Exercises Astronomical Observing Techniques, Set 2

Exercise 1

a) Give the units of the spectral radiances (specific intensities) L_ν and L_λ.

b) Give the units and an expression for the radiance (intensity) L, using L_ν or L_λ.

c) How are the radiant exitance (M), flux (Φ) and spectral irradiance (flux density) ($E_{\nu,\lambda}$) of a source defined ?

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

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 $\text{mag}_V = 0$ is 3.92×10^{-8} W m^{-2} μm^{-1}

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

c) Compute the number of photons hitting the detector.

Exercise 4

Derive the expressions for the Rayleigh-Jeans and Wien law from the Planck law (use frequency units).

Exercise 5

Using the definitions of the Stokes parameters I, Q, U, and V to show that $I^2 = Q^2 + U^2 + V^2$.