Name: ____________________

Section: ____________________

Date: ____________________

Prelab 6: Parallax

Resolution

Celestial bodies are so far away that they appear minuscule in the sky. Our eyes, not to mention most telescopes, are not powerful enough to actually see something so tiny; instead, the object appears as a blurry point of light and is said to be *unresolved*. The size of an unresolved object does not depend on how big or bright it is; it does depend, however, on the type of optics in your telescope: the better the optics, the better the image.

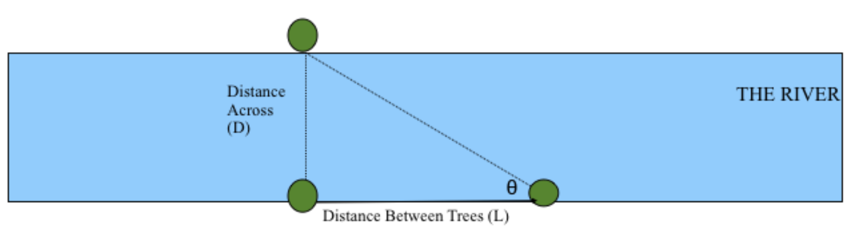
Almost everything seen in day-to-day life is resolved, even if it is far away (think about passing a billboard on the highway). There are some celestial objects that are resolved, too; for example, on the sun, we can see spots, and on the moon, we can see mountains and craters. On an object that is resolved, top, bottom, left, and right, are all distinct and can be separated, and features are usually distinguishable. Unlike unresolved objects, the size of a resolved celestial body is directly related to the size of the object and its distance from Earth.

1. (2 points) Think about a barely resolved object: if we were to take a star and move it to the point where it was still resolved, but just about to become unresolved, what would it look like in comparison to an "officially" unresolved object?

2. (2 points) Considering that so many objects in Astronomy are unresolved, how do you think Astronomers continue to study them? Think about what you have learned in class so far to help you brainstorm.

The Problem of Distance

Imagine you are walking through a forest, and happen upon a river with two trees on your side and another tree directly across the river from one of the trees on your side. You want to determine the distance across the river before you cross:



If you draw a triangle you might be able to solve for the distance across the river (D) in terms of the distance between the trees (L) and the angle (θ). The answer is given by the equation:

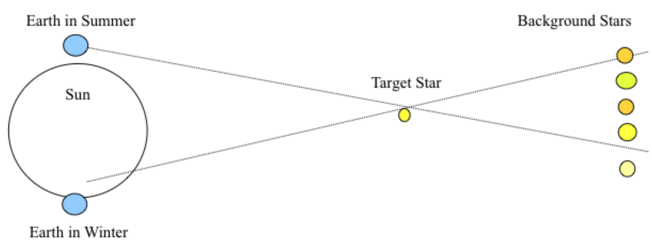
$$D = L \times \tan(\theta)$$

3. (2 points) If the distance between the trees on your side is 100 m and the angle is 30 degrees, what is the distance across the river? If you use a calculator, make sure it's in degree mode.

4. (2 points) If the distance across the river is extremely large, will θ become larger or smaller? (Hint: think about which angle θ approaches.)

Parallax

As mentioned, most stars are unresolved even with modern telescopes; one of the only ways to find the distance to a star is to use methods similar to the river example above. As the Earth revolves around the Sun, our orientation to the stars change, just as if you walked from one tree to the other in the example above. Look at the figure below, and notice that the target star will appear in a different location in the sky in the Summer and Winter. Depending on the location of Earth, the star will appear in a different position in the sky. If we know the distance from the Earth to the Sun, and can measure the angular distance the star changes in the sky, we can measure the distance to the star.



To get an idea of what's happening, hold a finger in front of your face. Close one eye, then the other. Your finger will appear in different places relative to the background of the room. This is because your eyes are are not in the same place. If you move your finger closer and farther from your face, the image will also change.

Measurement of precise positions makes possible one of the most powerful methods astronomers have of measuring the distances of objects in the sky, a method known as parallax. Parallax is the most direct way astronomers have of measuring the distances to stars. The parallax of an object is its apparent shift in position when you view the object from two different vantage points. In general, if you can measure the parallax, θ of an object as measured from two points separated by a baseline, you can measure its distance. Distance is related to parallax through an inverse relationship, and has the units of parsecs:

$$D = \frac{1}{\theta}$$

5. (2 points) If a star changes its position in the sky by $\frac{1}{3600}$ of a degree (that is, one arc-second), it has a parallax of 1.00. How far away is the star in parsecs? How far is that in AU?

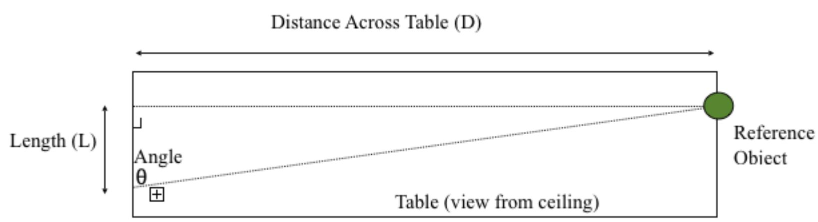
Name: ______________________________

Section: ______________________________

Date: ______________________________

Lab 6: Parallax

The purpose of this lab is to explore the relationship between distance and parallax. Before beginning, examine the diagram below:



Using trigonometry, we can find the distance across the table, the same way you calculated the distance across the river in the prelab. The formula is given below:

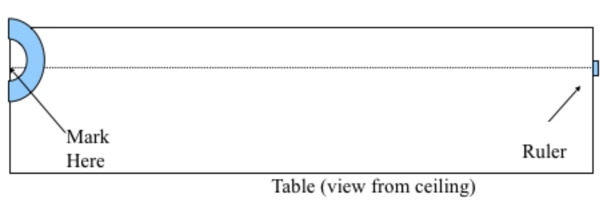
$$D = L \times \tan(\theta)$$

If we measure θ and L, we can plug these values into the above equation to find D. L is referred to as the "baseline."

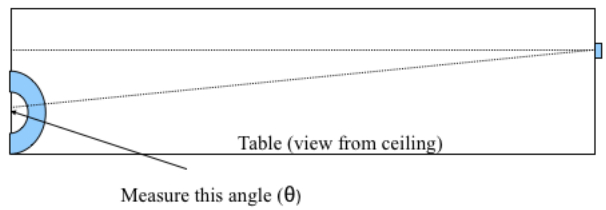
Instructions

1. To begin, tape a one-ft. ruler (vertically) on the opposite end of the table to use as a reference point. **Use the width (the short side) of the table. In the first diagram above, this is the side labelled L.**

2. Return to the side opposite the object and place a protractor flat against the edge of your table. Keeping the edge of the protractor flush with the edge of the table, try to line the object up with the 90 degree mark on the protractor. You may want to kneel down and use a pen or pencil to line up the protractor more precisely (or try closing an eye). Mark the table at this point (the center of the protractor) with a piece of masking tape. Refer to the diagram below for a visual aid:



3. Slide the protractor (still flat against the edge) several centimeters down the edge of the table. With the protractor, measure the angle the reference object (one-ft. ruler) makes from your edge of the table. Measure in degrees. The angle should be less than 90 degrees. This is your measurement of θ. Record the value on your worksheet.



4. Use a meter stick to record the distance you slid the protractor from the marker. Record your measurements in centimeters. This distance is L. Record the value on your worksheet.

5. Plug θ and L into the equation above to determine the distance across the table, D. Make sure your calculator is in degree mode!

6. Move the reference object several centimeters more and repeat these measurements two more times. For the last measurement make the angle as large as possible.

7. Repeat the experiment, but this time find the distance the long way down the table. Record your findings on the worksheet.

Name: ______________________________

Section: ______________________________

Date: ______________________________

Lab 6 Worksheet: Parallax

1. (6 points) Data Table (Remember units!)

θ	L	D

Actual Distance, Short Way: ______________________________

Actual Distance, Long Way: ______________________________

2. (4 points) Evaluate the following quantities in your calculator:

tan(89): ______________________________

tan(88): ______________________________

tan(15): ______________________________

tan(14): ______________________________

3. (2 points) The percent difference between two numbers A and B is:

$$\frac{2\times(|A-B|)}{(A+B)}$$

What is the percent difference between tan(89) and tan(88)?

4. (2 points) What is the percent difference between tan(15) and tan(14)?

5. (2 points) Think back to the calculations you just computed: if you have a large baseline, are the angles larger or smaller?

6. (2 points) If you have random error in your experiment and are typically off by a few degrees, is it better to have a large baseline or a small one? Justify your answer.

7. (2 points) The “baseline” or length (L) we use in Astronomy is the radius of Earth’s orbit around the Sun (1 AU). As we cannot change our baseline, and in light of this lab, explain why we cannot actually measure the distance to stars that are at a great distance from Earth.