The Hawking Temperature Intensive Crisis and a Possible Solution that Leads to an Intensive Schwarzschild Radius Temperature *

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Abstract

Crothers and Robitaille have recently pointed out that the Hawking temperature and the Unruh temperature are not intensive and how this is inconsistent with thermodynamics, which suggests that the theory around the temperature of black holes is flawed, incomplete, or at least not fully understood. Here we offer a modified Newtonian type acceleration field linked to the Planck scale that leads to a new modified intensive Schwarzschild surface temperature for so-called black holes.

Key words: Hawking temperature, Unruh temperature, Planck scale, Schwarzschild radius .

1 The Intensive Crisis in the Hawking Temperature and the Unruh Temperature

In 1974, Hawking [1] introduced the idea of black hole radiation and a corresponding temperature at the black hole's surface, better known today as Hawking radiation and Hawking temperature, see also [2]. The Hawking temperature is given by

$$T_H = \frac{\hbar g}{2\pi c k_B} \tag{1}$$

where c is the speed of light, k_b is the Boltzmann constant, and g is the gravitational acceleration field. The Hawking temperature was originally stated as what

> *"?one would expect if the black hole was a body with temperature of* $(\kappa/2\pi)(\hbar/2k_b)$*..."*
> – Stephen Hawking, 1974

and the Unruh temperature is very similar to the Hawking temperature

$$T_U = \frac{ha}{4\pi^2 c k_B} \tag{2}$$

The Newton gravitational acceleration at the Schwarzschild radius is given by

$$g = \frac{GM}{R_s^2} = \frac{GM}{\left(\frac{2GM}{c^2}\right)^2} = \frac{c^4}{2GM} \tag{3}$$

and when replaced in the Hawking temperature it is

$$T_H = \frac{hc^3}{8\pi^2 GM k_B} \tag{4}$$

When the mass increases, the Hawking temperature and Unruh temperature at the Schwarzschild radius will fall. It has been known for a long time that Hawking temperature not is intensive, see for example [3]. However, Crothers and Robitaille [4, 5] are the first one to clearly point out that this seems to be in strong conflict with thermodynamics. This leads to an intensive crisis in the Hawking temperature and the Unruh temperature at the Schwarzschild radius, since temperature must, according to thermodynamics, be intensive [6]. Landsberg went as far as claiming the intensity and extensive properties and their relations should be considered the fourth law of thermodynamics. So, could this

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indicate that the Hawking temperature is flawed or incomplete? In this paper, we are examining the Hawking and Unruh intensive crisis.

We think one should be careful with making harsh criticism of predictions at the Schwarzschild radius. The smallest Schwarzschild radius is the Planck length and, we will claim, the Schwarzschild radius is directly linked to the Planck scale. Recent research also shows that we can measure the Schwarzschild radius without any knowledge of general relativity theory or Newton's gravitational constant. The Schwarzschild radius is, in our view, essential for gravity, but what does it truly represent? See [7, 8]. Yet, the importance of the Schwarzschild radius seems to have little to do with the traditional view on black holes; it should instead be connected to our recent progress in quantum physics.

At the Planck scale, several physical laws could break down, including Lorentz symmetry; this is also predicted by several quantum gravity theories, so what we normally consider "laws" do not necessary hold at the Planck scale. The Planck scale is very special indeed. However, we do not expect the requirement of intensity of temperature to be one of the rules that breaks down at the Planck scale, and we think that the Crothers and Robitaille paper, which points out the intensive crisis in the Hawking and Unruh temperatures, is valid here. This means the intensive crisis should be investigated further and not ridiculed. After all there is not yet a unified quantum gravity theory, something is missing.

2 Modified Gravitational Acceleration Field

What is described in this section was first suggested by Haug [9] in early 2018, before Crothers and Robitaille pointed out the intensive crisis in the Hawking and Unruh temperatures. Thus, there is an interesting timeline with regard to thoughts on this subject in very recent history; we did not try to come up with the modification in gravitational acceleration field (as suggested below) simply to fudge the intensive crisis in Hawking and Unruh temperatures. In fact, we have been working on other gravity topics and came up with this suggestion before we had heard of the intensive crisis. The modified gravitational acceleration field, even if somewhat ad-hoc, is based on deep tinkering with gravity at the Planck scale and we have contributed to the literature on this subject previously.

The acceleration field is unrealistically low under classical Newtonian [10] physics at the Schwarzschild radius. And yet the escape velocity at the Schwarzschild radius is always the speed of light, as we think it should be. Assume a super-massive object that is 10^{14} solar masses. The gravitational acceleration field at the Schwarzschild radius is, under Newton's universal gravitation, only

$$g = \frac{GM}{R^2} = \frac{GM}{\left(2\frac{GM}{c^2}\right)^2} \approx 0.152 \text{ m}/s^2 \tag{5}$$

How can the escape velocity be c and at the same time the surface gravity field is much weaker than that on Earth, where it is about 9.8 m/s^2? According to Einstein's theory of general relativity, the gravitational acceleration field under the Schwarzschild metric is supposedly going towards infinite strength at the Schwarzschild radius. We will suggest that no acceleration field can be stronger than the Planck acceleration field

$$a_p = \frac{c^2}{l_p} \approx 5.56092 \times 10^{51} \text{ m}/s^2 \tag{6}$$

If the shortest possible time interval during which something can undergo acceleration is one Planck second, then if an object undergoes Planck acceleration for this time interval, it will reach the speed of light

$$a_p t_p = \frac{c^2}{l_p}\frac{l_p}{c} = c \tag{7}$$

As matter cannot travel at the speed of light, in our interpretation this means only a Planck mass particle can undergo this acceleration. As shown by Haug in a series of papers, the Planck particle is likely at absolute rest and within one Planck second will dissolve into pure energy [11]. This also explains why the mass can accelerate from rest-mass to the speed of c within a Planck second; it has to dissolve into pure energy in this time frame. From mathematical atomism, only the Planck mass particle can do this within a Planck second. We will assume the Planck acceleration is what we have at the Schwarzschild radius. Further, we will assume the inverse square rule basically holds for a radius going out from the Schwarzschild radius rather than from the very center of the mass. Based on this scenario, our modified formula for gravitational acceleration field is

$$g \approx \frac{GM}{r^2 - \left(\frac{2GM}{c^2}\right)^2 + \left(\frac{GM}{c^2}\right) l_p}$$

$$g \approx \frac{c^2 N l_p}{r^2 - (2Nl_p)^2 + Nl_p^2} \tag{8}$$

where N is the number of Planck masses in the object. Now the acceleration field for a 10^{14} solar mass object at the Schwarzschild radius, $r = \frac{2GM}{c^2}$, gives

$$g \approx \frac{GM}{r^2 - \left(\frac{2GM}{c^2}\right)^2 + \left(\frac{GM}{c^2}\right) l_p} = \frac{GM}{\left(\frac{2GM}{c^2}\right)^2 - \left(\frac{2GM}{c^2}\right)^2 + \left(\frac{GM}{c^2}\right) l_p} = \frac{c^2}{l_p} \approx 5.56092 \times 10^{51} \text{ m}/s^2 \tag{9}$$

Next, the mass of the Earth is approximately 2.74388×10^{32} Planck masses. Further, the radius of the Earth is 6,371,000 km; this gives an acceleration field of the Earth at the surface of Earth equal to

$$g \approx \frac{c^2 N l_p}{r^2 + N l_p^2 (1 - N)} = \frac{c^2 \times 2.74388 \times 10^{32} \times l_p}{6371000^2 + (2 \times 2.74388 \times 10^{32} \times l_p)^2 - 2.74388 \times 10^{32} \times l_p} \approx 9.8194 \; m/s^2$$

Still, this formula always gives the Planck acceleration at the modified Schwarzschild radius. We have not evaluated this adjustment completely yet, and it should be investigated further for possible weaknesses.

3 Back to the Intensive Crisis in Hawking Temperature

As shown in the last section, our modified gravitational acceleration field is always the Planck acceleration at the Schwarzschild radius

$$g_{r_s} \approx \frac{GM}{r_s^2 - \left(\frac{2GM}{c^2}\right)^2 + \left(\frac{GM}{c^2}\right) l_p} = \frac{GM}{\left(\frac{2GM}{c^2}\right)^2 - \left(\frac{2GM}{c^2}\right)^2 + \left(\frac{GM}{c^2}\right) l_p} = \frac{c^2}{l_p} \approx 5.56092 \times 10^{51} \text{ m}/s^2 \tag{10}$$

which gives a black hole surface temperature of always

$$T_H = \frac{h g_{r_s}}{4\pi^2 c k_B} = \frac{h \frac{c^2}{l_p}}{4\pi^2 c k_B} = \frac{\hbar}{l_p k_B} c \frac{1}{2\pi} \tag{11}$$

That is now intensive; no matter what the mass of the so-called black hole may be, our surface temperature is always the same, it is the Planck temperature divided by 2π, and it is intensive. This modified Schwarzschild surface temperature only corresponds to the Hawking temperature when we have a single Planck mass. The larger the black hole, the smaller is the Hawking temperature, while our temperature always stays the same. In our view, our temperature seems more logical and seems to return to the issue that modern physics lacks quantization in general relativity and Newtonian theory.

Newton's gravitational constant is, in modern physics, only an observed constant used to calibrate gravity, so it fits observations. The gravitational constant was first indirectly found by Cavendish in 1798, when he was using a Cavendish apparatus to weigh the Earth [12]. However, as Haug has pointed out in a series of papers, [13–15], Newton's gravitational constant is very likely a composite constant of the form $G = \frac{l_p^2 c^3}{\hbar}$. In 2014, McCulloch [16] derived basically the same gravitational constant from Heisenberg's uncertainty principle; his formula was

$$G = \frac{\hbar c}{m_p^2} \tag{12}$$

and because the Planck mass can be written as

$$m_p = \frac{\hbar}{l_p} \frac{1}{c} \tag{13}$$

we can see that this is the same as the Haug formula

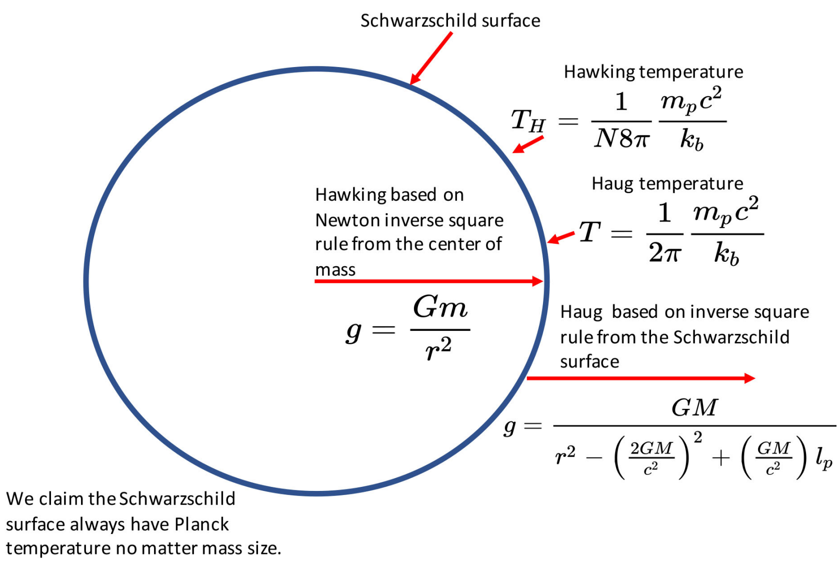
$$G = \frac{\hbar c}{\frac{\hbar}{l_p} \frac{1}{c} \frac{\hbar}{l_p} \frac{1}{c}} = \frac{l_p^2 c^3}{\hbar} \tag{14}$$

Newton's gravitational, constant is universal, but it is a composite. The Hawking temperature can therefore also be rewritten as[1] (known)

[1] See also [17].

$$T_H = \frac{c^3}{8\pi GM}\frac{\hbar}{k_b}$$
$$T_H = \frac{c^3}{8\pi\frac{l_p^2c^3}{\hbar}Nm_p}\frac{\hbar}{k_b}$$
$$T_H = \frac{c^3}{8\pi\frac{l_p^2c^3}{\hbar}N\frac{\hbar}{l_p}\frac{1}{c}}\frac{\hbar}{k_b} = \frac{1}{N8\pi}\frac{\hbar c}{l_pk_b} = \frac{1}{N8\pi}\frac{m_pc^2}{k_b} \tag{15}$$

where N is the number of Planck masses, m_p, in the black hole (gravity object). Only when $N = 1$, that is for one Planck mass the Hawking temperature gives the same prediction as our theory. Haug has recently shown that all well-known gravity predictions and observations can be done without any knowledge of the Newtonian gravitational constant G. It is the Planck length that is important for gravity, and it can be found independent of any knowledge of both G and $\hbar$. Also, the Schwarzschild radius embedded contains the Planck length, and it actually requires less information to find the Schwarzschild radius than G itself; the standard Schwarzschild radius formula is not needed to find the Schwarzschild radius itself. Our theory for a so-called black hole temperature (Hawking temperature) differs from Hawking in that we think the inverse square law of gravity for a gravity mass packed inside a Schwarzschild radius should hold from the Schwarzschild surface, not from the very center of the object. The standard gravity methods means mass(energy) can be infinitely densely packed, something we strongly doubt, there are also several other issues and problems with the standard approach that we will discuss more in the future. Our approche seems to give more logic, and leads to a series of predictions that fit observations. For example, we have recently shown how our theory, rooted in the Planck scale [8], seems to predict zero time dilation for high Z quasars, something that also fits observations, in strong contrast to existing the existing gravity theory that are not rooted in the quantum world.



This figure simple illustrates how we assume what is relevant for the gravitational acceleration field is the distance from the Schwarzschild surface, and not from the very center of the gravity object. This will only have implications (predict very different results than standard theory) when very close to the Schwarzschild surface.

4 Possible Implications for Quasars

As quasars are considered black holes (at least at their core), our modified Schwarzschild radius (Hawking) radiation should be valid for them. Our new model predicts that the quasar radiation is much higher than expected at the surface of the Schwarzschild object (quasar). This also means that the life expectancy of quasars would be much shorter than expected from modern cosmology. We observe that the life expectancy of quasars could also be dependent on the density of particles with mass surrounding the quasar. Particles with mass around the quasar will be moving towards the quasar due to gravity and will reflect radiation out from the quasar back to the quasar and therefore this will also increase the life expectancy. We suggest that the shortest possible life expectancy of a quasar (hypothetically surrounded by only a vacuum) is simply related to the Schwarzschild radius divided by the speed of light, which gives

$$T_{r_s} = \frac{R_s}{c} = \frac{2GM}{c^3} \tag{16}$$

We should keep in mind that the Schwarzschild radius is the reduced Compton frequency per Planck second multiplied by the Planck length, $R_s = \frac{2GM}{c^2} = 2N\frac{\frac{c}{\bar{\lambda}}}{\frac{c}{l_p}}l_p = 2Nl_p\frac{l_p}{\bar{\lambda}}$, be aware that both l_p and $\bar{\lambda}$ can be measured independent of GR and even any knowledge of big G. For a quasar with 10^{14} solar masses, this means (the suggested formula above) a minimum life expectancy of just 15.6 years. This means the quasar could lose much of its mass within a few years. Recently, astronomers [18, 19] have observed quasars vanishing (or at least changing dramatically) within a 10-year period, where previous theories predicted that this would take at least ten thousand years

> *Although quasars turn off, transitioning into mere galaxies, the process should take 10,000 years or more. This quasar appeared to have shut down in less than 10 years – a cosmic eyeblink.* – see [20]

Our theory also means that the quasars must be extremely bright objects, something they are indeed. Our theory even explains why no micro black holes have been observed. The life expectancy of a micro black hole would only be one Planck second, as the Schwarzschild radius of the smallest so-called black hole is the Planck length. Further, as we have pointed out in several papers, mass is time dependent [11]. However, this is only directly observable when we approach reduced Compton time observational windows, at least in general, and we are not there yet. As for the Planck mass particle, the micro black hole, the reduced Compton time is the Planck time.

5 The Black Hole Interpretation Crisis?

Crothers [21] has been very critical towards the modern physics interpretation of so-called black holes. We think he could be right in much/some of his criticism. Still, based on recent progress in theoretical and applied physics, we also think that the Schwarzschild radius represents something very important related to gravity [7]. The Schwarzschild radius is the reduced Compton frequency of the gravity object per Planck second times the Planck length. Both the reduced Compton frequency per Planck second and the Planck length can be found independent of GR and also independent of any knowledge of big G, see [22]. We claim that even particles with less mass than the Planck mass have a Schwarzschild radius, but the Schwarzschild radius is then probabilistic [8]. We suggest that so-called black holes should be understood from a totally new perspective, namely mathematical atomism, which is linked directly to a new and revolutionary understanding of the Planck scale. This is something we will likely return to in a later version of this paper.

A series of modern physics predictions around AGN (quasars/black holes) seem to be totally different than what is observed, such as expected time-dilation in high Z quasars [8, 23, 24], as well as how fast quasars can vanish or change their observable characteristics. In addition, the fact that Hawking temperature is not intensive should make us question the incompleteness of the fundamental principles of existing theories and look more closely at criticisms as well as potential alternatives. One cannot just keep patching holes in a theory by creating new holes; one must go back to take a closer look at the foundation.

6 Conclusion

Crothers and Robitaille have recently pointed out that the Hawking temperature is not intensive and pointed out that this is in conflict with theormodynamics; that is to say, the Hawking temperature seems to be incomplete or flawed in some way. Earlier this year, Haug has suggested a modified Newton gravitational acceleration field that gives the same gravitational acceleration in weak gravitational fields as predicted by Newton and as observed, but gives very different gravitational acceleration linked to the Planck scale at the Schwarzschild radius (very strong gravitational fields). Using this modified gravitational acceleration field, we get an intensive temperature at the Schwarzschild radius. We think the intensive crisis should be taken seriously and that alternative theories about gravity should be examined more closely.

References

[1] S. Hawking. Black hole explosions. *Nature*, 248, 1974.

[2] S. Hawking. Black holes and thermodynamics. *Physical Review D*, 13(191), 1976.

[3] D. Hochberg and P.-M. Juan. Liquid model analogue for black hole thermodynamics. *Physical Review D*, 55(4880), 1997.

[4] P. M. Robitaille. Hawking radiation: A violation of the Zeroth law of thermodynamics. *http://vixra.org/pdf/1803.0264v1.pdf*, 2018.

[5] S. J. Crothers and P. M. Robitaille. The Unruh effect: insight from the laws of thermodynamics. *http://vixra.org/pdf/1811.0157v1.pdf*, 2018.

[6] P. Y. Landsberg. *Thermodynamics*. Interscience Publishers, New York, 1961.

[7] E. G. Haug. Gravity without Newton's gravitational constant and no knowledge of mass size. *preprints.org*, 2018.

[8] E. G. Haug. Maximum velocity for matter in relation to the Schwarzschild radius predicts zero time dilation for quasars. *preprints.org*, 2018.

[9] 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.

[10] Isaac Newton. *Philosophiae Naturalis Principia Mathematics*. London, 1686.

[11] E. G. Haug. Revisiting the derivation of Heisenberg's uncertainty principle: The collapse of uncertainty at the Planck scale. *preprints.org*, 2018.

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

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

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

[15] E. G. Haug. Planck mass measured totally independent of big G utilising McCulloch-heisenberg newtonian equivalent gravity. *preprints.org*, 2018.

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

[17] E. G. Haug. A short note from myself to myself to better understand Hawking.

[18] LaMessa et. al. The discovery of the first "changing look" quasar: New insights into the physics phenomenology of AGN. *The Astrophysical Journal*, 800(2), 2015.

[19] S. Zhenfeng. et. al . Mid-infrared variability of changing-look AGN's. *The Astrophysical Journal*, 846(1), 2017.

[20] S. Hall. Galactic beacons get snuffed out in a cosmic eyeblink. *Quanta Magazine*, 2018.

[21] S. J. Crothers. Proof the the black hole has no basis in general relativity or newtonian gravitation and therefore does not exist. *http://vixra.org/pdf/1212.0010v1.pdf*, 2012.

[22] E. G. Haug. Finding the Planck length independent of Newton's gravitational constant and the Planck constant: The Compton clock model of matter. *https://www.preprints.org/manuscript/201809.0396/v1*, 2018.

[23] M. R. S. Hawkins. On time dilation in quasar light curves. *Mon. Not. R. Astron. Soc.*, 405:1940–1946, 2010.

[24] M. R. S. Hawkings. Time dilation and quasar variability. *The Astrophysical Journal*, 553:97–100, 2001.