# Galactic Voids as Possible Evidence of Hawking Radiation

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## Hawking Temperature

Black holes are not cold. They radiate a tiny amount of heat through the process of Hawking Radiation which accounts for quantum effects at the event horizon of a black hole. This has never directly been observed.

$$T_H = \frac{\hbar c^3}{8\pi G M k_b}$$

## Conservation of Angular Momentum

Consider what happens to a ring of 8 planets when the central star is instantaneously removed. They all go out tangentially, forming a bubble. The mass decay function suggests a similar mechanism to decaying black holes.

$$l = \mu v_\perp r \Longrightarrow r(t) = \frac{l}{v_\perp}\left(\frac{1}{m} + \frac{1}{M(t)}\right)$$

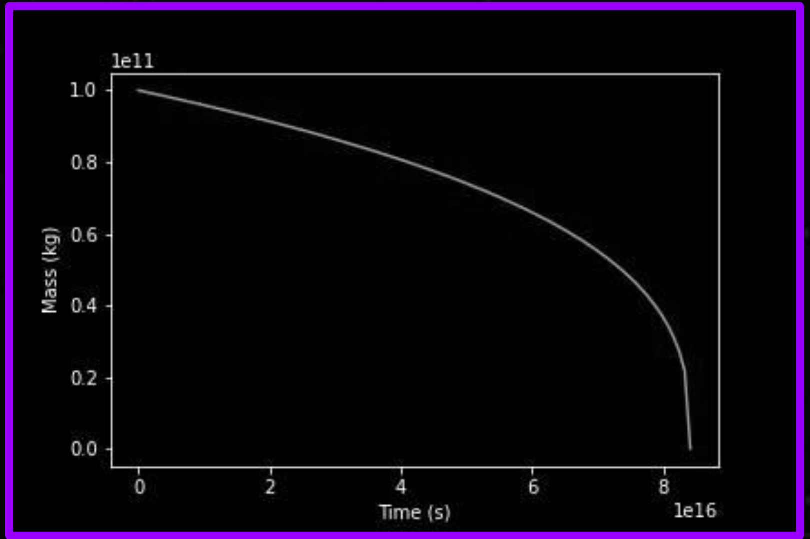
## Mass Decay Function

Over very long timescales, an isolated black hole will decay to zero mass with a massive explosion. A black hole of mass $1.7\times10^{11}$ kg would have evaporated within the lifespan of the observable universe. The Bekenstein-Hawking Luminosity gives the power output of this radiation, inversely proportional to $M^2$.

$$-\frac{dE}{dt} = \frac{\hbar c^6}{15360\pi G^2 M^2}$$

As the mass decreases, the black hole loses energy faster, further speeding the decay. This can be integrated to find an equation for the mass decay.

$$M(t) = M_0\left(1 - \frac{3\alpha}{c^2 M_0^3}t\right)^{1/3} \qquad \alpha = 3.56 \times 10^{32}\,\frac{kg^3 m^2}{s^3}$$




## Galactic Voids

We have observed vast regions of space without any matter. These regions are ellipsoids that can span thousands of galaxies. In literature, these regions are caused by quantum fluctuations from the big bang frozen into place, but I think the regions are too large to be due solely to quantum effects.

## Discussion

In my derivation, I took the tangential velocity to be constant while radius increases with the mass decay function, using the Taylor expansion to find

$$r(t) = r_0 + \frac{\alpha \mu_0 r_0}{c^2 M_0^4}t + \frac{2\alpha^2 \mu_0 r_0}{c^4 M_0^7}t^2 + \ldots$$

The velocity term suggests that a black hole of mass $10^9$ kg with minimum radius $10^4$ light years would have radial expansion that surpasses the speed of light.

This raises several questions about the dynamics of decaying black holes and galactic voids.

- Would the tangential velocity increase with a decrease in central mass?
- At what tangential velocity do galaxies on the surface of voids move?
- What would it mean to have a velocity component greater than the speed of light?

Potential for future experiment: An isolated black hole in the middle of a void would be the ideal spot to detect Hawking Radiation.