Ay 145 — Problem Set 1

Due Wednesday, February 16th, 2005

Problem 1. Properties of Light

Fortunately for astronomers, much information can be extracted from light (Electromagnetic radiation) to tell us about the sources that emitted (or reflected) the light. Can you list five (or more) properties of light that an astronomer can measure?

Problem 2. Distances and Magnitudes

The parallax angle for the star Sirius is $0.377''$.

a Find the distance to Sirius in units of (i) parsecs; (ii) light-years; (iii) AU; (iv) cm.

b Determine the distance modulus for Sirius.

c Sirius has a V apparent magnitude of -1.46. The bolometric correction for Sirius is $BC = -0.09$. Using the information above determine the absolute bolometric magnitude of Sirius and compare it to that of the Sun, $M_{\text{Sun}} = 4.76$. What is the ratio of Sirius' luminosity to that of the Sun?

Problem 3. Telescopes and the Uncertainty Principle

Some people consider the uncertainty principle (UP) the defining characteristic of Quantum Mechanics. In this problem, you will apply the UP to a macroscopic object (a telescope), in order to derive how the angular resolution of a telescope depends on its diameter and the observing wavelength. Note: do not worry about factors or 2π or other numerical constants here.

Loosely interpreted, the UP claims that one cannot know both the location, Δx, and momentum, Δp, of an object with arbitrary precision. In fact, the errors in each are related in the following way:

$$\Delta x \Delta p \gtrsim h \tag{1}$$

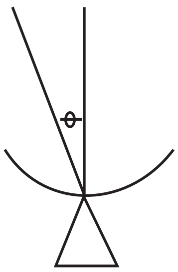
where h is Planck's constant.

The angular resolution of a telescope quantifies the ability of the telescope to locate the position of the source of light. In other words, if a telescope has 1 arcsecond resolution, then it is unable to distinguish sources that are less than 1 arcsecond apart on the sky (which can be considered as an uncertainty).

Using Equation 1, the relationship between a photon's momentum and its wavelength, and only simple algebra and trigonometry, derive the expression for the angular resolution, θ_{res}, of a telescope of aperture D at observing wavelength λ:

$$\theta_{res} \propto \frac{\lambda}{D} \tag{2}$$

What is the angular resoultion of the Hubble Space Telescope (2.4-m in diameter) at 5500Å?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