AST 475/875 Exercises #6 & #7

Due F, Dec 3rd Preferred (No Later than F Dec 10th)

It is easy to be mesmerized by the use of space-based telescopes compared to their optical counterparts. One reason to be mesmerized is, of course, the fact that they can perform IR, UV, and X-ray observations quite efficiently compared to ground-based facilities. One reason not to be mesmerized is that the space-based telescope apertures are small compared to the largest ground-based telescopes. What if we make either of these considerations a non-factor, however? These two exercises are designed to show the effects of lower sky background and pixel size differences for point-sources and extended sources when ground-based and space-based apertures are comparable and when working in the optical (which is perfectly doable from the ground). They are not technically challenging, but again require you to synthesize various bits of information from the course, and go through the tedium of carrying out realistic calculations.

The setup: Assume you want to measure a very faint stellar object (point source) at V using a CCD using either the 2.4 m HST or a 2.4 m telescope on Mauna Kea. Take the optical efficiency (telescope + instrumentation) and CCD device to be the same. Assume 0.3 for the optical efficiency, CCD read noise of 13 electrons, and dark current of 0.003 electrons/pixel/second. Assume a spatial resolution of 0.1 arcsec/pixel for HST and 0.4 arcsec/pixel for the Mauna Kea telescope. In addition, assume a sky background of 21.5 mag/square arcsecond at V for Mauna Kea and a zodiacal light background of 23 mag/square arcsecond for HST.

Exercise 6: Compute and graph the limiting magnitude as a function of time (from 1 second to 10,000 seconds) for a total S/N of 5 for both telescopes. Assume that the image of the star falls on 4 pixels.

Exercise 7: Now assume you want to measure a very faint extended object with both telescopes. Assume that the object's surface brightness is 3% of the night sky brightness at V, and that it extends uniformly (perhaps over a 2.2" x 2.2" region, but this doesn't matter). How long would you need to expose to detect this at a per pixel S/N of 10 from a 2.4-m telescope on Mauna Kea? How long would a similar exposure take using HST with its smaller pixels? [You can ignore overheads like readout, the need for multiple exposures, etc; in solving for *t*, you may find it useful to consider the limit of *t* being very large]. Notice that in this case the signal scales with the background, and is small in comparison to it.