Flux and Luminosity

ASTR 250

In astrophysics, the concept of flux is very important for characterizing the flow of energy.

Flux $\quad F =$ rate of energy, $\frac{dE}{dt}$, passing through a differential area dA

$$\frac{dE}{dt\,dA}$$

units $\quad erg \cdot s^{-1} \cdot cm^{-2}$ (cgs)

$\quad\quad\quad$ $Watts \cdot m^{-2}$ (MKS)

Note: $10^7\ erg \cdot s^{-1} = 1\,W$

The luminosity is the flux integrated over the total surface area of the object:

$$L = \int_{\text{surface}} F\, dA$$

$\frac{dE}{dt}$ $\quad$ units: $erg \cdot s^{-1}$

If the flux on the surface is constant and the object is a sphere:

$$L = 4\pi R^2 \cdot F$$

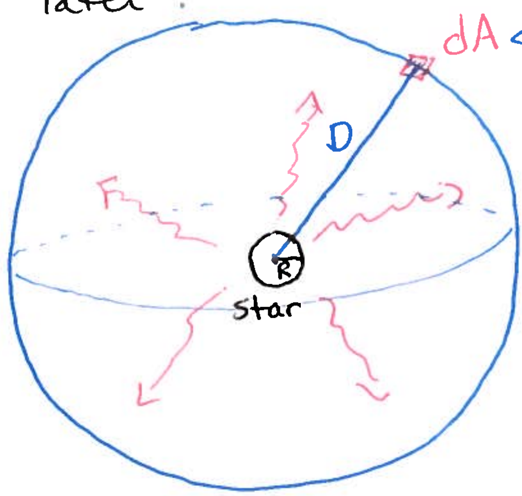
$4\pi R^2$: Surface area of sphere

F: Flux at surface of object

Flux obeys the inverse square law with Distance :

Consider a star with luminosity $L_* = 4\pi R_*^2 F_* = \frac{dE_*}{dt}$

Assuming energy is conserved, then the same rate of energy $\frac{dE_*}{dt}$ flows through a larger sphere at a distance D away from the star at some time later :



$$L_* = 4\pi R_*^2 F_* = \frac{dE_*}{dt} = 4\pi D^2 F_{obs}$$

Solve for F_{obs} :

$$F_{obs} = F_* \left(\frac{R_*}{D}\right)^2 \sim \frac{1}{D^2}$$

Monochromatic Flux (Sometimes called "Flux Density")

Sometimes we are only interested in the Flux at a particular frequency or wavelength. We use a subscript to denote the flux per Hz or per cm:

Monochromatic Flux	F_ν	F_λ
	$\dfrac{dE}{dt\,dA\,d\nu}$	$\dfrac{dE}{dt\,dA\,d\lambda}$
	$erg \cdot s^{-1} \cdot cm^{-2} \cdot Hz^{-1}$	$erg \cdot s^{-1} \cdot cm^{-2} \cdot cm^{-1}$

The total flux is related to the monochromatic flux by:

$$F = \int_0^\infty F_\nu \, d\nu = \int_0^\infty F_\lambda \, d\lambda$$

$erg \cdot s^{-1} \cdot cm^{-2}$

No subscript!

Important Note: $F_\nu \neq F_\lambda$ when $\nu = \lambda$!

This is because $d\nu \neq d\lambda$

$$\lambda \cdot \nu = c$$

$$\Rightarrow |d\nu| = \frac{c}{\lambda^2} |d\lambda|$$