Can We Measure the Diameter of the Sun?

How can we measure the sizes and distance of objects in space?

The measurement of sizes and distances in space has been crucial to establishing our current understanding of the scale of the universe. Many of these measurements have histories that go back thousands of years. For example, a little over 2,000 years ago the ancient Greeks used several methods (one based on observation of a Lunar eclipse, and one based on the phenomenon of *parallax*) to estimate the distance from the Earth to the Moon. Parallax is the apparent change in position of an object when viewed from different locations. For example, hold your finger out in front of your face. Close one eye and note the position of your finger relative to the objects in the background. Then view your finger with the other eye and its apparent position has shifted relative to the objects in the background. Once the distance from the Earth to the Moon was known (about 384,000 km), other distances, such as the distance from the Earth to the Sun (about 149 million km) could be estimated using geometry and the parallax.

If we know the distance to the Sun…

Have you ever noticed the circular spots of light on the ground under a tree? As the sunlight passes through the tree, images of the Sun are projected on the ground through small holes in the tree's canopy. The top image shows circles on the ground that are images of the Sun. As proof that these are images of the Sun (and not the shape of the hole), the bottom picture shows crescent shapes that were formed on the ground during a partial solar eclipse. Pinhole cameras work in the same way as an image is projected through a small hole.

Knowing the distance to the Sun, we can use a "pinhole camera" to measure the diameter of the Sun. First, examine the behavior of a simple pinhole camera: make a small pinhole in a piece of paper, take another piece of paper for projecting the image, and head outside. Face the pinhole toward the Sun, and examine the projected image on the other piece of paper. Change the distance between the pinhole and the paper, and observe the changes in the image.

Is the size of the image related to the size of the Sun?

Can you think of a way to relate the size of the projected image of the Sun to the size of the Sun? Talk with your group to come up with a method for calculating the diameter of the Sun

(Hint: If you know the characteristics of your measuring instrument and the distance between the Earth and the Sun, you have enough information to estimate the diameter of the Sun!)

1. Briefly explain your strategy for calculating the diameter of the Sun.

2. Use your "simple" pinhole camera measurements to estimate the diameter of the Sun. Calculate at least two estimates using two different measurements and show your work below.

Making a more precise measurement

Now that you have some idea of how the pinhole camera works, and of the relationship between the size of the image and the distance of the image from the pinhole, let's try making a more precise measurement. To do this, use a long cardboard tube with aluminum foil on one end (put a pinhole in the aluminum foil), and a piece of vellum graph paper on the other end (so that you can see the image and estimate its size). Measure the length of your tube, and the size of the image.

3. Determine the diameter of the Sun (show your work below) using the tube.

4. The actual diameter of the Sun is 1,392,000 km. How far off were your two estimates of the diameter of the Sun? Did the more precise measurement give you a better estimate?