Exercises Astronomical Observing Techniques – Set 9

24 November 2008

NAME: ____

Exercise 1

a) A star is imaged using a CDD with a read out noise (RON) of $7e^-$, assume that 1 photon corresponds to $1\ e^-$. The CCD has a pixel size of 0.2 arcsec and a quantum efficiency of 80%. The flux from the star integrated over the entrance aperture is 1 photon/s, the background flux is 100 photons/arcsec^2. The seeing is 0.5 arcsec. You may assume that the light from the star falls within a circle of diameter 0.5 arcsec. Determine the minimum exposure time needed to reach a signal to noise ratio SNR = 5 for the star.

b) Explain why a low RON is important if we want to achieve a high SNR within a short exposure time, and why this is less of an issue for long exposure times.

Exercise 2

The bandgap of a pure silicon semi-conductor is 1.11 eV

a) Calculate the cut-off wavelength in μm.

b) Estimate the numbers of electrons in the conduction band at T_1 = 300K and T_2 = 30K for a "pixel" of volume one mm^3. Note that m_{eff} in silicon is ~1.1 m_e.

Exercise 3

Now we consider a Si:As BIB detector, which is illuminated by a constant photon stream of 1,000,000 photons/s.

a) What is the resulting photo-current in Ampere that we would measure if we apply the right bias voltage? For simplicity we assume that the photo-conductive gain G = 0.5 and that the quantum efficiency is only reduced by reflection from the surface. (The refractive index of Si is ~3.4). Is a pre-amplifier necessary?

b) For this detector we calculate now the main noise components at T=300K. What are the G-R noise-current if we assume an integration time of 1 second, and the Johnson noise-current if we assume a read-out time of 10millisecond, a resistance of R=1 GΩ and an operating temperature of 30K?

c) What is the dominant component and how could the performance be improved?