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08/03/21 ASSIGNMENT #1

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Que 1 → $\gamma = 10^5$, $E_{ph} = 10\,KeV$

$h\nu = 10 \times 10^3 \times 1.6 \times 10^{-19}$

$\nu = \frac{1.6 \times 10^{-15}}{6.63 \times 10^{-34}} = 2.41 \times 10^{18}$ Hz

We know that in synchrotron emission, charateristic frequency is given by:-

$$\nu_c = \frac{3\gamma^2 e B}{4\pi m_e c}$$

Substituting the values, we find that:

$$2.41 \times 10^{18} = \frac{3 \times 10^{10} \times \cancel{1.6 \times 10^{-19}} \times B \times 3 \times 10^8}{4 \times \pi \times 511 \times 10^3 \times \cancel{1.6 \times 10^{-19}}}$$

$B = 1.721 \times 10^6$ Tesla

~~Now, if the magnetic field present~~

Now, if the emmited synchrotron photon undergoes Inverse Compton Scattering with the same electron, then energy of the Inverse Compton photon is given by:

$$\langle E \rangle = \frac{4}{3} \gamma^2 E$$

$$= \frac{4}{3} \times (10^5)^2 \times 10 \times 10^3 \text{ eV} = \underline{1.3 \times 10^{14} \text{ eV}}$$

Que 2 → We Know

$$L_{Edd} = 3.2 \times 10^4 \left(\frac{M}{M_\odot}\right) L_\odot$$

Now, Diameter of Event horizon $= 3 \times 10^8 \times 90 \times 60$ m
$= 1.62 \times 10^{12}$ m $\quad (D = c\Delta t)$

Radius ⇒ $R = \frac{1.62 \times 10^{12}}{2} = 0.81 \times 10^{12}$ m

Now, Schwarzschild radius, $R_s = \frac{2GM}{c^2}$

Thus, $\frac{2GM}{c^2} = 0.81 \times 10^{12} \Rightarrow M = \frac{0.81 \times 10^{12} \times 9 \times 10^{16}}{2 \times 6.67 \times 10^{-11}}$

$M = 5.46 \times 10^{38}$ Kg
$= 2.73 \times 10^8 \, M_\odot$

$L_{Edd} = 3.2 \times 10^4 \times 2.73 \times 10^8 \, L_\odot$
$= 8.736 \times 10^{12} \, L_\odot$
$= 8.736 \times 10^{12} \times 3.83 \times 10^{33}$ ergs s^{-1}
$= 3.35 \times 10^{39}$ W

Que 3 → $H_0 = 73.8$ Km / sec / Mpc $= 2.39 \times 10^{-18}$ s^{-1}
Lab wavelength of H-α ~~line~~ line is $= 656.28$ nm
$= 6562.8$ Å

observed wavelength $= 9000$ Å

Redshift $z = \frac{9000 - 6562.8}{6562.8} = 0.371$

An estimate of the distance may be found by using the relation:

$$\frac{zc}{H_0} = d$$ (Valid for only small redshifts)

$\therefore\ d = \dfrac{0.371 \times 3\times10^{8}}{2.39\times10^{-18}} = 4.66\times10^{25}\ m = 1.5\ Gpc$

Que 4 → Given $\gamma = 4\times10^{7}$; $E_{ph} = 20\,keV = h\nu$

$\nu = \dfrac{20\times10^{3}\times1.6\times10^{-19}}{6.6\times10^{-34}} = 4.83\times10^{18}\ Hz$

Energy of electron :-

$E = \gamma m_e c^2 = 10^7 \times 4\times10^7 \times 511\times10^3 \times 1.6\times10^{-19}$
$= 32.7\ erg$

Power emitted is $P = 1.7\times10^{-8}$ erg/s

Cooling time $= \tau = \dfrac{E}{P} = \dfrac{32.7}{1.7\times10^{-8}} = 60.99$ years

Cooling time = 61 years.

Power $P = \frac{4}{3} c\,\sigma_T \left(\frac{m_e}{m}\right)^2 \gamma^2 \frac{B^2}{8\pi}$

$= \frac{4}{3}\times3\times10^{10}\times6.65\times10^{-25}\times\dfrac{16\times10^{14}\times10^{-8}}{8\pi}$ erg s^{-1}

$= 1.69\times10^{-8}$ erg s^{-1}