HW ASHMITA PANDA
1811042

PULKIT OJHA
1811118

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1. Proton flux = no. of photons recieved /m²/sec²

$$(2eV)\,\phi = \frac{L}{4\pi R^2} = \frac{(2\times 10^{10} L_\odot)}{2eV \times 4\pi (z d_H)^2}$$

luminosity

energy per photon

no. of photons

here $(R \sim zH)$

for $z \ll 1$.

$$\Rightarrow \phi = \frac{(\cancel{2}\times 10^{10}) \times (2.4\times 10^{45})\,eV/s}{\cancel{2}(\cancel{eV}) \times 4\pi z^2 \times (4300\,Mpc)^2}$$

$$\boxed{d_H = 4300\,Mpc}$$

$$\Rightarrow \phi = \frac{2.4\times 10^{55}}{4\pi \times z^2 \times (4300\times 3.086\times 10^{19})^2}$$

$$d_H^2 = (4300\times 3.086\times 10^{19})^2\,Km^2$$

$$d_H^2 = (1.765\times 10^{\cancel{54}\,46})\,Km^2$$

$$\cancel{= \frac{2.4\times 10^{55}}{4\pi \times 1.765\times 10^{\cancel{54}\,46}\,z^2} \times 1000000\ \frac{m^{-2}s^{-1}}{z^2}}$$

Km² to m²

$$\cancel{\phi = \frac{2.4\times 10^{55+6-46}}{4\pi\times 1.765}}$$

$$\phi = \left(\frac{2.4\times \cancel{10^{55}}}{4\pi\times 1.765}\right)\frac{\times 10^{55}}{\times 10^{46}\times \underbrace{10^{6}}_{\text{for } Km^2 \text{ to } m^2}}\ \frac{m^{-2}s^{-1}}{z^2} \simeq \frac{108\ m^{-2}s^{-1}}{z^2}$$

2.

flux of nearby galaxy vs. flux of nearby star

$$= \frac{L_{gal}}{4\pi (R_{gal})^2} \cdot \frac{4\pi \times (R_{star})^2}{L_{star}}$$

taking

$L_{star} \approx L_\odot$

$L_{gal} = 2\times 10^{10} L_\odot$

$R_{gal} \sim 1\,\text{Mpc}$

$R_{star} \sim 1\,\text{pc}$

$$= \frac{2\times 10^{10}\, L_\odot \,(1\,\text{pc})^2}{L_\odot\, (10^6\,\text{pc})^2} = 2\times 10^{-2}$$

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3. no. of CMB photons $= 411/\text{cm}^3 = 4.11\times 10^8/\text{m}^3$

no. of stellar photons

$$\frac{\text{luminosity (present)} \times \text{age of universe}}{\text{energy per photon}} = \frac{\left(10^8 \frac{L_\odot}{\text{Mpc}^3}\right) \times \left(\frac{1}{H_0}\right)}{2\text{eV}}$$

$$= \frac{10^8 \times 2.4\times 10^{45}}{2\times \underbrace{(3.09\times 10^{19})^2}_{\text{Km}}} \times \frac{1}{70\ \text{Km/s Mpc}}$$

$$= \frac{10^8 \times 2.4\times 10^{45}\ \text{eV/s}}{2\times (3.09\times 10^{19})^2 \times 70{,}000\ \text{m/s} \times \underbrace{10^6}_{\text{Km}^2 \text{ to } \text{m}^2}} \simeq 1904/\text{m}^3 \ll n_{\gamma\,\text{CMB}}$$