

## GRS AS 710 HOMEWORK #5

Due: Tuesday, November 1st, 2011

Using IDL, develop an exposure time calculator. This calculator should return the minimum time needed to achieve a specific signal-to-noise ratio, given key stellar and observational and site attributes. The attributes include:

- stellar magnitude;
- pixel field of view;
- FWHM size of the stellar seeing disk;
- sky brightness (in magnitudes per square arcsecond);
- central wavelength of the observing band;
- bandwidth;
- aperture of the telescope;
- fractional blockage of the telescope due to secondary and supporting spiders;
- throughput of the telescope and instrument (together);
- conversion gain (electrons per digital count);
- quantum efficiency of the detector.

Note: Assume aperture photometry methods with aperture radii equal to twice the FWHM seeing.

- a.) Show that for the 14" telescope, with a 3" diameter secondary, operated in the Johnson V-band, at a plate scale of 0.5 arcseconds per pixel, for a sky brightness of 16<sup>th</sup> magnitude per square arcsecond, a quantum efficiency of 45%, a read noise of 80 electrons, a conversion gain of 7 electrons per ADU, and a total throughput of 80%, that if the seeing is 5" and the target star is 17<sup>th</sup> magnitude, the integration time needed to reach a S/N of 5 is 520 seconds.
- b.) Show that for the Perkins telescope, with 10% secondary blockage, operated in a narrow-band H $\alpha$  filter (central wavelength = 656 nm, bandwidth = 10nm), for 1.2" seeing on a sky of 20.5<sup>th</sup> magnitude per square arcsecond in the R-band (wider than the H $\alpha$  filter, note), a plate scale of 0.3 arcseconds per pixel, a read noise of 3 ADUs, a conversion gain of 3.1 electrons/ADU, a total throughput of 95%, quantum efficiency of 80%, and a stellar spectral flux of  $1.3 \times 10^{-16}$  ergs s<sup>-1</sup> cm<sup>-2</sup>, that a signal to noise of 3 is achieved in 2,200 seconds.
- c.) Make a plot of exposure time versus target magnitude for the Coit 14" telescope in the V-band. Assume 4" seeing, 0.4 arcseconds per pixel, a sky of 16<sup>th</sup> mag per square arcsec, 10% secondary blockage, read noise of 40 electrons, and a total throughput of 85% for a detector with QE of 80%. Calculate the necessary values to construct curves representing S/N = 3, 5, 10, and 50 for stellar magnitudes from 9 to 21. Plot all curves on the same plot, labeling each curve with its S/N value.