Farnham Astronomical Society

Exercise: How big is our Sun?
Difficulty: Basic

OBJECTIVE

Greek philosopher Aristarchus of the isle of Samos was the first to calculate the diameter of the Sun using trigonometry but his calculations underestimated the Sun's diameter by a factor of 20. His results may not have been accurate but we must still credit him with the idea of the Sun at the centre of our Solar System (a heliocentric solar system). Considering Aristarchus lived around 310 to 230 BC, it took almost 2,000 years for his idea to become firmly established (we now know it to be fact). In our era of space exploration and with modern telescopes we not only understand the workings of the solar system but also have very accurate data for the diameter of the Sun.

In this exercise you will make some very basic equipment to measure and calculate the diameter of the Sun. You will also learn how to observe the sun safely and without risking damage to your eyes.

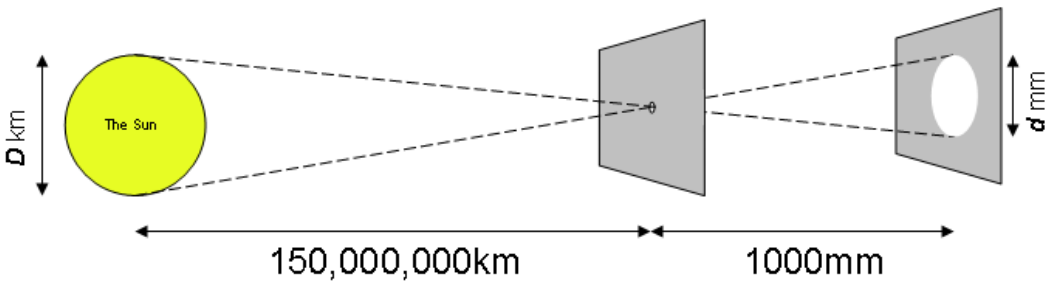
EQUIPMENT

All you need to perform this experiment are:

- A metre rule
- A soft pencil
- Blu-tack (or plasticine)
- Two pieces of card (25cm square and 15cm square)
- Something to make a hole in the card (a sharp pencil or knitting needle)
- A calculator
- Clear skies and suncream!

SOME BACKGROUND

By using a small hole it is possible to project an image of the Sun – it is a 'pinhole camera'. A property of a pinhole camera is that the ratio between the size of the image to the object is the same as the ratio of their respective distances from the hole.



$$\frac{D}{150{,}000{,}000} = \frac{d}{1000}$$

Rearranging this formula:

$$D = d \times 150{,}000km$$

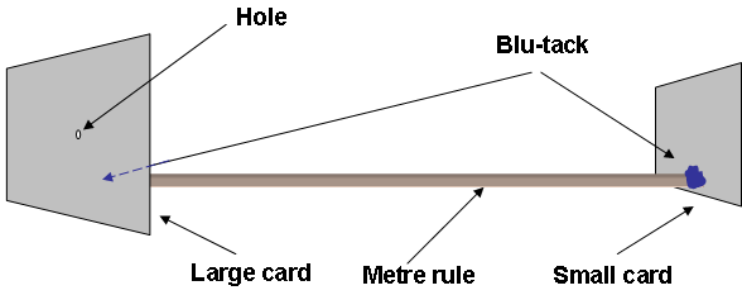
METHOD

Do not look at the Sun directly with your eyes (even if you are wearing sunglasses) and NEVER LOOK AT THE SUN THROUGH A TELESCOPE OR BINOCULARS. You will damage your eyesight and may even be blinded permanently.

Observing the Sun directly requires specialised equipment. However, the method described in this exercise is safe because, by following the instructions, you will not need to look at the Sun directly.

Make a small neat circular hole in the centre of one the large piece of card. The hole should be between 1mm and 2mm diameter. You can use the tip of a sharpened pencil or perhaps the tip of a knitting needle, but mind your fingers!

Attach this card to one end of your metre rule using a large blob of Blu-tack or plasticine. Attach the smaller piece of card to the other end of the rule with another large blob of Blu-tack (see below). The alignment of the cards will affect the accuracy of your results. Make sure that the two cards are at right angles to the metre rule and that the rule isn't bent.



Point the end with the hole towards the Sun. Adjust the alignment of the metre rule carefully until you can see a small image of the sun projected onto the lower card. The Sun's disk might be difficult to see due to sunlight. The larger card on the front of the rule should provide a little shade but you may need to get your friends to stand around the smaller card to help create some more shade.

Carefully draw around the image of the Sun's disk on the smaller card – you will need to do this with a very light touch so that you do not dislodge the card. A soft pencil will make this much easier and it may help to have a friend hold the ruler while you mark the card.

Measure the diameter of your drawing (***d*** - in millimetres)

Use the formula below to calculate the diameter of the sun in kilometres.

$$D = d \times 150{,}000km$$

ANALYSIS OF YOUR RESULTS

Does your result look sensible? Lookup the Sun's diameter on the internet. How does it compare? If your result differs by a significant distance, why do you think that is?

Calculate the accuracy of your result (calculate the difference between the calculated and actual distances as a percentage of the actual diameter of the Sun). Try to estimate the sensitivity of this method to:

- Misalignment of the cards (i.e. the separation between the two cards is not exactly 1000mm), and
- Your measurement of the projected image of the sun's disk (for example, how would an error in measurement of half of one millimetre affect your result)?

CREDITS

This exercise is based on an idea by Worsely Central School, Alberta Canada.