Exercises Astronomical Observing Techniques, Set 7

Exercise 1

The sky background in the V band is approximately 21 magnitude per sq. arcsec. How long would you have to integrate with a 3.6m telescope and detector (assume a perfect system without any losses or noise contributions) to detect a faint V mag 25.0 galaxy with a signal to noise ratio (SNR) > 3? Use that the spectral irradiance (flux density) of a source with $\mathrm{mag}_V = 0$ is 3.92×10^{-8} W m^{-2} μm^{-1} and take a seeing of 1 arcsec. The V-band filter used, is centered at 0.55 μm and has an effective bandwidth of $\Delta\lambda = 0.089$ μm.

Exercise 2

a) Explain the difference between Strehl ratio and Encircled Energy.

b) Calculate the Strehl ratio of telescope having a rms wavefront error of $\lambda/14$.

Exercise 3

When a circular pupil is illuminated by a point source, $I_0(\theta) = \delta(\theta)$, then the resulting PSF can be described by a 1st order Bessel function, also called the Airy function. The Airy pattern is characterized by a series of dark and bright rings about a central peak. Would it be possible to create a PSF for an optical system which does not have these bright and dark rings? (for example a nice almost Gaussian shaped PSF). If yes, how can this in practice be done? Would there be disadvantages compared to a standard optical system?

Exercise 4

Determine the pixel size (in arcsec) needed for the 2.4m Hubble Space Telescope to make images at a wavelength of of 0.5 μm without loosing spatial information.

Exercise 5

Explain why the 2.4m Hubble Space Telescope at optical wavelengths can detect fainter galaxies/stars than an 8m-class telescope located on the ground using the same amount of exposure time. (give three arguments)