Astronomy 11 — Fall 1998 (S.T. Myers)

Homework Set 5

Due Thursday November 5, 1998 (5pm)

1. The Hubble Space Telescope has a primary mirror of diameter 2.4 meters and focal ratio $f/24$. The HST has a CCD camera, the WFPC, that spans the wavelength range from 1150Å(UV) to 13000Å (IR). What is the resolution, in arcseconds, of the HST at wavelengths of 1150Å, 5000Å, and 13000Å?

What size pixels, in microns (μm) should you have at the focus so that there are 3 pixels across one "resolution element"? (Hint: this is a plate scale problem.)

How large a diameter would a radio telescope have to have, operating at a wavelength of $\lambda = 21$ cm (an important spin-orbit transition in neutral hydrogen), in order to have the same resolution as the HST at 6565Å (the Hα Balmer line, an important line in the optical)?

2. The Near Infrared Camera and Multi-Object Spectrometer (NICMOS) was added to the HST in the servicing mission in 1997. It operates at wavelengths from 0.8 μm to 2.5 μm. Calculate the resolution of NICMOS at these limiting wavelengths.

NICMOS has 3 separate 256×256 pixel square cameras. Camera 1 has 1 μm pixels. Calculate the pixel size in arcseconds and the field-of-view in arcminutes (the size of each 256 square frame).

3. On the rooftop of DRL is a Meade LX200 Schmidt-Cassegrain telescope with f/6.3 optics and a primary mirror diameter of 10 inches. Calculate the diffraction limit (in arcseconds) of the Meade at a wavelength of 5000Å. Why might we not be able to achieve this resolution in reality?

We have equipped the Meade telescope with an SBIG ST-7 CCD camera, which has a 765×510 pixel array with 9 μm pixels. Calculate the pixel size in arcseconds, and the field-of-view (corresponding to the two dimensions of the array) in arcminutes.

Jupiter will appear to have a maximum angular size at opposition. What is the approximate maximum angular diameter of Jupiter in arcseconds? How many pixels does this correspond to on the SBIG ST-7 CCD array?

The four Galilean satellites of Jupiter will appear as points to our telescope. What are the maximum distances (in arcseconds and pixels) that they will appear on the camera from the center of Jupiter (at opposition)?

4. In class, we calculated that the umbra of the Moon can just barely reach the Earth at the optimum orientation. Calculate the maximum length of the Moon's umbra when it is at perigee, taking into account the eccentricity of the Earth's and Moon's orbits. Then calculate the minimum distance between the center of the Moon and the surface of the Earth (assume the Moon is overhead at the equator and of course at perigee). Use these to calculate the approximate maximum diameter of the Moon's umbra on the surface of the Earth.