Exercises Astronomical Observing Techniques, Set 11

An AO system for a 8m telescope

We want to observe a planet at a wavelength of 2μm with the help of an AO system. The AO system is proposed to use a mag$_V$=16 guide star. A Shack Hartmann wavefront sensor is used operating in the V-band (center = 0.55 μm, bandwidth 0.089 μm). The wavefront sensor is read out at a speed of 100 Hz. The spectral irradiance (flux density) of a source with mag$_V$ = 0 is 3.92×10^{-8} W m^{-2} μm^{-1}. The seeing is 1 arcsec in the V-band.

a) Calculate the total number of photons received (per sec) from the star which can be used by the AO system. The QE for the AO wavefront sensor is 50%.

b) Calculate the number of sub-apertures needed to correct for the effects of seeing at the wavelength used for detecting the planet.

c) We assume that the star is detected by a single pixel in a sub-aperture. The CCD has a RON of 10e$^-$. Calculate the SNR per aperture per integration time used in the AO system. (you can neglect other noise sources of the detector). Is this enough to do an AO correction?

d) Assume that the SNR is too low for AO correction but that the centroid information from all sub-apertures combined is still enough to do a tip-tilt correction. Compute the resulting rms wavefront error at 2 μm after tip-tilt correction only.