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Due 12/4

Observational Practice Problem - Solutions

It turns out that there ***are*** aliens on Comet 3i/ATLAS and they've been trying to contact us! The aliens have cell phones and are trying to call. Unfortunately, their technology is not the newest, and are sending a signal at a frequency of 850MHz. Suppose the aliens are trying to signal us while at their perihelion distance of 1.35AU, Earth at opposition.

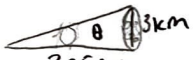
a. What is the radio beam size if observed by 10m telescope? (D)

$$\Omega_b = \pi\left(\frac{\theta}{2}\right)^2 = \frac{\pi}{4}\frac{\lambda^2}{D^2} = \frac{\pi}{4}\frac{c^2}{\nu^2 D^2} = \frac{\pi\,(3\cdot10^8\ m/s)^2}{4\,(850\cdot10^6\ 1/s)^2\,(10\ m)^2} = \boxed{9.78\cdot10^{-4}\ \text{ster}}$$

Luckily, the aliens can use the entire comet (estimated 3km in diameter) as the cell phone!

b. What is the source solid angle? (↳ supposes we can ignore the sun)

$d = 2.35\,AU = 3.52\cdot10^8\,km$




$$\theta = \tan^{-1}\left(\frac{3\,km}{3.52\cdot10^8\,km}\right) = 4.2\cdot10^{-8}\,rad \qquad \Omega_s = \pi\left(\frac{\theta}{2}\right)^2 = \boxed{1.38\cdot10^{-15}\ \text{ster}}$$

c. What is the intensity of the source if we measure an antenna temperature of 85K?

$$T_A = \frac{\Omega_s}{\Omega_b}T_B \qquad T_B = \frac{\Omega_b}{\Omega_s}T_A$$

$$T_B = \left(\frac{c^2}{2k\nu^2}\right)I_\nu \rightarrow I_\nu = \frac{2kT_B\nu^2}{c^2} = \frac{2kT_A\Omega_b\nu^2}{c^2\Omega_s} = \frac{2(1.38\cdot10^{-23})(85k)(9.78\cdot10^{-4})(850}{(3.10^8)^2(1.38\cdot10^{-15})}$$

$$I_\nu = 1.33\cdot10^{-8}\ J/m^2 s\,Hz\,str$$

d. Does this seem reasonable for the aliens to have created that signal?

It's a low signal, so possibly created by the aliens. However, its so small that detecting would be tricky