Photometric Concepts

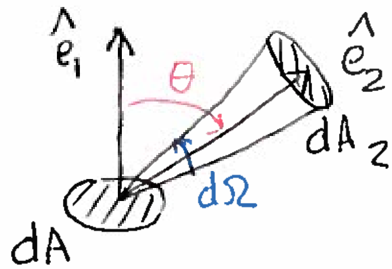
ASTR 300B

Monochromatic Specific Intensity: (I_ν or I_λ) Rate of energy $\frac{dE_\nu}{dt}$ flowing through an area dA to another area dA_2 per solid angle $d\Omega$

$I_\nu \rightarrow$ in a frequency interval $[\nu, \nu + d\nu]$

$I_\lambda \rightarrow$ or in a wavelength interval $[\lambda, \lambda + d\lambda]$

$$I_\nu = \frac{dE}{dt \, \cos\theta \, dA \, d\Omega \, d\nu} \quad \text{erg s}^{-1}\,\text{cm}^{-2}\,\text{ster}^{-1} \cdot \text{Hz}^{-1}$$

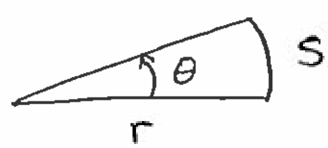


where $|\hat{e}_1| = |\hat{e}_2| = 1$

$\hat{e}_1 \cdot \hat{e}_2 = \cos\theta$

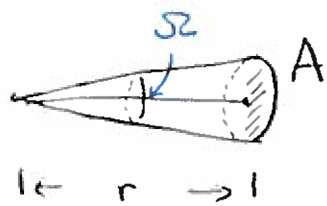
Solid Angle: Ω

1 Dimension



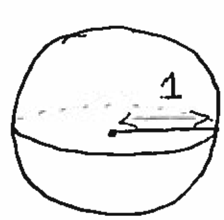
$\theta = \frac{s}{r}$ radians (rad)

2 Dimensions



$\Omega = \frac{A}{r^2}$ steradians (ster)

For a unit sphere



$$\Omega = \frac{4\pi r^2}{r^2} = 4\pi \text{ ster}$$

How are I_ν and I_λ related?

Define $I_\nu \, d\nu = - I_\lambda \, d\lambda$

since $\lambda \cdot \nu = c$

$$\nu = \frac{c}{\lambda}$$

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

$$\Rightarrow \boxed{I_\lambda = \frac{c}{\lambda^2} I_\nu}$$

Monochromatic specific intensity refers to specific intensity at a single λ or ν (I_λ or I_ν)

Total specific intensity integrates over $d\nu$ or $d\lambda$:

$$I = \int_0^\infty I_\nu \, d\nu \qquad \text{erg s}^{-1} \text{cm}^{-2} \text{ster}^{-1}$$

↑ No subscript means $\int_0^\infty d\nu$

Flux Density = Rate of energy flowing through dA from all solid angles (per Hz or per cm)

"Density" refers to Hz^{-1} or cm^{-1}

$$F_\nu = \int_\Omega I_\nu \cdot \cos\theta \, d\Omega \qquad erg \cdot s^{-1} \cdot cm^{-2} \cdot Hz^{-1}$$

UNIT DEFINITION: 1 Jansky = 1 Jy = 10^{-23} $erg \cdot s^{-1} \, cm^{-2} \, Hz^{-1}$

Flux = Flux Density integrated over ν or λ

$$F = \int F_\nu \, d\nu = \int I \cdot \cos\theta \, d\Omega \qquad erg \cdot s^{-1} \, cm^{-2}$$

UNITS OF FLUX

Power = Flux integrated over a collecting area

$$P = \int F \, dA \qquad erg \cdot s^{-1}$$

UNITS: 1 Watt = 10^{7} $erg \cdot s^{-1}$

Quantity	Definition	UNITS	Differential Relation
Monochromatic Specific Intensity	I_ν	$erg \cdot s^{-1} \cdot cm^{-2} \cdot ster^{-1} \cdot Hz^{-1}$	$\frac{dE}{dt \, dA \cos\theta \, d\Omega \, d\nu}$
Total Specific Intensity	$I = \int I_\nu d\nu$	$erg \cdot s^{-1} \, cm^{-2} \cdot ster^{-1}$	$\frac{dE}{dt \, dA \cos\theta \, d\Omega}$
Flux Density	$F_\nu = \int_\Omega I_\nu \cos\theta \, d\Omega$	$erg \cdot s^{-1} \, cm^{-2} \cdot Hz^{-1}$	$\frac{dE}{dt \, dA \, d\nu}$
Flux	$F = \int F_\nu d\nu = \int_\Omega I \cos\theta \, d\Omega$	$erg \cdot s^{-1} \, cm^{-2}$	$\frac{dE}{dt \, dA}$
Luminosity	$L = \int_{\text{enclosing surface area}} F^{+} dA$	$erg \cdot s^{-1}$	$\frac{dE}{dt}$