Observational Astronomy

Problems: Set 2.

1. In an X-ray CCD, the number of electrons released when a photon is incident on the detector is given by N = E / w, where E is the energy of the incident photon, and w is a constant which depends upon the material. The variance on the number of electrons released is given by $\sigma_N^2 = F\ N$, where F is the Fano factor. Calculate the energy resolution in electron Volts of an X-ray CCD for photons of energy 2.2 keV, if *w* for silicon is 3.65 eV, and the Fano factor for silicon is 0.12. Calculate the resolving power R.

2. An instrument measures N_*=1 photon/s from an astronomical source and N_{sky}=2 photons/s from the background. If the dark current and readout noise are negligible, how long an exposure is required to achieve a SNR of 50?

3. If the seeing at a good observatory site is 0.5 arc sec, at which wavelength do observations on a 20 cm (diameter) telescope become diffraction-limited instead of seeing limited?

4. The first CCDs consisted of 100 x 100 pixels, with an average quantum efficiency (QE) of 60%, while modern detectors contain 4000 x 4000 pixels (QE = 80%). Suppose that you were given a full night of observing time (8 hours) on a telescope with a mirror 6 m in diameter, equipped with such a modern CCD. How much longer would you have needed to cover the same area to the same depth with one of the early detectors? Assume that the pixel size is the same in both cases and that you use the same telescope.

5. Suppose that you were awarded observing time with the Hubble Space Telescope to observe the individual stars in a very compact multiple star consisting of five components. You have been able to measure magnitudes m of components to be 21.8±0.03, 19.8±0.01, 20.1±0.02, 19.4±0.01, 22.8±0.04. From the ground-based telescope, because of seeing-limited observing conditions, you will see just one brighter star instead of five components of a multiple star. Calculate its magnitude m and σ_m.