Teacher notes

DAYTIME ASTRONOMY

ACTIVITY 05

Three sessions. More able pupils in year 9 should understand the theories behind the experiments. For younger students the experiments demonstrate some physics principles that they can take with them to Key Stage 4.

Who says you need to stay up all night to do astronomy?

Before you begin...

This activity involves making observations of the Sun. It is important that students are told that they should never look directly at the Sun, because this can cause permanent blindness. They should also definitely not use sunglasses, cameras, binoculars or a telescope to look directly at the Sun – the light will burn their retinas.

In the following few sessions the students will be able to make observations of the Sun and be able to measure how long it takes for light to travel from the Sun to the Earth.

Session 1

The Sun might just look like a bright blob in the sky, but there is a surprisingly large amount going on if we could just see it. We can never look directly at the Sun, but to see what is going on we can build certain devices that reduce the brightness and the danger to our eyesight.

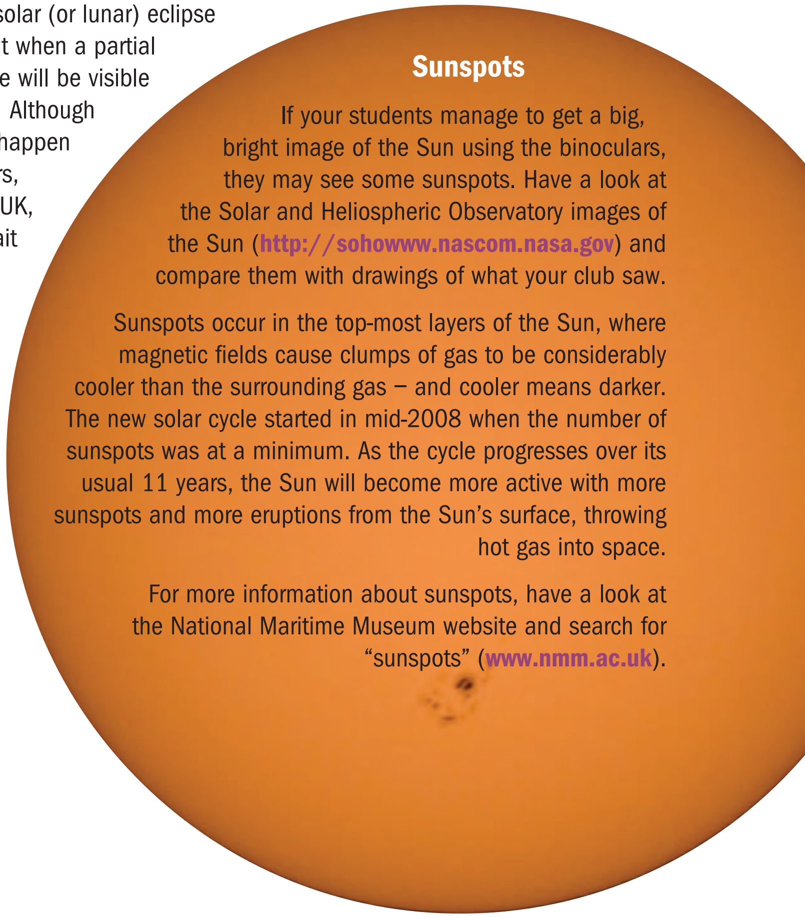
The first and most commonly used device is a pinhole camera. This is very easy to make but the image you get of the Sun is usually very small. See **www.scienceprojectideas.co.uk/tracking-sunspots-across-sun.html** if you would like to have a go.

Although the pinhole camera gives a nice, low-tech view of the Sun, if you use a pair of binoculars you can project a good image of the Sun onto a screen. This should be big enough and bright enough to see sunspots. Full instructions are given on the students' sheet.

Once they have made their observations of the Sun, there are many resources on the web that will help to explain what they've seen.

Eclipses

To find out when the next partial solar eclipse is, visit the NASA eclipse website (**http://eclipse.gsfc.nasa.gov/eclipse.html**). Use the JavaScript solar (or lunar) eclipse predictor to work out when a partial solar or lunar eclipse will be visible from where you live. Although total solar eclipses happen every couple of years, they are rare in the UK, and may have to wait several years even to see a partial eclipse.



Sunspots

If your students manage to get a big, bright image of the Sun using the binoculars, they may see some sunspots. Have a look at the Solar and Heliospheric Observatory images of the Sun (**http://sohowww.nascom.nasa.gov**) and compare them with drawings of what your club saw.

Sunspots occur in the top-most layers of the Sun, where magnetic fields cause clumps of gas to be considerably cooler than the surrounding gas – and cooler means darker. The new solar cycle started in mid-2008 when the number of sunspots was at a minimum. As the cycle progresses over its usual 11 years, the Sun will become more active with more sunspots and more eruptions from the Sun's surface, throwing hot gas into space.

For more information about sunspots, have a look at the National Maritime Museum website and search for "sunspots" (**www.nmm.ac.uk**).

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Although auroras aren't visible when observing the Sun, there are loads of resources about them on the web. The Sun doesn't just emit light – massive amounts of energetically charged particles are blasted off from it every second. The more sunspots that are visible, the more material that is being blasted into space. Some of these charged particles collide with the Earth and it takes around two days for them to get here. Instead of just filtering down into the Earth's atmosphere, these particles spiral around the Earth's magnetic field and give off light (accelerating charged particles emit light). The light creates beautiful patterns in the night sky, most frequently visible over the Arctic and Antarctic, but sometimes at much lower latitudes.

For more information about auroras, see the National Maritime Museum website (**www.nmm.ac.uk**).

For the prediction of auroras and sunspots, visit **www.spaceweather.com**.

You can also find videos of the effects on video sharing sites such as YouTube (**www.youtube.com**).

For more projects, information and activities related to the Sun, visit the Suntrek website (**www.suntrek.org**).

Session 2

Light doesn't travel instantly from place to place – it takes time. It may be very fast, but it still takes more than 8 min for light to travel from the Sun to the Earth. How do you measure something that fast? Well, you can do it indirectly using the frequency and wavelength of microwaves. You will need a microwave oven and lots of chocolate.

This works best as a demonstration, with the students doing the hard work of calculating the speed of light. If they get it right they can eat the unmelted chocolate. If your students are unwilling to do the maths, you can separate off the maths section on the students' sheet. You may or may not decide to give them the chocolate, however.

You will need:

- several packets of chocolate buttons, chocolate drops or Milky Bar stars for a celestial feel
- a microwave oven, either without a turntable or with a turntable that can be disabled or removed
- a microwave-safe plate
- a ruler

Microwaves are part of the same spectrum as light waves, so instead of using light we can use microwaves to calculate the speed of light.

What to do:

1. Take a large, flat plate and sprinkle the chocolate over it. It is best if you can cover the plate evenly and completely.
2. If your microwave has a turntable, take it out and turn it upside down so that it stops rotating. Check that your microwave will still work like this.
3. Put your plate of chocolate in the microwave and turn the power on: on full power it will take about 30 s. Keep an eye on it to make sure that the chocolate isn't overcooking, and don't let too much chocolate melt or you won't be able to measure the distance accurately.
4. Take the plate out and look at the uneven patches of melted chocolate. Some of it should still be solid while evenly spaced patches are melted.
5. Measure the distance between the melted patches of chocolate. Take care with microwave melted chocolate because it can be extremely hot.
6. Use the formulae on the next page to work out the speed of light, then work out exactly how long it takes light to reach us from the Sun.

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ACTIVITY 05

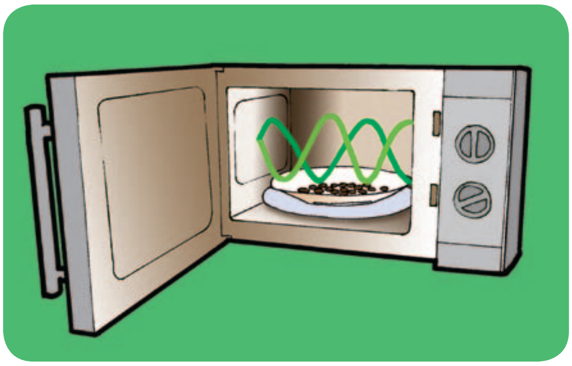
How to measure the speed of light in a microwave

A microwave oven generates microwaves (radio waves with a frequency of around 2.45 GHz), which bounce around inside the box containing the food. As the microwaves pass through the food, they are absorbed by the water, fat and sugar molecules, which become excited and jiggle about. Atomic motion is heat, and, since the microwaves can penetrate throughout the food immediately, the heating of it is quick and even.

The microwaves reflect off the inside of the oven and bounce back towards the source. At certain points the peak of one wave coming out of the generator meets the trough of a reflected wave and they cancel each other out. If your chocolate is at this point it won't melt. In other places the peak of one wave meets the peak of the reflected wave, so the chocolate at this point begins to melt. The same is true when a trough of the emitted wave meets a trough of the reflected wave.

You can find animations of the formation of a standing wave on the web.

The points where the chocolate melts tell us about the wavelength of the wave – this is the distance between the peaks of two waves, or the troughs of two waves. The standing wave is at a maximum at both the peak and the trough of the moving waves, so the distance between the melted chocolate patches is exactly half a wavelength.



Calculating the speed of light

The frequency of the radiation in the microwave should be labelled on the back of the microwave (usually around 2.45 GHz, or 2 450 000 000 Hz). You should find that the distance between the melted patches of chocolate is around 6 cm, giving the waves a wavelength of 12 cm (0.12 m).

For waves, we know that...

speed = wavelength x frequency

speed = 0.12 x 2 450 000 000

Using the numbers above, we arrive at a speed of 294 000 000 m/s, which is pretty much the speed of light.

If your club got the right speed for light, and even if they didn't, they can go on to work out how long it would take for light to reach the Earth from the Sun.

They will need to use the following formula:

time = distance/speed

If everything is in metres and seconds, we have...

speed of light = 300 000 000 m/s

distance between the Sun and the Earth is 149 000 000 000 m

giving a time of 496 s, which is 8 min 16 s.

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Session 3

By now the club should be amazed at the amount of astronomy that can go on during the day. They should also have picked up an enormous number of facts about the Sun and how it can influence the Earth.

Have a look at the Institute of Physics' "Know how now" and "Food physics" public campaigns to see how amazing facts can be made into colourful and eye catching designs (**www.physics.org/facts, www.physics.org/food-physics**).

Individually or in teams, the students can continue looking into different aspects of the Sun and astronomy. Can they produce a short and snappy design about a single fascinating fact? They could use their designs to produce a poster, a badge, a postcard or even a t-shirt. Don't forget: they will need to include an eye-catching image and they may need to know some background information in case someone wants to find out more.

Some more websites that they may like to use to produce their final poster:

Curious About Astronomy? (**http://curious.astro.cornell.edu/sun.php**)
How Stuff Works, the Sun (**www.howstuffworks.com/sun.htm**)
ESA Kids – Our Universe, including full instructions to build a model of SOHO (**www.esa.int/esaKIDSen/TheSun.html**)

and beyond...

If students want to go further and do some early night-time astronomy, they can join Moonwatch. Visit the website to find out how to spot a new crescent moon, with help for students on how to make and report on their observations (**www.crescentmoonwatch.org**).

You can study the night sky using a real telescope without leaving the classroom. Have a look at the resources available on the Faulkes Telescope Project (**www.faulkes-telescope.com**) and National Schools' Observatory websites (**www.schoolsobservatory.org.uk**).

Student worksheet

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ACTIVITY 05

The Sun is our main energy source. It keeps the Earth warm and bathes us in light, which drives photosynthesis in plants. The Sun isn't just a smooth round ball of gas – it is constantly exploding material into space, releasing the energy formed in the intense pressure of its core.

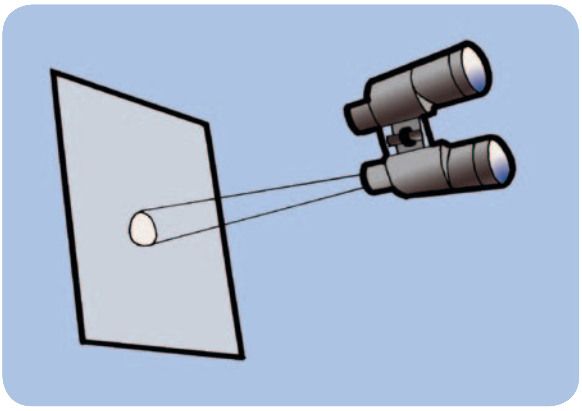
Session 1

WARNING Never look directly at the Sun – it can cause permanent blindness. Do not use a camera, binoculars or a telescope to look at the Sun either as these will cause permanent damage to the retina at the back of your eye.

To make observations of the Sun we need to use binoculars to project an image of it onto a flat surface. **Do not look through binoculars at the Sun.**

You will need:

- a large piece of paper
- a pencil
- binoculars, preferably with a tripod



What to do:

1. If you don't have a tripod, the best way to keep the binoculars steady is to use your shoulder. Cover one of the binoculars' lenses.
2. Hold the binoculars on your shoulder with your back to the Sun and with the wide end of the binoculars towards the Sun. The eyepiece of the binoculars should point towards a paper screen, which is taped in place on a wall, or on the floor if the Sun is high overhead.
3. Move the binoculars towards or away from the screen until you get a large image of the Sun. Then change the focus of the binoculars until the image is very sharp.
4. It is difficult to hold the binoculars steady, but do your best and get your friend to draw round the image of the Sun. Look carefully for any dark spots and mark these on the drawing – you may have found your first sunspots.

Student worksheet

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Session 2

The light that leaves the Sun doesn't immediately appear on the Earth – it takes time for it to reach us. If the Sun disappeared in a puff of smoke, how long would it be before we found out that all life on Earth was doomed? All you will need to work this out are a few facts, a microwave oven and some chocolate.

Microwaves are part of the same spectrum as light waves, so instead of using light waves to calculate the speed of light, we can use microwaves produced by a microwave oven. If your club leader has demonstrated the microwave experiment then you should know the distance between the melted patches of chocolate.

Use the following formula to work out how fast light travels from one place to another:

speed of light = wavelength of microwaves × frequency of microwaves

The wavelength of the microwaves is twice the distance between the patches of melted chocolate (don't forget that it needs to be in metres). The frequency of the microwaves in a microwave oven is 2 450 000 000 Hz.

Have you worked out the speed of light? You should have a value in metres per second.

To work out how long it will take light from the Sun to reach the Earth you will need the following formula.

time taken = distance travelled/speed of light

You have just worked out the speed of light. The distance between the Sun and the Earth is 149 000 000 000 m. How long does it take for light to reach us?

The Sun is so far away that it takes a surprisingly long time for light to reach us, but not so long that we would be able to do very much if the Sun did just pop out of existence.