radiation

November 23, 2016

1 Synchrotron

The synchrotron energy loss rate of a single electron in a large-scale random magnetic field of constant strength B is

$$|\dot{\gamma}|_{\rm S} = \frac{4\sigma_{\rm T}c}{3m_{\rm e}c^2}U_{\rm B}\gamma^2 \tag{1}$$

$U_{\rm B} = B^2/8\pi = 0.22\ b_3^2$ eV cm^{-3}, where $B = 3b_3\ \mu$G.

2 Inverse Compton Scattering

The inverse Compton energy loss rate of a single electron in one graybody photon field is

$$|\dot{\gamma}|_{\rm C} = \frac{4\sigma_{\rm T}cW}{3m_{\rm e}c^2}\frac{\gamma_{\rm K}^2\gamma^2}{\gamma_{\rm K}^2+\gamma^2} \tag{2}$$

The critical Klein–Nishina Lorentz factor

$$\gamma_{\rm K} = \frac{3\sqrt{5}}{8\pi}\frac{m_{\rm e}c^2}{k_{\rm B}T} = \frac{0.27m_{\rm e}c^2}{k_{\rm B}T} \tag{3}$$

if $\gamma \ll \gamma_{\rm K}$, return to the Thomson limit

$$|\dot{\gamma}|_{\rm C}(\gamma \ll \gamma_{\rm K}) \simeq \frac{4\sigma_{\rm T} c W}{3 m_{\rm e} c^2} \gamma^2 \tag{4}$$

if $\gamma \gg \gamma_{\rm K}$, obtain the energy-independent extreme Klein–Nishina limit

$$|\dot{\gamma}|_{\rm C}(\gamma \gg \gamma_{\rm K}) \simeq \frac{4\sigma_{\rm T} c W}{3 m_{\rm e} c^2} \gamma_{\rm K}^2 \tag{5}$$