ASTR 340
Origin of the Universe

Fall 2006
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HOMEWORK SET #1

Problem 1:

(a) Examine your thumb's position at arm's length relative to a fixed object on the wall alternatively closing each eye. You will see that the thumb's position appears to change relative to the fixed object. You can measure the angular shift and you find that it is, say, 3 degrees. If the length of your arm is .6 meters. Find the distance between the left and right eye.

(b) Two observatories 1000 km apart on the earth measure the distance to Mars as shown in Figure 1. The observations are simultaneous and they report the distance as .5 AU (1 AU = 1.5×10^8 km). In order to find this distance they measured the angle p (called parallax angle). What is the value of p in arc-minutes? (1 degree has 60 arc-minutes, 1 minute has 60 arc-seconds, 360 degrees correspond to 2π radians, $\pi = 3.14$).

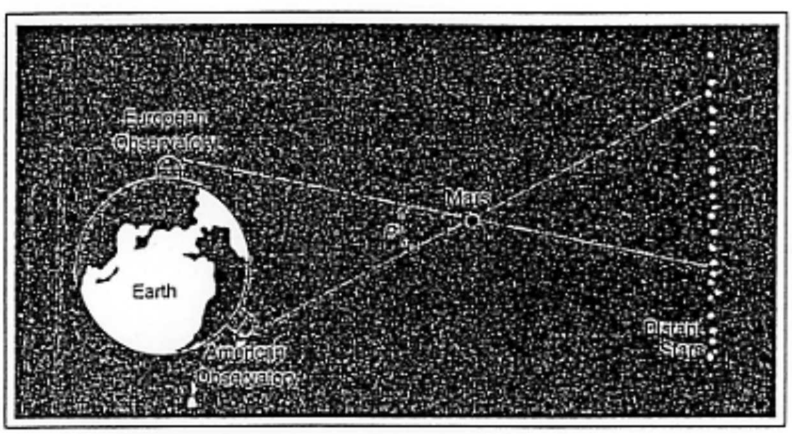


Figure · 1 PARALLAX OF A PLANET
Two observatories on the earth can measure the distance to Mars by triangulation, or parallax. The distance is given by the separation between the observatories divided by the angle of parallax, P, expressed in radians.

(c) The distance from the earth to α–Centauri was determined by measurements made 6 months apart as shown in Figure 2. The parallax was fund to be equal to .75 arc-secs. What is the distance of α–Centauri in units of AU and light-years. (Take the distance between the two observations (baseline) as 2 AU).

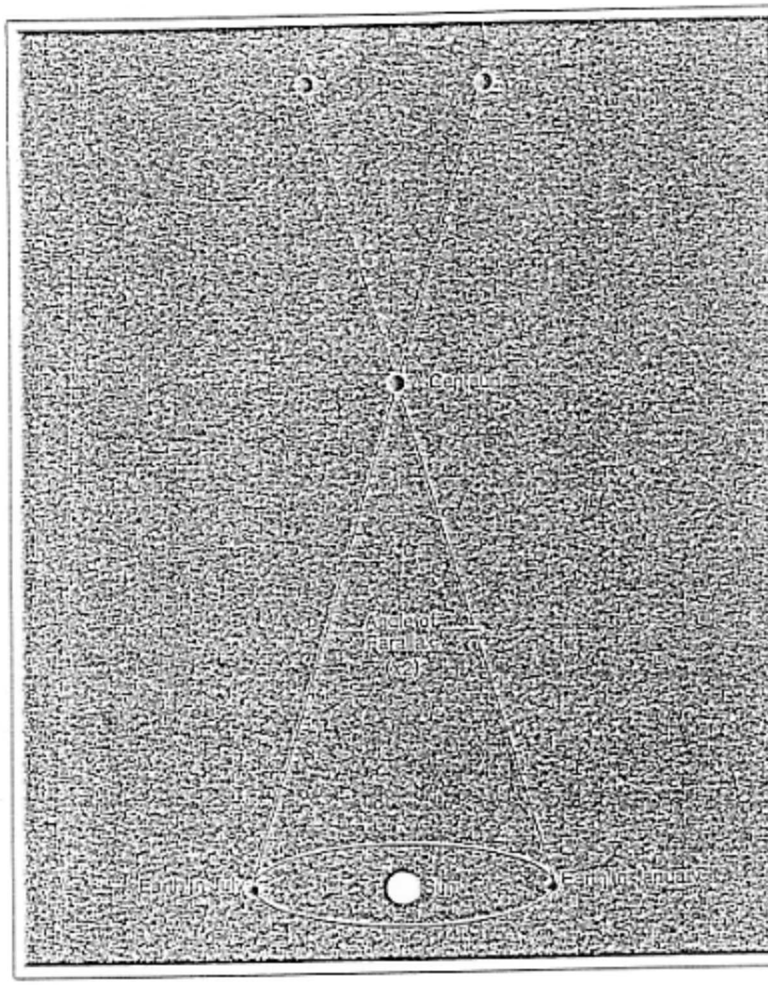
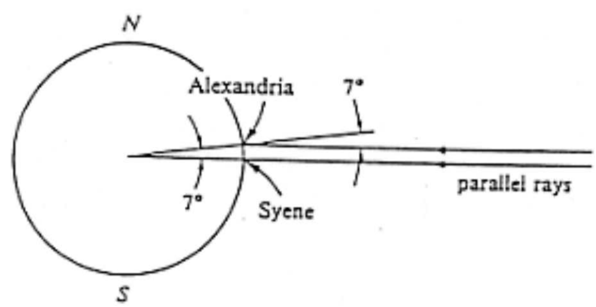


Figure 2 PARALLAX OF A NEARBY STAR
A nearby star is observed at six-month intervals. The shift in its apparent position from A to B between January and July gives the star's parallax. The distance to the star is equal to the mean radius of the earth's orbit divided by the angle of parallax. The star Alpha Centauri has a parallax of 0.75 arc-second, and its distance is therefore 1.3 parsecs (or 4 light-years).

(d) A unit of distance often used in astronomy is a parsec (an abbreviation for parallax of one arc-second) as seen from a 2 AU baseline. Give the value of 1 parsec in light-years, AU and kilometers.

Problem 2:

We begin with the size of the Earth. From the shape of the shadow cast by the Earth on the Moon during a lunar eclipse, it can be inferred that the Earth is a sphere. Erastothenes assumed that the Sun was far enough away that the rays from the Sun are virtually parallel when they strike the Earth (see figure here). Erastothenes then observed that, at noon on the first day of



summer, sunlight struck the bottom of a deep well in Syene, Egypt. In other words, the Sun at that time was directly overhead. At the same time in Alexandria, however, the Sun rays made an angle of about 7° to the vertical. Erastothenes concluded that Syene and Alexandria must be separated by a fraction $7°/360° \simeq 1/50$ of a great circle around the Earth. Assume that this distance of 1/50 of the circumference of the Earth can be paced off to be 800 km. Calculate the radius of the Earth. Compare your answer with the known value of 6.37×10^3 km.

Reconsider now the observation of the shadow cast by the Earth during a lunar eclipse. Assume still that the rays from the Sun make parallel lines, and draw diagrams to show how a comparison of the curvature of the Earth's shadow on the Moon with the curvature of the Moon's edge allows one to infer the relatives sizes of the Earth and Moon. This deduction is a slight modification of the method used by the Aristarchos to find that the Moon's diameter is about a third of that of the Earth. The modern value of 0.27. With Erastothenes's value for the

the radius of the Earth, calculate the diameter D_M of the Moon. Given that the Moon subtends an angular diameter at Earth of about half a degree of arc, calculate the distance r_M of the Moon.

Problem 3:

Which one of the following persons was the first to recognize the correct geometric form of the orbits of the planets? (a) Tyco Brahe; (b) Copernicus; (c) Ptolemy; (d) Kepler.

Problem 4:

Kepler derived his three laws of planetary motion (a) from Newton's laws of motion and of gravitation; (b) following a helpful suggestion by Galileo; (c) from study of Tycho Brahe's observational data; (d) within the general context of the Ptolemaic model of the solar system.

Problem 5:

State Kepler's three laws of planetary motion.