BLACK HOLE RADIATION: ENERGY OF A PARTICLE FROM A SOLAR MASS BLACK HOLE

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Reference: Moore, Thomas A., *A General Relativity Workbook*, University Science Books (2013) - Chapter 16; Problem P16.1.

The crude calculation presented earlier gives the energy at infinity of a particle created near the event horizon of a black hole as

$$E_{\infty}=\frac{\hbar}{4GM} \tag{1}$$

In GR units

$$\begin{aligned} \hbar &= 3.5153\times10^{-43}\text{ kg m} && (2)\\ E_{\infty} &= \frac{8.788\times10^{-44}}{GM}\text{ kg} && (3)\end{aligned}$$

For a solar mass black hole $GM=1477$ m, so

$$E_{\infty}=5.95\times10^{-47}\text{ kg} \tag{4}$$

In other units, this is (using $1\text{ eV}=1.602\times10^{-19}$ J)

$$\begin{aligned} E_{\infty} &= mc^{2} && (5)\\ &= 5.355\times10^{-30}\text{ J} && (6)\\ &= 3.34\times10^{-11}\text{ eV} && (7)\end{aligned}$$

This is an almost unimaginably small energy. For comparison, the energy of a single photon of visible light (with a wavelength of 500 nm) is around 2.5 eV:

$$E=h\nu=\frac{hc}{\lambda}=6.626\times10^{-34}\times\frac{3\times10^{8}}{5\times10^{-7}\times1.602\times10^{-19}}\text{ eV} \tag{8}$$