Exercises Astronomical Observing Techniques, Set 3

Exercise 1

a) A galaxy has a spectral irradiance (flux density) of 10 mJy at a wavelength of 0.55 μm. Calculate the spectral irradiance in units of W m^{-3} and W m^{-2} Hz^{-1}.

Exercise 2

The direction of light as it passes through the atmosphere is changed because of refraction since the index of refraction changes through the atmosphere. The amount of change is characterized by Snell's law: $n_1 sin(z_1) = n_2 sin(z_2)$. Let z_0 be the true zenith distance, z be the observed zenith distance, z_i be the observed zenith distance at layer i in the atmosphere, $n(\lambda)$ be the index of refraction at the surface, and $n_i(\lambda)$ be the index of refraction at layer i ($i = 1, ...N$).

a) Show that the refraction depends only the index of refraction near the earth's surface.

b) In which direction does an object move by refraction (away or towards the zenith)?

c) We define astronomical refraction, R, to be the angular amount that the object is displaced by the refraction of the Earth's atmosphere. Derive that the refraction as function zenith angle $R(z)$ is (approximately) given by $R = (n_\lambda - 1)tan(z)$. (Hint: you can use that $sin(u \pm v) = sin(u)cos(v) \pm cos(u)sin(v)$, and that $r << 1$)

d) How large is this effect for an object observed at a zenith angle of 45 $^\circ$ (take a typical index of refraction of 1.00029).

Exercise 3

A spherical galaxy has a magnitude of $m_V = 18$ and spans 30 arcsec on the sky. Calculate the surface brightness of this galaxy in mag arcsec^{-2} (you can assume the light is homogeneously distributed over the galaxy).

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 $\tau << 1$, use wavelength units). The average temperature of the atmosphere is $\bar{T} = 250$ 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} μm^{-1}.