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

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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.

This *Mathematica* notebook is to be considered as official and final as any more formally published version.

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.

Using the relativized extended standard model (ref6) and a calculation of black hole temperature (ref 7) 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. (cite 8 the APS talk with link to slides.)

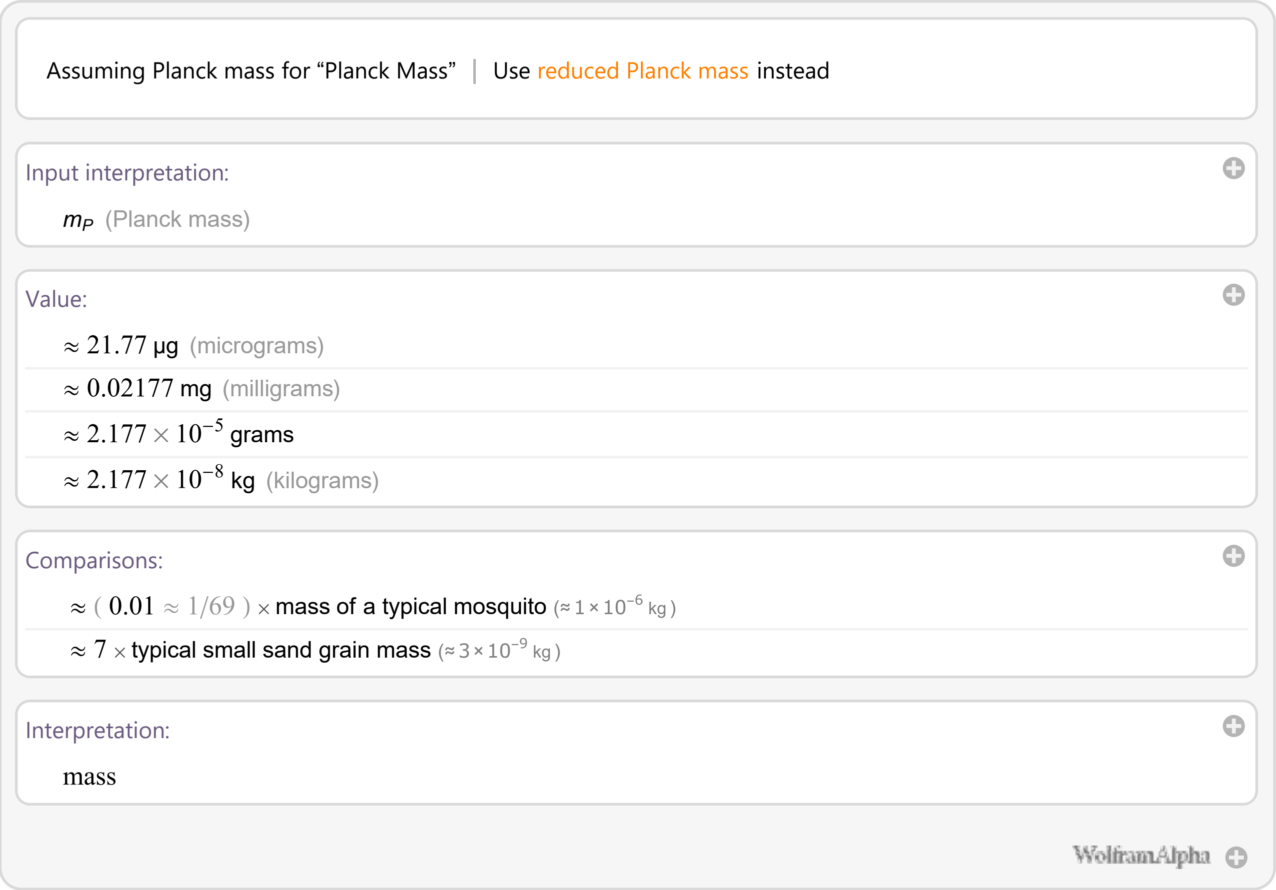
```
In[54]:= Clear["Global`*"]

In[55]:= n = 1

Out[55]= 1
```

I am interested in a Planck Mass black hole.

```
In[56]:= Planck Mass
```



Assuming Planck mass for “Planck Mass” | Use reduced Planck mass instead

Input interpretation:

m_P (Planck mass)

Value:

≈ 21.77 μg (micrograms)

≈ 0.02177 mg (milligrams)

≈ 2.177×10^{-5} grams

≈ 2.177×10^{-8} kg (kilograms)

Comparisons:

≈ (0.01 ≈ 1/69) × mass of a typical mosquito (≈ 1×10^{-6} kg)

≈ 7 × typical small sand grain mass (≈ 3×10^{-9} kg)

Interpretation:

mass

Calculations

```
In[71]:= M = 2.177*^-8
Out[71]= 2.177 × 10^-8
```

Then the reduced Planck constant.

```
In[72]:= ℏ = 6.626*^-34
Out[72]= 6.626 × 10^-34
```

The exact speed of light will also be useful.

```
In[73]:= c = 299 792 458
Out[73]= 299 792 458
```

The Cavendish constant.

```
In[74]:= G = 6.667*^-11
Out[74]= 6.667 × 10^-11
```

The Schwarzschild radius of a black hole.

In[75]:= $L = (2\, G\, M)\big/c^2$

Out[75]= 3.22981×10^{-35}

R_0=Λ=**$2.036\times10^{-35}\, s^{-2}$ = 2.265*^−52 m^{-2}** [1] .

In[76]:= $R_0 = 2.26536{*}\verb|^|{-52}$

Out[76]= 2.26536×10^{-52}

The Planck time is also required to convert this quantity into SI units.

In[77]:= $t_p = 5.391 * 10 \verb|^| -44$

Out[77]= 5.391×10^{-44}

The luminosity of the Hawking Radiation from the black hole at the center of the galaxy will be.....

In[78]:= $$L_{\mathrm{BH}} = \frac{1}{16}\left|\frac{\hbar^2\left(a_{n+\frac{1}{2}}\left(-8\, G^2\, M^2\, R_0\right) + b_{n+\frac{1}{2}}\left(-8\, G^2\, M^2\, R_0\right)\right)}{G^4\, M^5\, t_p}\right|$$

Out[78]= 2.37089×10^{55}

With stefan’Stefans constant...

In[79]:= $\sigma = 5.670 * 10 \verb|^| -8$

Out[79]= 5.67×10^{-8}

and a standard formula the temperatures are.

In[80]:= $$T_{\mathrm{BH}} = \frac{\sqrt[4]{L_{\mathrm{BH}}}}{2\,\sqrt[4]{\pi}\,\sqrt{G}\,\sqrt{M}\,\sqrt[4]{\sigma}}$$

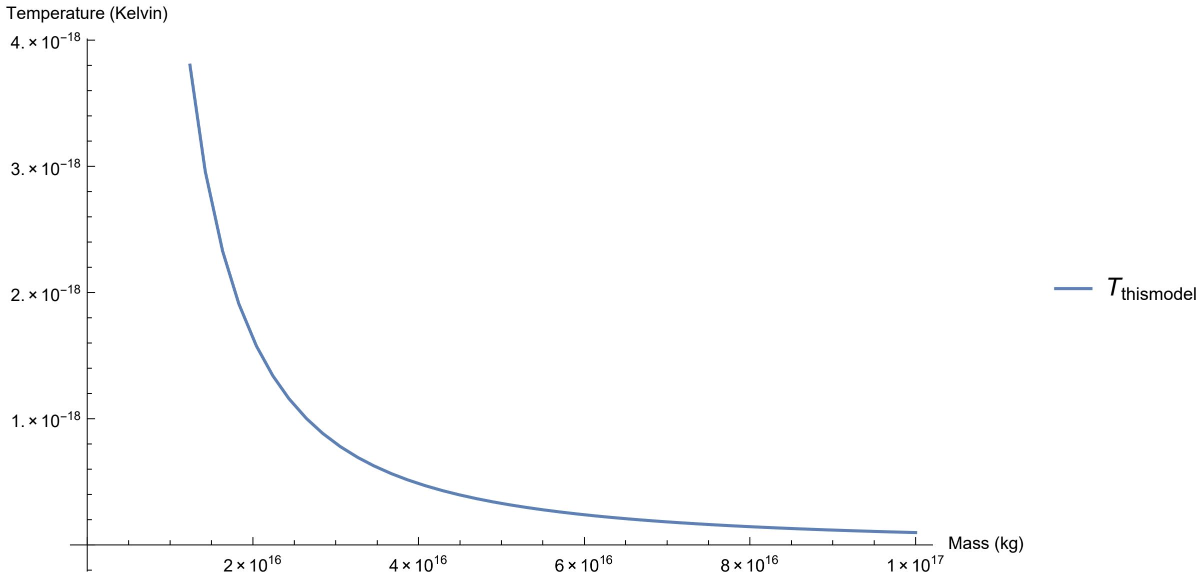
Out[80]= 1.40968×10^{24}

For a Planck mass black hole the temperature will be 1.410 septillion kelvin. For a hypothetical one kilogram black hole the temperature due to hawking radiation would be 55 billion Kelvin.   For a stellar mass black hole the Hawking radiation would be 1.4×10^{-44} Kelvin. For Sagittarius A* this corresponds to a temperature of $5.9\times10^{-54}\, K$. The mass temperature relationship is plotted below.

In[89]:=

$$\mathbf{Plot}\left[\left\{\frac{\sqrt[4]{\frac{1}{16}\left|\frac{\hbar^2\left(a_{n+\frac{1}{2}}\left(-8\,G^2\,\text{Mass}^2\,R_0\right)+b_{n+\frac{1}{2}}\left(-8\,G^2\,\text{Mass}^2\,R_0\right)\right)}{G^4\,\text{Mass}^5\,t_p}\right|}}{2\sqrt[4]{\pi}\,\sqrt{G}\,\sqrt{\text{Mass}}\,\sqrt[4]{\sigma}}\right\},\ \{\text{Mass},\ 0,\ 100\,000\,000\,000\,000\,000\},\ \text{AxesLabel}\to\{\text{"Mass (kg)"},\ \text{"Temperature (Kelvin)"}\},\ \text{PlotLegends}\to\{T_{\text{thismodel}}\}\right]$$

Out[89]=



What causes the firewall is that as the infalling quantum enters the hole it gains enough energy to collapse into a quantum black hole and then radiates at an incredible temperature. The infalling 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 (Cite 9) 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. It just isn’t simple to write out a formula for how to retrieve that information.

References

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