

HOMEWORK PROBLEMS:

1.) (25 points)

Suppose the MESSENGER spacecraft, which recently made a close pass of Mercury, decided to communicate with the Cassini probe, now exploring Saturn and its moons. When Mercury is closest to Saturn in their orbits, it takes 76.3 minutes for the radio signals from Mercury to reach Saturn. A little more than half a Mercurian year later, when the 2 planets are furthest apart in their orbits, it takes 82.7 minutes.

a.) What is the distance between Mercury and the Sun?

b.) What is the distance between Saturn and the Sun?

Please give answers in both light-minutes and astronomical units.

Assume that the planets have circular orbits.

[HINT: Draw a diagram.]

[HINT: A light-minute is a distance: how far light goes in 1 minute.]

2.) (20 points)

a.) Stars Donald & Hillary have the same luminosity, but Hillary is 10 pc away while Donald is 30 pc away. Which star appears brighter as seen from earth, and how many times brighter is it?

b.) Stars Spongebob and Patrick are equally bright as seen from the earth, but Spongebob is 40 pc away while Patrick is 400 pc away. Which star has the greater luminosity, and how many times greater is it?

3.) (25 points) The angular resolution of a telescope (or other optical system) is a measure of the smallest details which can be seen. Because of the distorting effects of earth's atmosphere, the best angular resolution which can be achieved by optical telescopes from earth's surface is normally about 1 arcsecond. This is why much clearer images can be obtained from space. The angular resolution of the Hubble Space Telescope (HST) is about 0.03 arcsecond, and the smallest angle that be measured accurately with HST is actually a fraction of one resolution element, or about 0.005 arcsecond.

a.) What is the distance of a Cepheid variable star whose parallax angle is measured to be 0.005 arcsecond? Express your answer in both light years and parsecs.

b.) Suppose that the parallax angle is not measured with infinite precision, but has an uncertainty of + or - 0.001 arcseconds? What are the range of distances consistent with the measured parallax angle of 0.005 +/- 0.001 arcseconds? Express your answer in parsecs.

4.) (30 points) The faintest stars that can be detected with the Hubble Space Telescope have apparent brightnesses which are  $4 \times 10^{21}$  times fainter than the Sun!

a.) How far away could a star like the Sun be, and still be detected with the Hubble Space Telescope? Express your answer in light years.

b.) Cepheid variable stars are very important distance indicators because they have large and well-known luminosities. How far away could a Cepheid variable with 20,000 times the luminosity of the Sun be, and still be detected with the Hubble Space Telescope? Express your answer in light years.

c.) Cepheid variables are luminous enough to detect in other galaxies. There are galaxies in the Virgo cluster whose distances are estimated with Cepheid variables. Type Ia supernovae have also been observed in some of the same galaxies. This is exciting (for me, at least!) because it means that we can measure the distances to very remote galaxies, using supernovae as standard candles. Type Ia supernovae have well-known luminosities, and at their peak are 10 billion times more luminous than the Sun. How far away could a Type Ia supernovae be, and still be detected with the Hubble Space Telescope? Express your answer in light years.