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PHYSICS

A Simple Calculation That Shows Black Hole Firewalls Exist and How Hot They Are.

HONTAS FARMER[1 2]
1. College of DuPage
2. Malcolm X College

This very short paper resolves the matter of black hole firewalls by computing the approximate temperature of a Planck mass black hole. Based on previously published work on black hole temperature I present a precise prediction of the temperature of the Hawking radiation in this situation. The quantum that collapses into the black hole experiences a temperature of 1.410 septillion Kelvin. This high temperature would last for about one Planck time. This certainly qualifies as a firewall.

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CORRESPONDENCE:
hfarmer@ccc.edu

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INTRODUCTION

Several papers have been published arguing for and against black hole firewalls. The idea is that as a pair of entangled particles fall into a black hole the entanglement is broken. This releases a great amount of energy as heat. (D. N. Page 1993) (D. N. Page 1993) (Almheiri, Marolf, et al. 2013) (Almheiri, Marolf, et al. 2013)

Using the relativized extended standard model (Farmer 2015) (Farmer 2015) and a calculation of black hole temperature (Farmer 2015) I will compute the temperature of a Planck scale black hole.

The reason to consider quantum black holes is that theoretically any quantum falling into a black hole will, as it crosses the horizon, gain enough energy that itself will collapse into a quantum black hole. The decay of this quantum black hole by way of Hawking type radiation will tell us about the existence of firewalls.

Suppose a high energy pure state collapses to form a Planck scale black hole. Rather than speculate on it I can calculate about it. In a previous paper I gave an approximate relationship for black hole luminosity and temperature as a function of mass. This relationship unlike that of Hawking is based on a framework that unifies quantum field theory with relativity by making QFT more relativistic, it is called relativization. (Farmer 2015)

CONCEPT.

A simple view of Hawking radiation would be as follows. A quantum interacts with another quantum and becomes entangled. As figure 1 illustrates, one of the quanta falls into a black hole and as it falls it gains energy, the wavelength shortens and just as it hits the event horizon, it collapses into a quantum black hole. About one Planck time after the formation of this quantum black hole it decays via Hawking radiation into a thermal spectrum of quanta of all kinds at a very high temperature.

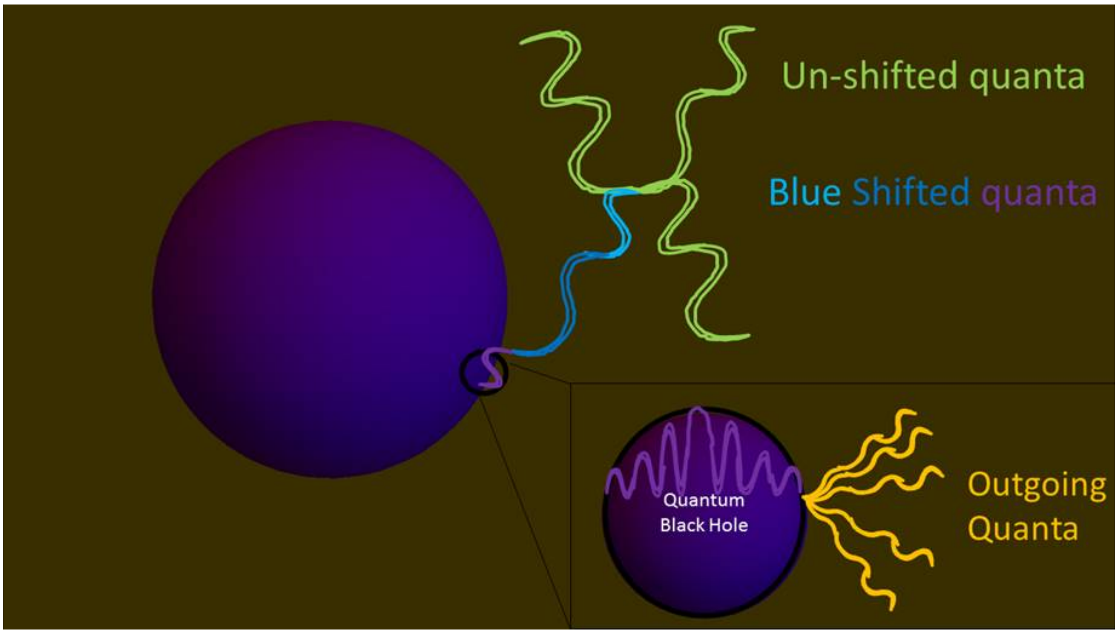

Figure 1: A simple view of Hawking radiation. A quantum, here represented as spin 2 bosons, interacts with another quantum and becomes entangled. One of the quanta falls into a black hole and as it falls it gains energy, the wavelength shortens and just as it hits the event horizon, it collapses into a quantum black hole. Inset, about one Planck time after the formation of this quantum black hole it decays via Hawking radiation into a thermal spectrum of quanta of all kinds at a very high temperature.

CALCULATIONS

The calculation that is needed will rely on previously published work which told me the luminosity and temperature of a black hole. The key equations are

$$L_{BH} \approx \frac{1}{16}\left|\frac{\hbar^2\left(a_{n+\frac{1}{2}}(-2L^2R_0)+b_{n+\frac{1}{2}}(-2L^2R_0)\right)}{L^4 M t_p}\right|$$

which gives the luminosity of a black hole of mass M, where L is the Schwarzschild radius of the black hole, R_0 is a constant space-time curvature assumed equal to the cosmological constant, and t_p is the Planck time. The other key equation relates luminosity to temperature.

$$T_{BH} = \frac{\sqrt[4]{L_{BH}}}{2\sqrt[4]{\pi}\sqrt{G}\sqrt{M}\sqrt[4]{\sigma}}$$

The only new constant is σ which is Stefan's constant. Calculations are done in the Mathematica notebook which accompanies this paper. The firewall temperature works out to

$$T_{BH} = 1.410 \times 10^{24}\ K$$

In words that is 1.410 *septillion* Kelvin. That is a firewall by any definition. Looking at a plot of black hole temperature Vs mass (figure2) this result makes sense the black hole temperature increases very quickly as the mass decreases. Notice for these larger masses the black hole temperature is much colder than the cosmic microwave background.

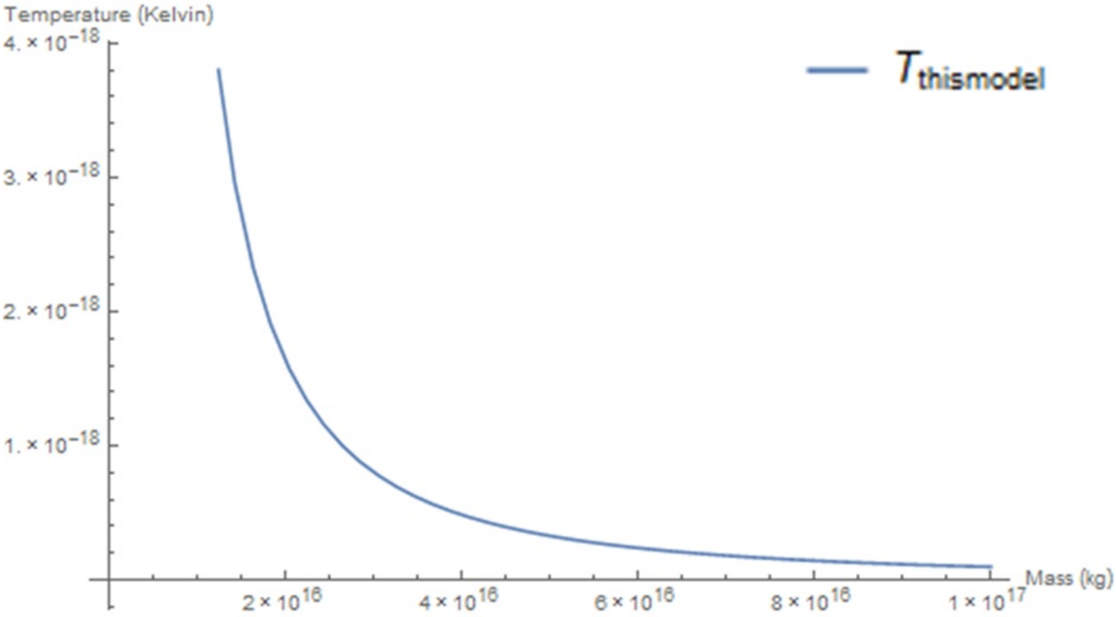

Figure 2: A plot of black hole temperature with respect to mass. Notice two things about this graph. First, as the mass decreases the temperature increases markedly. Second, for black holes well below a stellar mass their temperatures are well below that of the CMB. The firewall phenomena only exist because as individual quanta are pulled in they temporarily form a quantum black hole due to the aforementioned blue shift then radiate away most of their energy. On average, at the macroscopic level, any black hole you encounter will appear colder than ice until you contact it.

CONCLUSION

What causes the firewall is that as the in falling quantum enters the hole it gains enough energy to collapse into a quantum black hole and then radiates at an incredible temperature. The in falling pure state transforms into a mixed state. The entanglement between the outgoing pure state and any one quantum of this radiation would be minimal if any (Yang 2006) but not zero since the number of quanta emitted would be finite. So information can be preserved even with firewalls as hot as 1.410 septillion kelvin.

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