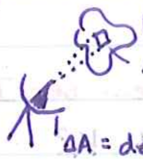
Radio 101:

Eugene's radiation notes:



blob

$\Delta\Omega$: observed solid angle

ΔA = detector area (dish size)

Δt = exposure time

} over time Δt, you collect ΔE over wavelength range $\Delta\lambda$ or $\Delta\nu$

$$\frac{\Delta E}{\Delta t\, \Delta\nu\, \Delta A\, \Delta\Omega} \rightsquigarrow I_\nu = \frac{dE}{dt\, d\nu\, dA\, d\Omega} = \text{SPECIFIC INTENSITY}$$

$[I_\nu] = [\text{ergs s}^{-1}\text{ cm}^{-2}\text{ Hz}^{-1}\text{ sr}^{-1}]$

specific intensity is per everything

if we want to know what the whole blob is doing

integrate over Ω! F_ν = flux density $\approx \int I_\nu\, d\Omega$

a Jansky is a unit of flux density $\text{Jy} = 10^{-23}\text{ ergs s}^{-1}\text{ cm}^{-2}\text{ Hz}^{-1}$

(for POINT SOURCES, all you measure is F_ν!)

Surface brightness = total power over ν-range emitted along some direction

$\Sigma_\nu = \int I_\nu\, d\nu$

$[\Sigma_\nu] = \text{ergs s}^{-1}\text{ cm}^{-2}\text{ sr}^{-1}$

TOTAL FLUX = integrate both in ν and in Ω = total power from source

$F = \int I_\nu\, d\nu\, d\Omega$

$[F] = \text{ergs s}^{-1}\text{ cm}^{-2}$

$L = \int F dA \rightarrow$ luminosity can be derived from the flux

$[L] = \text{ergs s}^{-1}$

Specific intensity is conserved along a ray! (as long as the source is resolved...)

if we move away to 2x the distance, the source's power decreases by a factor of 4, but the area of the source we are measuring increases by 4, canceling out.

↳ this means I_ν (at telescope focal plane) = I_ν (source)

The blackbody temperature: $I(\nu) = \frac{2h\nu^3}{c} \frac{1}{e^{h\nu/kT} - 1}$ } but we are at the RJ limit $\frac{h\nu}{kT} \ll 1$

$$\boxed{I(\nu) = \frac{2kT}{\lambda^2}}$$

"radio astronomers – being as lazy as anyone else... see $I(\nu) \propto T$"

why not switch ergs s^{-1} cm^{-2} sr^{-1} Hz^{-1} to one unit: K?

$$\boxed{T_B = \frac{I(\nu)\lambda^2}{2k}}$$ (this is not necessarily the PHYSICAL temperature, but makes the units very understandable)

The power received is thus: $P(\nu) = \frac{2kT_B(\nu)}{\lambda^2}\, dA\, d\Omega$; $dA\,d\Omega = \lambda^2$!

$\therefore P(\nu) = 2kT_B(\nu)$

$= 2k\,T_{Antenna}(\nu)$ – same lazy trick as before

$\therefore$ for a resolved source $T_B = T_A$

In that case:

$$\boxed{T_A = T_B}\ \frac{\Omega_s}{\sqrt{\Omega_B^2 + \Omega_s^2}}$$

assuming the brightness is approximately uniform:

$$S(\nu) = \int I(\nu)\, d\Omega = I(\nu)\,\Omega_s = \frac{2kT_B\Omega_s}{\lambda^2} \quad \text{or} \quad \Omega_s T_B = S(\nu)\frac{\lambda^2}{2k}$$

(IF $\Omega_s << \Omega_b$...)

$$kT_A = \left(\frac{\lambda^2}{\Omega_b}\right)\frac{S(\nu)}{2} \qquad \text{since } \Omega_B = \frac{\lambda^2}{A_{dish}}$$

$$kT_A = \frac{S(\nu)\,A}{\underbrace{2}_{\text{polarization.}}}$$ the T_{ant} is just equal to total power per Hz collected by the telescope

Antennas are not only sensitive to a single direction. They are diffraction limited, thus the collecting area has to take into account a preferred direction.

$$\boxed{A_{eff} = \varepsilon_A A_{tot}}$$