Lab 2: How Big is the Sun?

Purpose

This experiment will show you how the size of an object as huge and as distant as the Sun can be measured with simple home-made equipment. It will also acquaint you with the formation of images by lenses, and with the structure of a rudimentary astronomical telescope.

Warning! Need we tell you that the light of the Sun is very intense? At no time here or elsewhere attempt to look directly at the Sun through a lens or any other instrument (unless it is a special solar telescope). Never stare at the Sun with the naked eye. Failure to observe such precautions can result in the creation of a permanent blind spot on the retina of your eye!

Observation of the image of the Sun on a screen, as we do in this experiment, is perfectly safe.

Introduction

If one knows how far away an object is, one can estimate its true size by noticing how large it appears to be. (Astronomers denote this apparent size by measuring the angle subtended by the object). As long ago as the "classical" period of ancient Greece, thinkers attempted to guess the size of the Sun by using this kind of reasoning. The crucial importance of the Sun as the prime source of light and heat was evident to the Greeks, as it was to all cultures, many of whom understandably elevated the Sun to the status of a deity.

When Anaxagoras suggested in 434 BC that the Sun was a ball of molten rock as large as the Greek peninsula, his reward was to be banished from Athens. In the 3rd century BC, Aristarchus concluded that the Sun was at least as big as the entire Earth, and a century later Hipparchus raised its size to seven times the diameter of the Earth. While the reasoning of these worthies was sound, large errors in their methods of estimating the distance of the Sun led to vast underestimates of the solar diameter. It was not until 1672, over 1800 years later, that the Italian astronomer G. D. Cassini, who now had the use of telescopes, arrived at what we would regard as a "reasonable" value for the distance of the Sun.

In our experiment, we will assume that we know the distance of the Sun and use some simple geometry to calculate its diameter. Our results will be much better than those of the famous Greeks, and should even improve on Cassini's, whose error was about 10%. We will use a rudimentary solar telescope rather like the ancient device illustrated in Figure 2.1 (dress is optional in our lab). The principle of the experiment is shown in Figure 2.2. A simple lens forms an image of the Sun on a screen at a distance from the lens f, which is called the focal length. We carefully measure the diameter i of the image. Notice that the triangles on either side of the lens are similar triangles, so we can write

$$\frac{i}{f} = \frac{s}{d}$$

where s is the diameter of the Sun and d is its distance. Since we can measure i and f in the laboratory, and since d is now well-known ($\sim$1 AU), we can readily solve for s.