Many early universe theories predict the creation of Primordial Black Holes (PBHs). The PBHs could have masses ranging from the Planck mass to $10^{20}$ solar masses or higher depending on the formation scenario. Hawking showed that any Black Hole (BH) has a temperature which is inversely proportional to its mass. Hence a sufficiently small BH will thermodynamically radiate particles at an ever-increasing rate, continually decreasing its mass and raising its temperature. The final moments of this evaporation phase should be explosive. In this work, we investigate the final few seconds of the BH burst using the Standard Model of particle physics and calculate the energy dependent burst time profiles in the GeV/TeV range. We use the HAWC (High Altitude Water Cherenkov) observatory as a case study and calculate PBH burst light curves which would be observed by HAWC.

**Hawking Radiation Basics**

According to Quantum Mechanics, virtual particles are continuously created and destroyed in the vacuum. The strong gravitational field near the event horizon of a Black Hole (BH) can separate particle-antiparticle pairs and as a result, some particles can emerge from the vacuum as real particles by obtaining energy from the BH. Alternatively, the emitted particles can be regarded as quantum tunneling across the event horizon.

Black holes will radiate particles whose Compton wavelength is of the order of the Schwarzschild radius of the BH. If we take the Schwarzschild radius (2GM/c²) of a BH of mass M and temperature $T < 1/M$ as the Compton wavelength ($\lambda$), the energy of the particles emitted can be estimated as

$$E = kT \propto pc \propto \frac{hc}{\lambda} \propto \frac{hc^3}{2GM}$$

The luminosity can be estimated from the Stefan-Boltzmann relation (the area of the BH horizon times the radiation intensity) as

$$L = c^2 \frac{dM}{dt} = \left(4\pi \lambda^2 \right) \left( f T^4 \right) \propto \frac{1}{M^3}$$

where $f$ is proportional to the number of degrees of freedom of the particles emitted. The time taken for the BH to emit away its mass can be estimated as

$$t \approx \frac{M}{dM/dt} \propto M^3$$

The estimated BH temperature, luminosity and time to expire are summarized below:

$$T \approx 10^{33} \frac{8}{M} \text{ GeV}$$

$$L \approx 10^{39} \frac{10^{-3} M}{M} \text{ erg s}^{-1}$$

$$t \sim 10^{15} \frac{M}{M_{\odot}} \text{ yr}$$

**Observational Characteristics of the Final Stages of Evaporating Primordial Black Holes**

**Introduction**

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**Summary and Conclusions**

- We have developed approximate analytical formulae for the instantaneous PBH spectrum which includes both the directly Hawking radiated photons and the photons arising from the other directly Hawking radiated species.
- For the first time, we have calculated the PBH burst light curve and studied its energy dependence at a detector.
- For low energies $E_{\gamma} < 10$ TeV the light curve profile does not show much evolution with energy and is well described by a power law index of $\sim -0.66$. However, at high energy the light curve displays significant energy dependence that may be used as an unique signature of PBH bursts. The HAWC observatory is sensitive in this high energy range and potentially can be used to uniquely identify PBH bursts.