Q3) $\Delta t \Rightarrow \frac{E}{dE_c/dt} = \frac{E}{P_{compton}} = \gamma m_e c^2 = 100\,GeV$

$P_{compton} = \frac{4}{3}\sigma_T c \gamma^2 \beta^2 U_{ph}$ $\qquad U_{ph} = \sigma_{SB} T^4$

$\Delta t = \frac{3\gamma m_e c^2}{4\sigma_T c \gamma^2 \beta^2 \sigma_{SB} T^4} = \frac{3\gamma m_e c}{4\sigma_T \sigma_{SB} T^4}$

$\beta \approx 1$

$E = \gamma m_e c^2, \quad \gamma = \frac{E}{m_e c^2} = \frac{100\times10^9\,eV}{0.5\times10^6\,eV} = 2\times10^5$

$g \cdot cm/s = ergs$

$$\Delta t = \frac{3(2\times10^5)(10^{-28}\,g)(3\times10^{10}\,cm/s)}{4(7\times10^{-25}\,cm^2)\left(6\times10^{-5}\,\frac{ergs}{s\cdot cm^2\cdot K^4}\right)(2.73\,K)^4}$$

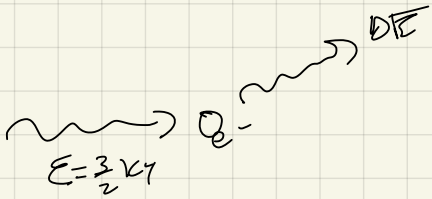
$$\approx \frac{3\cdot2\cdot3}{6\cdot4\cdot7\cdot55}\cdot 10^{-28+10+25+5-4}$$

$55 \rightarrow T^4$

$$\Delta t \sim 10^{-3} \cdot 10^{8} = 10^{5} \text{ seconds}$$

b)

$$E = \frac{hc}{\lambda} \qquad \Delta\lambda = \frac{hc}{\Delta E}$$



Photon gains at most $\langle \Delta E_{max} \rangle = \frac{4}{3} \langle \gamma \rangle^2 \epsilon$

$$\Delta E_{max} = \frac{4}{3} \langle \gamma^2 \rangle \frac{3}{2} kT = 2(2\times10^{5})^2 (1.4\times10^{-16} \text{ ergs/K})(2.73 \text{ K})$$

$$= 3.05\times10^{-5} \text{ ergs}$$

$$\Delta\lambda = \frac{(10^{-27} \text{ ergs})(3\times10^{10} \text{ cm/s})}{(3.05\times10^{-5} \text{ ergs})} = 9\times10^{-13} \text{ cm} \cdot \frac{1 \text{ m}}{100 \text{ cm}} = 9\times10^{-15} \text{ m}$$

$\Delta\lambda \sim 10^{-15}$ m = Gamma band