

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

$$(1) \quad E_{\infty} = \frac{\hbar}{4GM}$$

In GR units

$$(2) \quad \hbar = 3.5153 \times 10^{-43} \text{ kg m}$$

$$(3) \quad E_{\infty} = \frac{8.788 \times 10^{-44}}{GM} \text{ kg}$$

For a solar mass black hole $GM = 1477 \text{ m}$, so

$$(4) \quad E_{\infty} = 5.95 \times 10^{-47} \text{ kg}$$

In other units, this is (using $1 \text{ eV} = 1.602 \times 10^{-19} \text{ J}$)

$$(5) \quad E_{\infty} = mc^2$$

$$(6) \quad = 5.355 \times 10^{-30} \text{ J}$$

$$(7) \quad = 3.34 \times 10^{-11} \text{ eV}$$

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:

$$(8) \quad E = h\nu = \frac{hc}{\lambda} = 6.626 \times 10^{-34} \times \frac{3 \times 10^8}{5 \times 10^{-7} \times 1.602 \times 10^{-19}} \text{ eV}$$