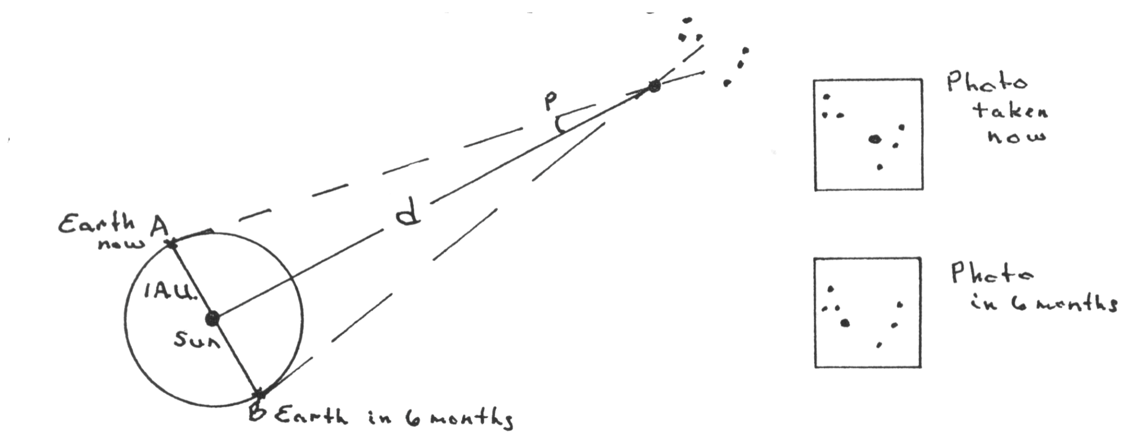
USING PARALLAX TO FIND DISTANCE

PARALLAX: The apparent change in the position of an object due to the change in location of the observer.

Parallax is used to define a measurement of distance – the distance to a star with a parallax angle of 1 second of arc is one parsec.

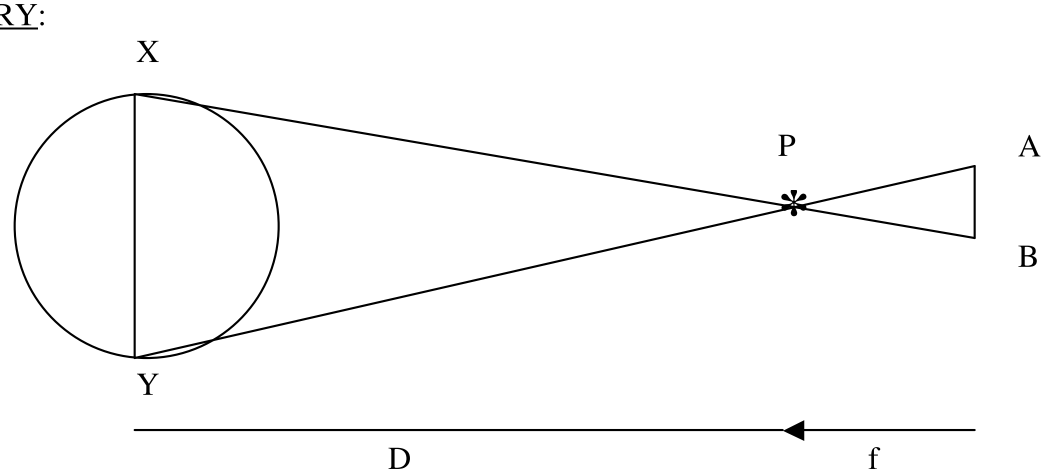
$$d = 1/p \qquad \textbf{equation 1}$$

d is measured in parsec (pc) and p is the parallax angle measured in seconds. See diagram below.



The distance from A to B is called the baseline.

THEORY:



The small triangle in the picture above is what the telescope “sees”. The two triangles are similar. Therefore we have

$$D / XY = f / AB$$

where f = focal length of the telescope; AB is the parallax motion of the star in two photographs; D is the distance to the star; and XY the baseline.

Rearranging the terms gives us $D = (XY) f / AB$ **equation 2**

Using the small angle formula, P in radians = AB / f substituting into the above equation gives:

$$D = 2 \text{ Astr. Units} / P \text{ in radians.}$$

This is the same as the parallax equation only in different units. Instead of making a lot of unit conversions we just give everything a different name:

$$D \text{ (in parsec)} = 1/\text{angle in sec}$$

Looking at the drawing above it is obvious that the smaller the angle p the farther away the star and the larger the angle p the closer the star. In the simulation that we will be doing

<u>SIMULATION</u>:

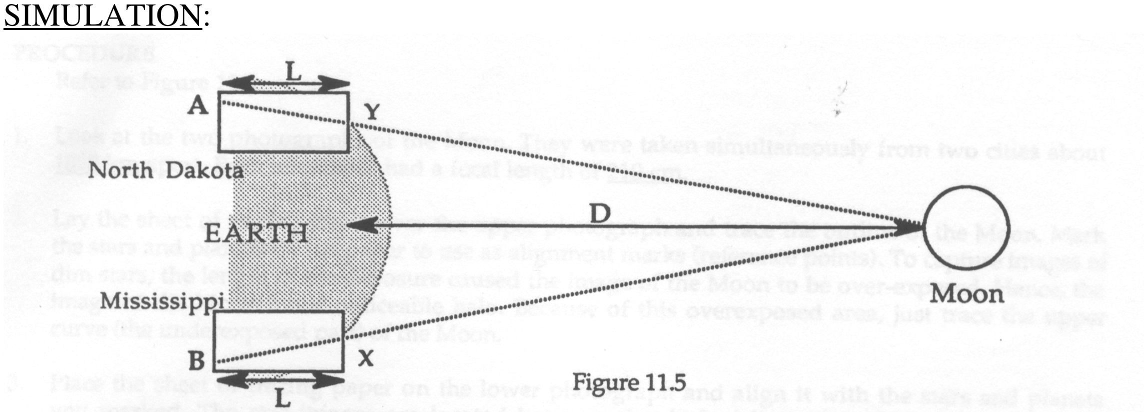


Figure 11.5

Above you see a drawing of two telescopes on Earth each taking a picture of the Moon. Since the Moon is much closer than a star and we must remember to stay true to the SMALL ANGLE formula and make our baseline smaller.

Using equation 2 above and the **information about the photographs of the moon.**

- The baseline XY is the distance between the telescopes: 1850 km.
- The focal length of the telescopes used in 210 cm.

Procedure:

Use the photographs given to you by the teacher.

1. Look at the two photographs of the Moon. They were taken simultaneously from two cities about 1850 km apart. Both telescopes had a focal length of 210 cm.
2. Lay a sheet of tracing paper over the upper photograph and trace the outline of the Moon. Mark the stars and planets on the paper to use as alignment marks (reference points). Do not trace the dashed lines. Trace a dot in the center of the dashed lines where a faint star is located. Because of the quality of the copy you may not see the actual star, but it was there on the original photo. To capture images of dim stars, the length of the exposure cause the image of the Moon to be over-exposed. Hence, the image of the Moon has a noticeable halo. Because of this overexposed area, just trace the upper curve (the under exposed part of the Moon.
3. Place the sheet of tracing paper on the lower photograph and align it with the stars and planets you marked. You may have to rotate the sheet to get the images to overlay. Use the images of Jupiter and Venus as a guide. Again trace the outline of the Moon (the underexposed part).

Calculations:

1. The parallax shift in the images of the Moon is _____________ cm.
2. The distance between the two observers is _______________ km.
3. The focal length of the telescopes is _____________ cm.
4. Calculate the distance between the Earth and the Moon (Use equation 2). Show, on the back, the equation used (using letters). Show the numbers that replaced each letter. Use a calculator.
   The distance is ____________________ km.
5. According to your textbook the distance to the Moon is between 363,300 km and 405,500 km. Does your answer fall within this range? ___________________