. We do not delve into how this could possibly be unified with standard quantum mechanics here, as that is beyond the scope of this article. What is important to understand here is that general relativity theory can be quantized in this manner. The quantization is directly linked to the reduced Compton frequency in matter. This quantum gravity will be deterministic for masses equal to or significantly larger than the Planck mass, while it will exhibit quantum probabilistic effects for masses considerably smaller than the Planck mass.

3. The Planck Computer Is the One (Planck) Bit Computer

The reduced Compton frequency from a Planck mass is given by

$$f_p = \frac{c}{l_p} = 1.85 \times 10^{43} \text{ bps} \tag{7}$$

If the shortest time interval is the Planck time, then the Planck mass frequency per Planck time is

$$f_p = \frac{c}{l_p} t_p = \frac{c}{l_p} \frac{l_p}{c} = 1 \text{ bpp} \tag{8}$$

The Planck mass represents in our model a photon-photon collision lasting the Planck time. Each such Planck mass event can be considered equivalent to one bit. Additionally, as demonstrated in the previous section, the Planck scale is intricately related to gravity.

In the shortest time interval, which is the Planck time, the smallest reduced Compton frequency above zero that can be observed is one. This hypothetical Planck mass particle plays a central role in gravity and what we define as a quantum gravity computer.

The Planck computer is essentially a single Planck mass computer, capable of calculating one bit per Planck time. In one second, this amounts to an enormous quantity of bits, specifically approximately 1.85×10^{43} bits per second (bps).

In a one kg mass (of any type), we have a reduced Compton frequency per second of

$$f_{1kg} = \frac{c}{\bar{\lambda}_{1kg}} \approx 8.52 \times 10^{50} \text{ bps} \tag{9}$$

This is the number of Planck mass events in one kilogram per second. Each of these photon–photon collisions can be considered a count or a bit, and the reduced Compton frequency in matter sets the upper limit on what a one-kilogram quantum gravity computer's capacity, and indeed any computer. The number of bites (photon–photon collisions) in the Planck time in one kilogram is :

$$f_{1kg} = \frac{c}{\bar{\lambda}_{1kg}} t_p \approx 45,994,327 \text{ bpp} \tag{10}$$

4. We Live inside a Gigantic Hubble Sphere Quantum Gravity Computer (HSQGC)

Vopson [28] recently estimated that there are 6×10^{80} bits of information stored in all the matter particles of the observable universe, based on the number of particles in the observable universe and theoretical assumptions about the information capacity of each particle. This estimate closely relates to what is known as the Eddington number. Lloyd [29] calculated a similar information capacity for the universe, estimating it to be about 10^{90} bits. Lloyd also proposed a limit of $\left(\frac{t_H}{t_p}\right)^2 \approx 10^{120}$ operations that could be performed throughout the entire lifetime of the universe.

Our new quantized theory of general relativity and gravity provides interesting insights here as well, but it offers predictions that appear quite different from those of Vopson and Lloyd, albeit based on fundamentally different principles. We base everything on the reduced Compton frequency in the universe.

Starting with the critical Friedmann equation:

$$H_0^2 = \frac{8\pi G\rho}{3} \tag{11}$$

where H_0 is the Hubble parameter, ρ is the mass density of the Hubble sphere, and G is the Newtonian gravitational constant. Solving this equation for mass gives us the well-known critical Friedmann mass of the universe:

$$M_c = \frac{c^3}{2GH_0} \approx 9.29 \times 10^{52}\ \text{kg} \tag{12}$$

where H_0 is the Hubble constant, with a value of $H_0 = 66.87$ (km/s)/Mpc, as reported by Tatum et al. [30], but other H_0 studies can naturally also be used (for example, [31–34]) with relatively little difference in value for the purpose here. However, we have chosen to use the value from the Tatum et al., study, as it has an incredibly low uncertainty in its value due to a new and deeper understanding of the relation between CMB and the Hubble constant; see also [24]. This mass equivalent can represent both energy and mass due to their equivalence $E = mc^2$; thus, we do not distinguish between energy and mass here. This implies that the reduced Compton wavelength of the critical Friedmann universe is

$$\bar{\lambda} = \frac{\hbar}{M_c c} = \frac{2\hbar G H_0}{c^4} \approx 3.7845 \times 10^{-96}\ \text{m} \tag{13}$$

when using a Hubble constant of $H_0 = 66.87$ (km/s)/Mpc.

Even though the reduced Compton wavelength of the universe is not a physical Compton wavelength, it can still be used to calculate the correct number of Planck bits in the universe, which are physical.

Therefore, the reduced Compton frequency per second in the critical Friedmann universe is given by

$$f_c = \frac{c}{\bar{\lambda}_c} = \frac{c}{\frac{\hbar}{M_c c}} = \frac{c^5}{2GH_0\hbar} \approx 7.92 \times 10^{103}\ \text{frequency per second.} \tag{14}$$

This represents the number of bits the universe needs to compute per second to sustain itself. Alternatively, it represents the number of these Planck mass events per second in the universe, where each Planck mass event corresponds to one bit. However, the second is an arbitrary unit of time. In contrast, the Planck time is, in our view, the shortest possible physical time. If we calculate the reduced Compton frequency in the critical Friedmann universe per Planck time, we obtain

$$f_c = \frac{c}{\bar{\lambda}_c} t_p = \frac{c}{\frac{\hbar}{M_c c}} t_p = \frac{c^4 l_p}{2GH_0\hbar} \approx 4.28 \times 10^{60}\ \text{frequency per Planck time.} \tag{15}$$

This is the number of bits that need to be calculated per Planck time in the critical Friedmann universe to sustain its state. Interestingly, this also represents the information capacity; 4.28×10^{60} bits are stored in the universe over the Planck time. We could also refer to this as the computation speed of the universe.

In the Λ-CDM model, where the Friedmann equations serve as foundational principles, the amount of energy and mass is considerably higher than in the critical Friedmann model.

In the extremal universe [35], derived from the Reissner–Nordström extremal solution to Einstein's field equations, the universe's mass is given by

$$M_u = \frac{c^3}{GH_0} \tag{16}$$

This mass is twice the critical mass in the Friedmann model. However, a factor of 2 does not significantly alter the discussion here. This means the reduced Compton wavelength of the extremal universe is

$$\bar{\lambda}_u = \frac{\hbar}{M_u c} = \frac{\hbar G H_0}{c^4} \approx 1.98 \times 10^{-96}\ \text{m} \tag{17}$$

The Compton frequency of the extremal universe can also be expressed as

$$f_u = \frac{c}{\frac{\hbar}{M_u c}} = \frac{c^2}{\frac{\hbar}{\frac{c^3}{GH_0}}} = \frac{c^5}{GH_0\hbar} \tag{18}$$

and since $\frac{GH_0\hbar}{c^4} = \bar{\lambda}_u$, then the Compton frequency is simply the speed of light divided by the reduced Compton wavelength of the equivalent universe mass, that is,

$$f_u = \frac{c}{\bar{\lambda}_u} \approx 1.58 \times 10^{104}\ \text{Planck bits per second} \tag{19}$$

when using a Hubbe constant of 66.87 $(km/s)/Mpc$. Further, the number of bits per Planck time is

$$\frac{l_p}{\bar{\lambda}_u} \approx 8.16 \times 10^{60}\ \text{bpp.} \tag{20}$$

The energy per second needed to maintain the universe is therefore in the extremal universe about

$$E = \hbar \frac{c}{\bar{\lambda}_u} \approx 1.67 \times 10^{70}\ \text{Joules.} \tag{21}$$

and in the critical Friedmann universe about

$$E = \hbar \frac{c}{\bar{\lambda}_c} \approx 8.35 \times 10^{69}\ \text{Joules.} \tag{22}$$

Converted to mass, this is $\frac{E}{c^2} \approx \frac{1.67\times 10^{70}}{c^2} \approx 1.86 \times 10^{53}$ kilograms, and $\frac{E}{c^2} \approx \frac{8.35\times 10^{69}}{c^2} \approx 9.29 \times 10^{52}$ kilograms. This essentially means the universe is alive; it continuously utilizes and reuses all its energy. The universe is a perpetual motion machine, adhering to the conservation of energy principle.

Returning to the interpretation of the universe as a computer: All objects in the universe are constantly being updated in a 3D computational framework, akin to 3D printing as an analogy, or we could say 4D as the updating process clearly also involves time. Time emerges from change, as objects are continuously updated. We are indeed living inside quantum gravity computers, and we ourselves are quantum gravity computers, just like all other objects. For example, a person weighing 80 kg requires the following computations per second:

$$f_{80kg} = \frac{c}{\frac{\hbar}{80\ \text{kg} \times c}} \approx 6.82 \times 10^{52}\ \text{bps} \tag{23}$$

This represents an enormously powerful computer. We are quantum gravity computers within a quantum gravity computer — all integral parts of the vast computer known as the observable universe.

5. Thermodynamics Calculations Give the Same End Results

Haug [24] has recently demonstrated that the reduced Planck frequency per Planck time in the Hubble sphere simply is given by:

$$\frac{l_p}{\bar{\lambda}_c} = \frac{T_{CMB}^2}{T_{Haw}^2} \tag{24}$$

where T_{CMB} is the measured (or predicted) Cosmic Microwave Background temperature (CMB) in the universe and T_{Haw} is the Hawking [36,37] radiation temperature of the Hubble sphere in a black hole universe. The Hawking radiation temperature is given by

$$T_{Haw} = \frac{\hbar c}{4\pi k_b R_h} \approx 1.32 \times 10^{-30}\ \text{K} \tag{25}$$

where $R_h = \frac{c}{H_0}$ is the Hubble radius. The CMB temperature is measured very accurately by Dahl et al., [38] to 2.725007 ± 0.000024 K; see also [39–41]. This gives a predicted reduced Compton frequency in the Hubble sphere of

$$\frac{l_p}{\bar{\lambda}_c} = \frac{T_{CMB}^2}{T_{Haw}^2} \approx 4.28 \times 10^{60}\ \text{bpp} \tag{26}$$

Haug [42] has recently shown that in the critical Friedmann universe, the reduced Compton frequency per second can also be described as

$$n_p = \frac{l_p}{\bar{\lambda}_c} = \frac{T_{CMB}^2}{H_0^2} \frac{k_b^2 16\pi^2}{\hbar^2} \approx 4.28 \times 10^{60}\ \text{frequency per Planck time (bpp).} \tag{27}$$

This matches the result we obtained in the previous section and is derived simply as $\frac{l_p}{\bar{\lambda}_c} = \frac{T_{CMB}^2}{T_{Haw}^2}$.

6. How Many Calculations in the Time of the Universe

This depends on the universe model. Here, we only perform such calculations for the so-called $R_h = ct$ black hole cosmological models. The idea that our universe, the Hubble sphere, could be a black hole dates back at least to a paper by Pathria [43] published in 1972. Even though much less popular than the Λ-CDM model, a black hole universe is actively discussed to this day; see, for example, [44–48]. Furthermore, the $R_h = ct$ principle in cosmology appears to be favored in terms of many observations compared with the Λ-CDM model, see [49]. All we can say at this stage is that further investigation into a series of cosmological models should be preferred before making hasty conclusions.

In such a model, the universe starts out with a Planck mass black hole and grows into the critical Friedmann mass or, alternatively, into an extremal black hole, and by this has twice the mass of the critical Friedmann mass. This means the number of operations (bits) since the beginning of the universe in the critical Friedmann $R_h = ct$ universe is given by the arithmetic sequence of Planck mass events from the beginning of the universe to now, which must be

$$\#ops = n\left(\frac{1+n}{2}\right) = \frac{l_p}{\bar{\lambda}_c}\left(\frac{1+\frac{l_p}{\bar{\lambda}_c}}{2}\right) = \frac{c^4 l_p}{2GH_0\hbar}\left(\frac{1+\frac{c^4 l_p}{2GH_0\hbar}}{2}\right) \approx 9.14 \times 10^{120} \tag{28}$$

This is very close to the 10^{120} predicted by Lloyd [29] for a matter-dominated universe at its critical density. This is better understood if we rewrite our Equation (28) as

$$\#ops = \frac{c^4 l_p}{2GH_0\hbar}\left(\frac{1+\frac{c^4 l_p}{2GH_0\hbar}}{2}\right) = \frac{\frac{t_H}{2t_p}+\left(\frac{t_H}{2t_p}\right)^2}{2} \approx \frac{t_H^2}{8t_p^2} \approx 9.14 \times 10^{120}$$

In the extremal universe, we obtain the following number of bits operations since the beginning of the $R_h = ct$ universe:

$$\#ops = n\left(\frac{1+n}{2}\right) = \frac{c}{\bar{\lambda}_u}\left(\frac{1+\frac{c}{\bar{\lambda}_u}}{2}\right) = \frac{c^4 l_p}{GH_0\hbar}\left(\frac{1+\frac{c^4 l_p}{GH_0\hbar}}{2}\right) \approx 3.65 \times 10^{121} \tag{29}$$

which is also not far from what has been predicted by Loyd. Equation (29) can be rewritten as

$$\#ops = \frac{c^4 l_p}{2GH_0\hbar}\left(\frac{1+\frac{c^4 l_p}{GH_0\hbar}}{2}\right) = \frac{\frac{t_H}{2t_p}+\left(\frac{t_H}{t_p}\right)^2}{2} \approx \frac{t_H^2}{2t_p^2} \approx 3.65 \times 10^{121}$$

and Loyd, in a matter-dominated universe based on critical density, predicted the number of operations to be $\approx \frac{t^2}{t_H^2} \approx 10^{120}$. We see our approach based on reduced Compton frequency in a $R_h = ct$ universe leads to about the same number of operations since the beginning of the universe; this is no big surprise since, in particular, our critical Friedmann $R_h = ct$ universe indeed is also rooted in the Friedemann equation.

The Bekenstein–Hawking [50,51] entropy of a black hole Hubble sphere is given by

$$S_{BH} = \frac{A}{4l_p^2} = \frac{4\pi r_s^2}{4l_p^2} = \frac{\pi r_s^2}{l_p^2} \tag{30}$$

This can be rewritten as (sometimes the black hole entropy is written with the Boltzmann constant in the front and sometimes not; adding the Boltzmann constant is trivial.)

$$\begin{aligned} S_{BH} &= \frac{4\pi r_s^2}{4l_p^2} \\ S_{BH} &= \frac{4\pi 4\frac{l_p^4}{\bar{\lambda}_c^2}}{4l_p^2} \\ S_{BH} &= \pi 4\frac{l_p^2}{\bar{\lambda}_c^2} \end{aligned} \tag{31}$$

We can further take advantage of the fact that $H_0 = \frac{\bar{\lambda}_c c}{2l_p^2}$ and that $t_H = \frac{1}{H_0} = \frac{2l_p^2}{\bar{\lambda}_c c}$; see [52]. This means we have

$$\#ops = \frac{t_H^2}{8t_p^2} = \frac{\frac{4l_p^4}{\bar{\lambda}_c^2 c^2}}{8\frac{l_p^2}{c^2}} = \frac{l_p^2}{2\bar{\lambda}_c^2} \approx 9.14 \times 10^{120} \tag{32}$$

This means we can also approximate the numbers of operations in the critical universe since its beginning of the universe as

$$\#ops \approx \frac{S_{BH}}{8\pi} \approx 9.14 \times 10^{120} \quad (33)$$

So, we have

$$S_{BH} = \frac{A}{4l_p^2} = 4\pi\frac{l_p^2}{\bar{\lambda}_c^2} = 4\pi\frac{l_p^2}{\bar{\lambda}_c^2} = 4\pi\frac{t_H^2}{2t_p^2} \quad (34)$$

7. Summary of the Hubble Quantum Computer

It appears that the Hubble sphere can be modeled as a quantum gravity computer, where one bit corresponds to a Planck mass event lasting the Planck time. This implies that we inhabit an immense quantum gravity computer. If this computer were created by an entity beyond our current understanding, it could even be termed the God Computer. Alternatively, from a pantheistic perspective, where the universe and God are seen as one, we reside within the God quantum computer. Regardless of the philosophical interpretation, it is remarkable to consider the enormous computational power required to operate the Hubble sphere, updating approximately 10^{104} bits per second. Unlike conventional computers, no additional energy is consumed for these computations, as energy conservation remains a fundamental principle in physics and the universe.

Table 1 summarizes our primary findings regarding the Hubble sphere quantum computer. Depending on whether we base our calculations on the critical Friedmann mass or the extremal solution of the Reissner–Nordstrom solution, we arrive at a computational capacity of 7.92×10^{103} bps or 1.58×10^{104} bps. Other cosmological models, when quantized based on reduced Compton frequency, are expected to yield results close to these figures. To our knowledge, this framework represents the first consistent approach to a quantized version of general relativity theory incorporating the Planck scale, and it can likely be unified with slightly modified quantum mechanics.

Table 1. The table shows the quantum computer aspects of the Hubble sphere in the Critical Friedmann universe, as well as in the extremal universe. The calculated values are based on a Hubble constant of $H_0 = 66.87$ (km/s)/Mpc.

Property at Present	Critical Friedmann Universe	Extremal Universe
Bits per second (bps)	$f_c = \frac{c}{\bar{\lambda}_c} = \frac{c^5}{2GH_0\hbar} \approx 7.92 \times 10^{103}$	$f_u = \frac{c}{\bar{\lambda}_u} = \frac{c^5}{GH_0\hbar} \approx 1.58 \times 10^{104}$
Bits per Planck time (bpp)	$\frac{l_p}{\bar{\lambda}_c} = \frac{c^4 l_p}{2GH_0\hbar} \approx 4.28 \times 10^{60}$	$\frac{l_p}{\bar{\lambda}_u} = \frac{c^4 l_p}{GH_0\hbar} \approx 8.58 \times 10^{60}$
Bits per Planck time (bpp)	$\frac{l_p}{\bar{\lambda}_c} = \frac{T_{CMB}^2}{H_0^2}\frac{k_b^2 16\pi^2}{\hbar^2} \approx 4.28 \times 10^{60}$	$\frac{l_p}{\bar{\lambda}_u} = \frac{T_{CMB}^2}{H_0^2}\frac{k_b^2 32\pi^2}{\hbar^2} \approx 8.56 \times 10^{60}$
Bits per Planck time (bpp)	$\frac{l_p}{\bar{\lambda}_c} = \frac{T_{CMB}^2}{T_{Haw}^2} \approx 4.28 \times 10^{60}$	$\frac{l_p}{\bar{\lambda}_u} = 2\frac{T_{CMB}^2}{T_{Haw}^2} \approx 8.56 \times 10^{60}$
Operations since beginning of $R_h = ct$ universe:	$\#ops = \frac{c}{\bar{\lambda}_c}\left(\frac{1+\frac{c}{\bar{\lambda}_c}}{2}\right) \approx 9.14 \times 10^{120}$	$\#ops = \frac{c}{\bar{\lambda}_u}\left(\frac{1+\frac{c}{\bar{\lambda}_u}}{2}\right) \approx 3.66 \times 10^{121}$
Operations since beginning of $R_h = ct$ universe:	$\#ops \approx \frac{t_H^2}{8t_p^2} \approx 9.14 \times 10^{120}$	$\#ops \approx \frac{t_H^2}{2t_p^2} \approx 3.66 \times 10^{121}$
Operations since beginning of $R_h = ct$ universe:	$\#ops \approx \frac{S_{BH}}{8\pi} \approx 9.14 \times 10^{120}$	$\#ops \approx \frac{S_{BH}}{2\pi} \approx 3.66 \times 10^{121}$

8. Conclusions

The universe is a colossal quantum gravity computer. The Hubble sphere requires approximately 10^{70} Joules per second to update itself and performs 10^{104} bits of calculations per second. Further, the number of operations since the beginning of the universe is about

10^{120}, which corresponds closely to what other researchers have found based on reasoning from a somewhat different angle. This supports that the reduced Compton frequency in matter is the quantization of gravity. Speculatively, we therefore, in essence, are living inside an immense computer—we are quantum gravity computers. Our ultimate goal should be to master this computer comprehensively. This could speculatively not only provide us with extremely powerful computers but potentially provide us with virtually unlimited clean energy for practical purposes.

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References

1. Ladd, T.; Jelezko, F.; Laflamme, R.; Nakamura, Y.; Monroe, C.; O'Brian, J.L. Quantum computers. *Nature* **2010**, *45*, 464. [CrossRef]
2. Nandhini, S.; Harpreet, S.; Akash, U.N. An extensive review on quantum computers. *Adv. Eng. Softw.* **2022**, *174*, 103337. [CrossRef]
3. Baaquie, B.E.; Kwek, L.-C. *Quantum Computers: Theory and Algorithms*; Springer: Berlin/Heidelberg, Germany, 2023.
4. La Cour, B. Advances in quantum computing. *Entropy* **2023**, *25*, 1633. [CrossRef]
5. Hardy, L. Quantum gravity computers: On the theory of computation with indefinite causal structure. In *Quantum Reality, Relativistic Causality, and Closing the Epistemic Circle*; The Western Ontario Series in Philosophy of Science; Springer: Berlin/Heidelberg, Germany, 2009; Volume 73. [CrossRef]
6. Planck, M. *Natuerliche Masseinheiten*; Der Königlich Preussischen Akademie Der Wissenschaften: Berlin, Germany, 1899. Available online: https://www.biodiversitylibrary.org/item/93034#page/7/mode/1up (accessed on 6 August 2020).
7. Planck, M. *Vorlesungen über Die Theorie der Wärmestrahlung*; J.A. Barth: Leipzig, Germany, 1913; p. 163.
8. Einstein, A. Näherungsweise integration der feldgleichungen der gravitation. In *Sitzungsberichte der Königlich Preussischen Akademie der Wissenschaften Berlin*; Publisher of the Royal Academy of Science: Berlin, Germany, 1916.
9. Eddington, A.S. *Report on the Relativity Theory of Gravitation*; The Physical Society of London, Fleetway Press: London, UK, 1918.
10. Bridgman, P.W. *Dimensional Analysis*; Yale University Press: New Haven, CT, USA, 1922.
11. Adler, S.L. Six easy roads to the Planck scale. *Am. J. Phys.* **2010**, *78*, 925. [CrossRef]
12. Hossenfelder, S. Can we measure structures to a precision better than the Planck length? *Class. Quantum Gravity* **2012**, *29*, 115011. [CrossRef]
13. Hossenfelder, S. Minimal length scale scenarios for quantum gravity. *Living Rev. Relativ.* **2013**, *16*, 2. [CrossRef]
14. Cahill, K. The gravitational constant. *Lett. Nuovo C.* **1984**, *39*, 181. [CrossRef]
15. Cahill, K. Tetrads, broken symmetries, and the gravitational constant. *Z. Für Phys. C Part. Fields* **1984**, *23*, 353. [CrossRef]
16. Cohen, E.R. Fundamental Physical Constants. In *Gravitational Measurements, Fundamental Metrology and Constants*; Sabbata, V., Melniko, V.N., Eds.; Kluwer Academic Publishers: Amsterdam, The Netherland, 1987; p. 59.
17. Haug, E.G. Finding the Planck length multiplied by the speed of light without any knowledge of *G*, *c*, or *h*, using a Newton force spring. *J. Phys. Commun.* **2020**, *4*, 075001. [CrossRef]
18. Haug, E.G. Progress in the composite view of the Newton gravitational constant and its link to the Planck scale. *Universe* **2022**, *8*, 454. [CrossRef]
19. D'Auria, S. *Introduction to Nuclear and Particle Physics*; Springer: Berlin/Heidelberg, Germany, 2018.
20. De Broglie, L. Recherches Sur la Théorie des Quanta. Ph.D. Thesis, University of Paris, Paris, France, 1924. Available online: https://www.semanticscholar.org/paper/Recherches-sur-la-th%C3%A9orie-des-quanta-Broglie/1425eb56d31b2dc024173422a13b9ebf5eb1bbb1 (accessed on 4 September 2024).
21. De Broglie, L. *An Introduction to the Study of Wave Mechanics*; Metheum & Co.: Essex, UK, 1930.
22. Haug, E.G. The Compton wavelength is the true matter wavelength, linked to the photon wavelength, while the de Broglie wavelength is simply a mathematical derivative, understanding this leads to unification of gravity and new quantum mechanics. *Qeios* **2023**. [CrossRef]
23. Haug, E.G. Different mass definitions and their pluses and minuses related to gravity. *Foundations* **2023**, *3*, 199–219. [CrossRef]
24. Haug, E.G. CMB, Hawking, Planck, and Hubble scale relations consistent with recent quantization of general relativity theory. *Int. J. Theor. Phys.* **2024**, *63*, 57. [CrossRef]
25. Schwarzschild, K. über das gravitationsfeld einer kugel aus inkompressibler flussigkeit nach der einsteinschen theorie. In *Sitzungsberichte der Deutschen Akademie der Wissenschaften zu Berlin, Klasse fur Mathematik, Physik, und Technik*; Deutsche Akademie der Wissenschaften zu Berlin: Berlin, Germany, 1916; p. 424. Available online: https://ui.adsabs.harvard.edu/abs/1916skpa.conf..424S/abstract (accessed on 4 September 2024).

26. Reissner, H. Über die eigengravitation des elektrischen feldes nach der Einsteinschen theorie. *Ann. Phys.* **1916**, *355*, 106. [CrossRef]
27. Nordström, G. On the energy of the gravitation field in Einstein's theory. *Koninklijke Ned. Akad. Wet. Proc.* **1918**, *20*, 1238.
28. Vopson, M.M. Estimation of the information contained in the visible matter of the universe. *AIP Adv.* **2021**, *11*, 105317. [CrossRef]
29. Lloyd, S. Computational capacity of the universe. *Phys. Rev. Lett.* **2002**, *88*, 237901. [CrossRef]
30. Tatum, E.T.; Haug, E.G.; Wojnow, S. High precision Hubble constant determinations based upon a new theoretical relationship between CMB temperature and H_0. *HAL Arch.* **2023**. *under review*. Available online: https://hal.science/hal-04268732 (accessed on 6 August 2024).
31. Hotokezaka, K.; Nakar, E.; Gottlieb, O.; Nissanke, S.; Masuda, K.; Hallinan, G.; Mooley, K.P.; Deller, A.T. A Hubble constant measurement from superluminal motion of the jet in gw170817. *Nat. Astron.* **2019**, *3*, 940. [CrossRef]
32. Freedman, W.L.; Madore, B.F.; Hatt, D.; Jang, I.S.; Beaton, R.L.; Burns, C.R.; Lee, M.G.; Monson, A.J.; Neeley, J.R.; Phillips, M.M.; et al. The Carnegie-Chicago Hubble program. viii. an independent determination of the Hubble constant based on the tip of the red giant branch. *Astrophys. J.* **2019**, *882*, 24. [CrossRef]
33. Kelly, P.L.; Rodney, S.; Treu, T.; Oguri, M.; Chen, W.; Zitrin, A.; Birrer, S.; Bonvin, V.; Dessart, L.; Diego, J.M.; et al. Constraints on the Hubble constant from supernova Refsdal's reappearance. *Science* **2023**, *380*, 6649. [CrossRef]
34. Sneppen, A.; Watson, D.; Poznanski, D.; Just, O.; Bauswein, A.; Wojtak, R. Measuring the Hubble constant with kilonovae using the expanding photosphere method. *Astron. Astrophys.* **2023**, *678*, A14. [CrossRef]
35. Haug, E.G. The extremal universe exact solution from Einstein's field equation gives the cosmological constant directly. *J. High Energy Phys. Gravit. Cosmol.* **2024**, *10*, 386. [CrossRef]
36. Hawking, S. Black hole explosions. *Nature* **1974**, *248*, 30–31. [CrossRef]
37. Hawking, S. Black holes and thermodynamics. *Phys. Rev. D* **1976**, *13*, 191. [CrossRef]
38. Dhal, S.; Singh, S.; Konar, K.; Paul, R.K. Calculation of cosmic microwave background radiation parameters using cobe/firas dataset. *Exp. Astron.* **2023**, *56*, 715–726. [CrossRef]
39. Fixsen, D.J.; Kogut, A.; Levin, S.; Limon, M.; Lubin, P.; Mirel, P.; Seiffert, M.; Wollack, E. The temperature of the cosmic microwave background at 10 GHz. *Astrophys. J.* **2004**, *612*, 86. [CrossRef]
40. Fixsen, D.J. The temperature of the cosmic microwave background. *Astrophys. J.* **2009**, *707*, 916. [CrossRef]
41. Noterdaeme, P.; Petitjean, P.; Srianand, R.; Ledoux, C.; López, S. The evolution of the cosmic microwave background temperature. *Astron. Astrophys.* **2011**, *526*, L7. [CrossRef]
42. Haug, E.G. God Time = Planck Time: Finally Detected! And Its Relation to Hubble Time. *Open J. Microphys.* **2024**, *14*, 40. [CrossRef]
43. Pathria, R.K. The universe as a black hole. *Nature* **1972**, *240*, 298. [CrossRef]
44. Stuckey, W.M. The observable universe inside a black hole. *Am. J. Phys.* **1994**, *62*, 788. [CrossRef]
45. Easson, D.A.; Brandenberger, R.H. Universe generation from black hole interiors. *J. High Energy Phys.* **2001**, *2001*, JHEP06(2001). [CrossRef]
46. Christillin, P. The Machian origin of linear inertial forces from our gravitationally radiating black hole universe. *Eur. Phys. J. Plus* **2014**, *129*, 175. [CrossRef]
47. Popławski, N. The universe in a black hole in Einstein–Cartan gravity. *Astrophys. J.* **2016**, *832*, 96. [CrossRef]
48. Gaztanaga, E. The black hole universe, part II. *Symmetry* **2022**, *14*, 1984. [CrossRef]
49. Melia, F. A comparison of the $R_h = ct$ and Λ-CDM cosmologies using the cosmic distance duality relation. *Mon. Not. R. Astron. Soc.* **2018**, *481*, 4855. [CrossRef]
50. Bekenstein, J. Black holes and the second law. *Lett. Nuovo Cimento* **1972**, *4*, 737–740. [CrossRef]
51. Hawking, S. Particle creation by black holes. *Commun. Math. Phys.* **1975**, *43*, 199. [CrossRef]
52. Haug, E.G. Cosmological scale versus Planck scale: As above, so below! *Phys. Essays* **2022**, *35*, 356–363. [CrossRef]