Common Units in Astronomical Images

Name(s)	Symbol(s)	Units	Formula
Intensity, Brightness	I_ν	$W/m^2/Hz/sr$	$I_\nu = dP/(d\nu\ dA\ d\Omega)$
Surface Brightness	S_ν	$W/m^2/Hz/sr$	
(Integrated) Intensity, Brightness	I, B	$W/m^2/sr$	$I=\int_0^\infty I_\nu d\nu \approx \sum I_\nu\ \Delta\nu$
Flux Density	F_ν	$W/m^2/Hz$	
Flux	F	W/m^2	$F=\int_0^\infty F_\nu\ d\nu$
Luminosity	L	W	$L = 4\pi D^2 F$
(Apparent) Magnitude	m	mag	$m_{\odot,\lambda} - m = -2.5\ \log_{10}(F/F_{\odot,\lambda})$

Conversions

To → From	I_ν, S_ν [$W/m^2/Hz/sr$]	I [$W/m^2/sr$]	F_ν [$W/m^2/Hz$]	F [W/m^2]	L [W]
I_ν, S_ν [$W/m^2/Hz/sr$]	···	$\Delta\nu$	Ω_{sr}	$\Delta\nu \cdot \Omega_{sr}$	$A_{sphere} \cdot \Delta\nu \cdot \Omega_{sr}$
I [$W/m^2/sr$]	$1/\Delta\nu$	···	$\Omega_{sr}/\Delta\nu$	Ω_{sr}	$A_{sphere} \cdot \Omega_{sr}$
F_ν [$W/m^2/Hz$]	$1/\Omega_{sr}$	$\Delta\nu/\Omega_{sr}$	···	$\Delta\nu$	$A_{sphere} \cdot \Delta\nu$
F [W/m^2]	$1/(\Delta\nu \cdot \Omega_{sr})$	$1/\Omega_{sr}$	$1/\Delta\nu$	···	A_{sphere}
L [W]	$1/(\Delta\nu \cdot \Omega_{sr} \cdot A_{sphere})$	$1/(A_{sphere} \cdot \Omega_{sr})$	$1/(A_{sphere} \cdot \Delta\nu)$	$1/A_{sphere}$	···

Mag: $F = F_{\odot,\lambda} \cdot 100^{(m_{\odot,\lambda}-m)/5}$ to get Flux, then use above conversions

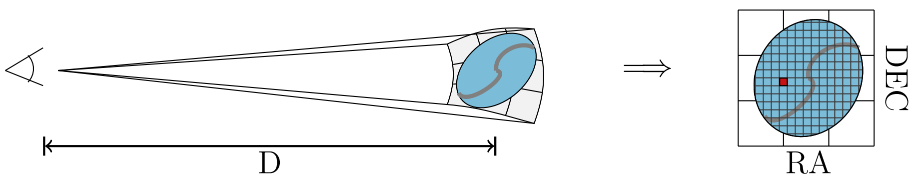
(Can use Luminosity $L = L_{\odot,\lambda} \cdot (D/D_\odot)^2 \cdot 100^{(m_{\odot,\lambda}-m)/5}$ as well. $L_{\odot,\lambda}$ from, e.g., Binney & Merrifield)

Mag / square arcsec: I = F / square arcsec = $F_{\odot,\lambda}/\text{arcsec}^2 \cdot 100^{(m_{\odot,\lambda}-m)/5}$ to get brightness, then use above conversions

Jy/beam * m/s: multiply by $\partial\nu/\partial v = \nu_0/c$ to get intensity (then use above conversions):

$$I\left[\frac{W}{m^2 bm}\right] = I\left[\frac{Jy}{bm}\cdot m/s\right] \times 10^{-26} \cdot \frac{\partial\nu}{\partial v} = I\left[\frac{Jy}{bm}\cdot m/s\right] \times 10^{-26} \cdot \frac{\nu_0}{c}$$

Additional partial derivative factors: $\partial\lambda/\partial v = \lambda_0/c$, $\partial\lambda/\partial\nu = c/\nu^2$, $\partial\nu/\partial\lambda = c/\lambda^2$



$A_{sphere} = 4\pi\ D^2$

Ω_{sr} = pixel size in sr (not source area)

$\Delta\nu$ = bandwidth of detector

Beam area $\simeq 1.133\ FWHM_{maj}\ FWHM_{min}$