DARA Unit 1 Nairobi November 2017
Examples covering material in lecture 2

1. What are the dominant emission mechanisms from the following sources of radio radiation - Venus? - A human being? - A quasar? - Interstellar dust - A gaseous nebula ionized by a hot star

2. Estimate at what frequency the Rayleigh-Jeans approximation will begin to break down seriously if the temperature of the emitting source is 100K.

3. Over the past 50 years the total collecting area of the world's radio observatories has been equivalent to 40 radio telescopes of diameter 25m. If the typical power received by *each* of these telescopes was 10^{-16} W over this period what has been the total energy received? How long would this illuminate a standard torch bulb (3V; 0.5A)?

4. Calculate the flux density in Jy of a mobile phone at a distance of 1km if it is radiating 0.20W isotropically over a bandwidth of 200 kHz. Comment on your answer.
[Hint: first work out the spectral power radiated per Hz]

Answers

Q.1 Venus: thermal radiation - quasi black body

Human Being: thermal radiation - quasi black body

Quasar (AGN): synchrotron radiation from the jet (also quasi-thermal radiation from the accretion disk)

Interstellar Dust: thermal radiation - quasi black body

A gaseous nebula ionized by a hot star: free-free (Bremsstrahlung) radiation (thermal radiation)

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1) R-J OK when $kT \ll h\nu$
poor " $kT \sim h\nu$

$\therefore$ for T = 100K
OK for $\nu \ll \underbrace{\frac{1.38\times10^{-23} \times 100}{6.62\times10^{-34}}}_{2.08\times10^{12}\ Hz}$

= <u>2080 GHz</u> or ~ 2 THz

in notes the rule-of-thumb
$\nu(GHz) \ll 20.T$ ↕ same approximation

$\therefore$ for T = 100K $\nu(GHz) \ll 2000$

Lesson: R-J regime usually assumed to extend into 100's GHz → THz for "normal" temperatures of 100's K and above. BUT take care for CMB when T ~ 3K!

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2) 10^{-16} W × 40 (telescopes) = $4\times10^{-15} \times (3\times10^7)$ (≈ secs in 1 year) × 50 (years)

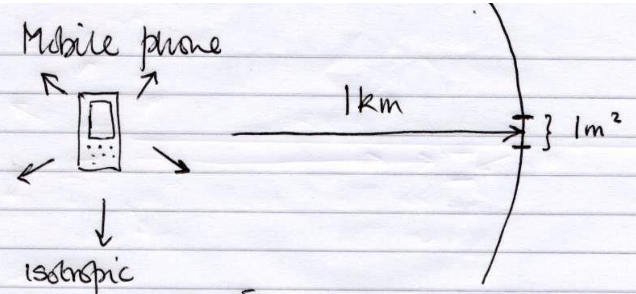
$= 6\times10^{-6}$ J

Torch bulb 3v, 0.5A = 1.5 W

$\Rightarrow$ ∑ telescopes ≡ torch bulb for 4 μ sec!

(Example in notes had bigger telescope (although only 1) & looking at strongest source in sky)

3) Mobile phone



0.2 W; $\Delta\nu = 2\times10^5$ Hz

Spectral power $= \frac{0.2}{2\times10^5} = 10^{-6}\ W\ Hz^{-1}$

$\therefore$ at 1km power intercepted per m² $= \frac{10^{-6}}{4\pi(10^3)^2} = 7.9\times10^{-14}\ W\ m^{-2}\ Hz^{-1}$

$= 7.9\times10^{12}$ Jy !!

Lesson: mobile phones can easily swamp radio sources (in the band in which they operate)

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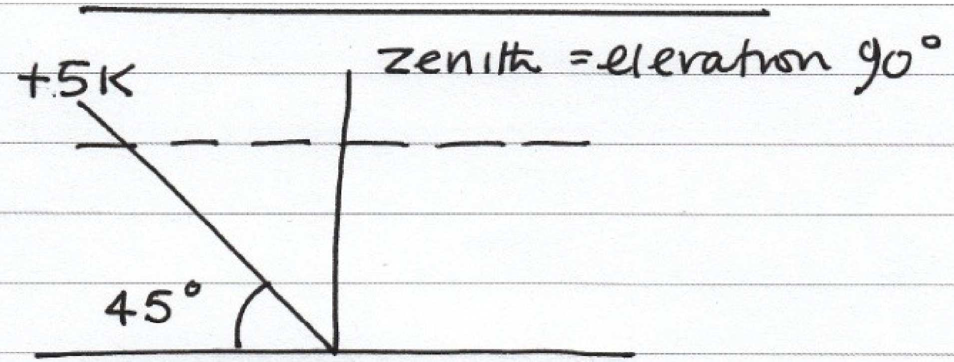
5.



At zenith : $T_{REC} + T_{ATMOS,90°}$

At 45° : $T_{REC} + (T_{ATMOS,90°} / \sin 45°)$

$= T_{REC} + 1.41\, T_{ATMOS,90°}$

$\Rightarrow 5K = 0.41\, T_{ATMOS,90°}$ (difference from zenith)

$\Rightarrow T_{ATMOS,90°} = 12.2K$ (at zenith)

Assuming $T_{atmos} = 270K$

$270(1 - e^{-\tau}) = 12.2 \rightarrow e^{-\tau} = 0.9548$

$\rightarrow \underline{\tau_{zenith} = 0.0463}$ (zenith)