

Astronomical Observing Techniques 2013:
Exercises on Optics
(Due on 22 October 2013 at 12:15)

October 14, 2013

1 Strehl Ratio and Encircled Energy

- a) Explain the difference between Strehl ratio and Encircled Energy with help of a drawing.
- b) Calculate the Strehl ratio of telescope having a rms wavefront error of $\lambda/14$.

2 Diffraction-Limited Sampling

Determine the pixel size (in arcsec) needed for the 2.4m Hubble Space Telescope to make images at a wavelength of $0.5 \mu\text{m}$ without losing spatial information.

3 Sky Background

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)

4 Integration Time

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 $\text{mag}_V = 0$ is $3.92 \times 10^{-8} \text{ W m}^{-2} \mu\text{m}^{-1}$ and take a seeing of 1 arcsec. The V-band filter used, is centered at $0.55 \mu\text{m}$ and has an effective bandwidth of $\Delta\lambda = 0.089 \mu\text{m}$.

5 Removing Diffraction Rings

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?