

Ay 20: Basic Astronomy and the Galaxy

Fall Term 2010

Problem Set 1

Due on: 13 Oct 2010 by 5pm

Many questions are from *Carroll & Ostlie (C&O), An Introduction to Modern Astrophysics*, 2nd ed., Addison-Wesley.

PROBLEM 1 (C&O Problem 6.8):

- (a) Using the Rayleigh criterion, estimate the theoretical diffraction limit for the angular resolution of a typical 20 cm (8 in) amateur telescope at 550 nm. Express your answer in arcseconds.
- (b) Using the information in Appendix C, estimate the minimum size of crater on the moon that can be resolved by a 20 cm (8 in) telescope.
- (c) Is this resolution limit likely to be achieved? Why or why not?

PROBLEM 2 (C&O Problem 6.9):

The New Technology Telescope (NTT) is operated by the European Southern Observatory at Cerro La Silla. This telescope was used as a test-bed for evaluating the adaptive optics technology used in the VLT. The NTT has a 3.58-m primary mirror with a focal ratio of $f/2.2$.

- (a) Calculate the focal length of the primary mirror of the NTT.
- (b) What is the value of the plate scale of the NTT?
- (c) ϵ Bootes is a double star system whose components are separated by 2.9". Calculate the linear separation of the images on the primary mirror focal plane of the NTT.

PROBLEM 3:

Caltech, Cornell, and JPL are working to construct a large sub-millimeter telescope in the high Andes of northern Chile, the Cornell Caltech Atacama Telescope (CCAT). It is planned to be a 25 m diameter telescope high (altitude 5600 m) in the Atacama Desert of northern Chile that will operate at wavelengths as short as 200 μm to 2200 μm (which is well into far-IR). Calculate the theoretical angular resolution of this telescope at both the above mentioned wavelengths? Now assume, some astronomer is interested in resolving a binary that is separated by 10 A.U. At what distance from Earth would the binary have to be, for him/her to just be able to resolve the binary (at both wavelengths)?

PROBLEM 4:

Calculate, in arc-seconds, the angular resolutions of some famous diffraction-limited telescopes:

- (a) Caltech's CARMA array of mm-wave telescopes, with longest baseline of 2 km, operating at the 115 GHz frequency of the ground-state transition of Carbon monoxide.
- (b) The 2.4 m Hubble Space Telescope, observing at the shortest wavelength of its late lamented ACS camera, 380 nm.

- (c) The 0.85 m Spitzer Space Telescope, operating at the shortest wavelength of its imaging photometer, $24\mu\text{m}$.
- (d) The planned Caltech TMT (Thirty Meter Telescope), with the adaptive optics instrument NFIRAOS (high-speed deformable mirrors and six laser-created guide 'stars' in the upper atmosphere) canceling earth's seeing at the shortest well-correctable wavelength, 1.0 microns.

PROBLEM 5(C&O Problem 1.4):

List the right ascension and declination of the Sun when it is located at the vernal equinox, the summer solstice, the autumnal equinox and the winter equinox.

PROBLEM 6 (C&O Problem 1.6):

Circumpolar stars are stars that never set below the horizon of the local observer or stars that are never visible above the horizon. After sketching a diagram similar to Fig 1.12,

- (a) Calculate the range of declinations of these two groups of stars for an observer at the latitude L .
- (b) At what latitude(s) on Earth will the Sun never set when it is at summer solstice?
- (c) Is there any latitude on Earth where the Sun will never set when it is at the vernal equinox? If so, where?

PROBLEM 7 (Variation of C&O Problem 1.8):

Proxima Centauri is the closest star to the Sun and is a part of a triple star system (the other two are called α Centauri A and B). It has epoch 2000.0 coordinates $(\alpha, \delta) = (14^{\text{h}} 29^{\text{m}} 43^{\text{s}}, -62^{\circ} 40' 46'')$ while the brightest star in the system, α Centauri A, is located at $(\alpha, \delta) = (14^{\text{h}} 39^{\text{m}} 36^{\text{s}}, -60^{\circ} 50' 8'')$.

- (a) What is the angular separation between Proxima Centauri and Centauri A?
- (b) If the trigonometric parallaxes for Proxima Centauri and Centauri A are measured to be $0.758''$ and $0.741''$, respectively, what is the total distance between the two stars? Give your answer in all of the following units: parsecs, astronomical units, and centimeters.
- (c) What is the angular diameter of Centauri A, assuming that its radius is similar to that of the sun? (you should be able to do this problem without looking up the radius of the sun in meters).

PROBLEM 8 (C&O Problem 3.3):

The parallax angle for Sirius is $0.379''$

- (a) Find the distances to Sirius in units of (i) parsecs, (ii) light-years, (iii) A.U., (iv) m.
- (b) Determine the distance modulus for Sirius.