Exercises Astronomical Observing Techniques, Set 1

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Exercise 1

A very faint unresolved galaxy of magnitude $m_V = 29$ is observed by a detector system. The entrance aperture of the system has a diameter of 3.6 m and the system has an efficiency of 70%. A V-band filter is used centered at 0.55 μm and having an effective bandwidth $\Delta\lambda = 0.089$ μm.

a Calculate the spectral irradiance (flux density) of this galaxy. Use that the spectral irradiance (flux density) of a source with $m_V = 0$ is 3.92 x 10^{-8} W m^{-2} μm^{-1}.

b What is the spectral irradiance (flux density) in Jy (Jansky) of this source?

c Compute the number of photons hitting the detector.

Exercise 2

A 1000 K spherical blackbody source with a radius of 1 m is viewed from a distance of 1000 m by a detector system. The entrance aperture of the system has a radius of 5 cm, the optical system has a half-angle field of view of 0.1°, the detector operates at a wavelength of 1 μm and has a spectral bandpass of 1%, the optical system is 50% efficient.

a Compute the spectral radiances (specific intensities) in both frequency and wavelength units.

b Calculate the corresponding spectral irradiances (flux densities) at the detector entrance aperture, and the power received by the detector.

c Compute the number of photons hitting the detector each second.

d Describe how these answers will change if the blackbody source were 10 m in radius rather than 1 m.

Exercise 3

The flux of a star is reduced by absorption from the atmosphere: $I = I_0 e^{-\tau}$, with $\tau = A \int \rho(z)\kappa(z)dz$, with A the Airmass, κ the absorption coefficient and z the altitude. The Airmass is given by $1/cos(\theta)$, with θ the zenith angle. The optical depth (τ) is in practice difficult to calculate as $\rho(z)$ and $\kappa(z)$ are not precisely known. Show that if we do two measurements of the received flux (I_1, I_2) at different Airmasses $(A_1; A_2)$ we can find I_0 (assuming the properties of the atmosphere do not change with time).

Exercise 4

a Calculate the spectral radiance (at the zenith) of the sky background in the L band (3.4μm), the optical depth $\tau = 0.15$ (you can assume $\tau \ll 1$, use wavelength units). The average temperature of the atmosphere is $T = 250$ K.

b Calculate the sky brightness in mag arcsec^{-2}, use that for mag$_L$ = 0, the spectral irradiance is 8.1*10^{-11} W m$^{-2}\mu$m^{-1}.