



Name:

Date:

PARALLAX EXERCISE¹

The goal of this exercise is to introduce the student to the concept of parallax, which is a method used to measure distances here on Earth as well as in space.

EQUIPMENT: Ruler, Calculator

INTRODUCTION

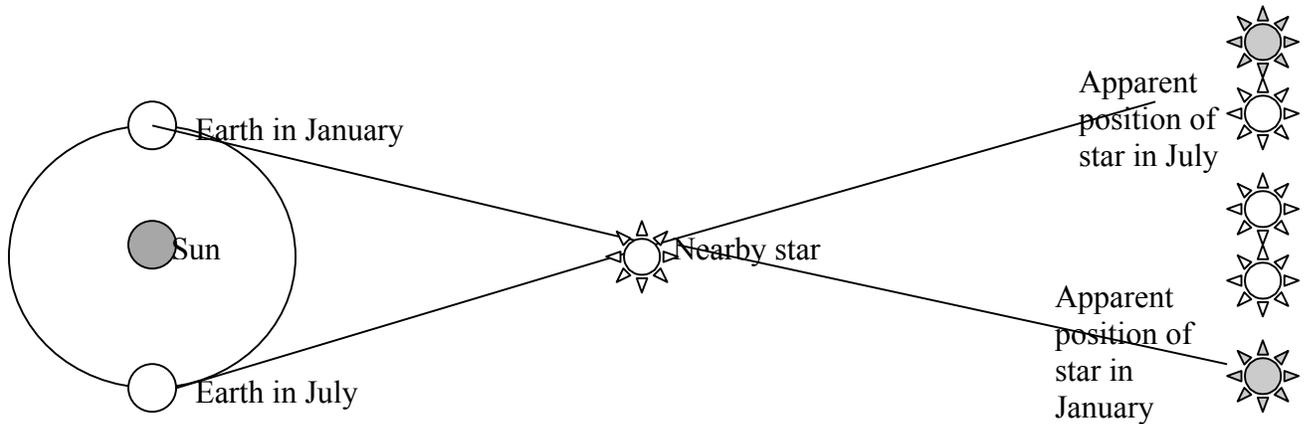
Compare the Sun to another star in the sky. They look completely different, and it was once believed that they *were* different types of objects. In fact, the Sun was once considered a planet! We now know the Sun is just another star, and the reason that the Sun appears different to us is that it is so much closer.

Determining distances to celestial objects is one of the most important and most difficult measurements in astronomy. The most direct method of distance measurement is *parallax*, the apparent shift in the position of an object due to the change in position of the observer. To see an example of this, hold a finger up at arm's length in front of you. Close one eye, and line up your finger with a distant object. Now look at your finger with the other eye – it will no longer be lined up with the distant object. As you close one eye and then the other, your finger appears to move back and forth. Your finger is not really moving, but the position from which you view your finger is changing. The shift you see is called *parallax*.

1. Place your finger at several positions from your face and repeat the experiment above. How does the parallax (the apparent shift of the position of your finger) change as your finger is moved closer to your face?

¹ Based on exercise developed at Arizona State University

What does this have to do with stars? As the Earth moves around the Sun, we view the stars from a continuously changing position. Thus, the nearby stars appear to change positions compared to the distance stars.



The measurements that you made above are quite similar to those made by astronomers in order to measure the distances to nearby stars. The big difference is that even the nearest stars are quite far away compared to the diameter of the Earth's orbit around the Sun.

Because the stars are so far away, the parallax angle of even the nearest star is extremely small. The nearest star, Proxima Centauri, has a parallax angle of only 0.75" (arcseconds), which is only 1/4800 of a degree. Using such small angles in the formula we used above is somewhat difficult. Thus, astronomers have created a special unit, the *parsec*, for working with the distances to the stars. A parsec is the distance at which a star will have a parallax shift of exactly one arcsecond as observed from the Earth; a parsec is also equal to 3.26 light-years. Using the units of *parsecs* for distances and *arcseconds* for the parallax angle, we may rewrite the distance formula in the following simple way:

$$D = 1/p$$

where D is the distance to the star in *parsecs* and p is the parallax angle of the star measured in *arcseconds*. (The definition of the parsec in this way is the reason why we use only the angle *p*, and not the full parallax shift $2p$, when we talk about parallax angle.) Thus, if a star has a parallax shift of 0.5", its distance is 2 parsecs.

2. Each of the following pairs of boxes contains a bright star exhibiting parallax. Which pair contains the *more distant* star? Explain your reasoning.



3. As stated previously, Proxima Centauri has a parallax angle of $0.75''$. What is its distance in parsecs?
4. The star Sirius is known to be 8.6 light-years away. What is its parallax angle?
5. If you built a telescope on Mars and measured the parallax angle of a nearby star, how would your measurement compare to the parallax angle of the same star as measured from Earth? Draw a picture and explain in words. (For your information, Mars is farther from the Sun than the Earth is.)

