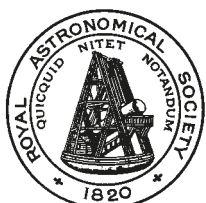


How to observe an eclipse safely



*Advancing
Astronomy and
Geophysics*



Introduction



On Friday 20 March 2015, the whole of the UK will be treated to a partial eclipse of the Sun. These are quite rare, and this one will be a major event. That morning, the Moon will pass right in front of the Sun, blotting out up to 90% of its disc. The Sun will look like a crescent instead of a disc, and there'll be various other things to look for.

However, it is extremely dangerous to just go out and look up. The Sun is so bright that just looking at it can blind you, so you'll need to prepare beforehand. There are various ways to observe it safely, using both everyday materials and telescopes or binoculars. So read this leaflet to find out what will happen and how you can see all the stages of the event.

This booklet was written by the Royal Astronomical Society with The Society for Popular Astronomy and is endorsed by the British Astronomical Association



The Royal Astronomical Society, founded in 1820, encourages and promotes the study of astronomy, solar-system science, geophysics and closely related branches of science.

www.ras.org.uk



sky and get involved. We even have a special Young Stargazers section, run by TV's Lucie Green.

www.popastro.com

The Society for Popular Astronomy is for beginners of all ages. Our aim is to make astronomy fun, and our magazine, *Popular Astronomy*, is full of information to help you get to know the



Formed in 1890, the British Astronomical Association has an international reputation for the quality of its observational and scientific work. Membership is open to all persons interested in astronomy.

www.britastro.org

1: What is a solar eclipse?

When the Sun goes out

A solar eclipse occurs when the Moon comes between the Sun and the Earth and casts a shadow on Earth. Anyone within a certain area will see the Moon cross in front of the Sun. In a very narrow band across the Earth's surface, the Moon passes centrally in front of the Sun's disc, completely blotting it out for a few minutes. Over a much wider area, which on 20 March 2015 includes the whole of the UK, the Sun is only partially covered by the Moon. It's not as spectacular, but it's a great thing to watch, and something you'll remember for the rest of your life. Let's hope it's clear on 20 March!

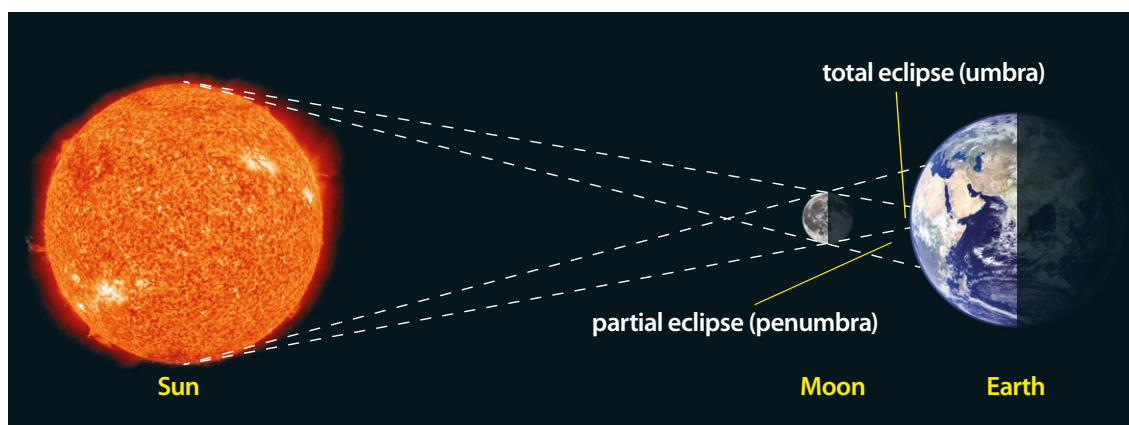
Solar eclipses do not happen very often because the conditions are quite specific. If the orbit of the Moon was in the same

plane as Earth's orbit around the Sun, total solar eclipses would happen every month. However, as is often the case with science, things are a little more complex than that, because the Moon's orbit around the Earth is tilted compared with the Earth's orbit

around the Sun, and both orbits are squashed into an ellipse. So for an eclipse to occur, the Moon has to be in the right place at the right time.

Because the Moon is smaller than Earth, its shadow during an eclipse covers only part of Earth's surface. So although there are always at least two solar eclipses a year, from any one spot you usually see a solar eclipse only every few years, usually a partial eclipse, though it may be total elsewhere. See the box on forthcoming eclipses ("If you miss this one...") for more information. ●

"You'll remember it for the rest of your life"



How a solar eclipse works

A solar eclipse occurs when the Moon comes between the Earth and the Sun and blocks out the light from the Sun. As the Earth and the Moon continue to move in relation to the Sun, the area of the total eclipse moves across the surface of the Earth. Thus the eclipse can be seen at different times from different parts of the world. (Note that the diagram above is not to scale.)

Did You Know?

The last total solar eclipse visible from the UK was in 1999, when thousands of people flocked to Cornwall to catch a glimpse. But for most of them it was cloudy. Just a few places saw the event through a break in the clouds.

What is a solar eclipse? (cont.)

Solar eclipse buzz words

First contact The moment when the Moon first starts to block the Sun and the first small "bite" appears in the edge of the Sun.

Second contact The moment during a total eclipse when the Sun is completely covered by the Moon.

Totality The period of time (usually a few minutes) in a total eclipse after second contact when the Sun is completely blocked by the Moon and a small part of the Earth is in full shadow.

Partial phase The period of time when only a section of the Sun is blocked by the Moon. In the UK none of us will see the Sun completely covered, so the eclipse will be partial throughout.

Third contact The moment in a total eclipse when the Sun reappears from behind the Moon.

Fourth contact The moment when the Sun is completely uncovered again.

Photosphere The visible "surface" of the Sun. As the Sun is gaseous, this is

not a solid surface but is actually a layer about 500 km thick, which is very thin seeing as the Sun is 1,391,684 km across. The photosphere is completely covered during the total eclipse.

Chromosphere Above the photosphere is a pink-red layer of gas, about 2500 km thick, known as the chromosphere. During totality it is possible to see the chromosphere in detail, as a ring around the darkness of the Moon's silhouette.

Baily's beads Because the edges of the Moon are not perfectly smooth, at the start and end of totality some sunlight shines through the valleys between mountains, with the appearance of beads. These are called Baily's beads after the scientist Francis Baily.

Diamond ring Just before third contact, when only one of Baily's beads is left shining, a diamond ring effect can be seen around the lunar silhouette.

Annular eclipse This occurs when the Moon's disc is smaller than the Sun's, so the Sun is not fully covered.

If you miss this one...

Here is a list of eclipses coming up in the next 15 years visible from the UK. All are partial as seen from the UK.

date and time of maximum eclipse	% coverage from centre of UK	comments
20 March 2015 09:31	89	total from N. Atlantic
21 August 2017 19:03	10	total from USA
10 June 2021 10:12	35	annular from Siberia and Canada
25 October 2022 09:57	26	
29 March 2025 11:03	45	
12 August 2026 18:11	93	total from N. Atlantic and Spain
2 August 2027 08:59	49	total from N. Africa
26 January 2028 16:47	63	annular from S. America and Spain
1 June 2030 05:23	56	annular from Mediterranean

2: What you'll see

Safety first

Remember, you can only view the eclipse using suitable filters or projection methods – see section 3.

There are so many special features associated with solar eclipses because each one is unique due to weather conditions, location and several other factors. But, once you've seen one, you'll be smitten!

The next total solar eclipse will take place on Friday 20 March 2015. Totality only occurs in a narrow path across the surface of the Earth and the only land in its path will be the Faroe Islands and Svalbard. The maximum point of totality is in the North Atlantic, about 700 km north of Shetland, where totality will last 2 minutes and 47 seconds at 9:45 a.m. GMT. If you are viewing the eclipse in the Faroe Islands, totality is shorter, but it will go dark (like twilight) in the morning for more than two minutes.

Away from the path of totality, the same eclipse will be a partial solar eclipse of varying degrees, visible across a region thousands of kilometres wide. If you live in Europe you will witness a partial eclipse of 60–95% coverage of the Sun by the Moon. The further north you are located, the more of the Sun will be obscured.

All of the UK will witness a partial eclipse of over 80% and, if the weather is favourable, at the maximum point of the

eclipse the Sun will look like a crescent. Because it will be a partial eclipse in the UK, we will not be able to view Baily's beads or the diamond ring effect. Daytime will not turn into night time, but it will still certainly be quite a spectacle.

The eclipse begins with first contact. You can't see details on the disc of the Moon, or the whole of the disc, during a partial eclipse – all you see is that a bit of the bright Sun is missing. It may take a minute or so before you notice it.

The Moon continues to move ever so slowly across the Sun until after 70 minutes (on this occasion) it has reached its maximum, and the Sun will appear as quite a thin crescent. The exact timings depend on where you are in the UK. Then the Moon moves off again, and after another 70 minutes it's all over, with fourth contact. What happened to second and third contacts? They only apply during a total eclipse, which we won't see this time. You'll either have to travel abroad or wait until 2090 to see a total eclipse from mainland UK.

"You'll have to wait until 2090 to see a total eclipse from mainland UK"

Things to look for

This won't be a total eclipse, which would give amazing views of the Sun's outer atmosphere (the corona) and maybe prominences, which look like flames around the edge of the Sun. During totality,

When to look

Exact timings vary by a few minutes within the UK, but from the centre of the country the timings are:

event	time (GMT)	direction	Sun's altitude
first contact	08:26	ESE	19°
maximum eclipse (89%)	09:31	SE	27°
fourth contact	10:41	SSE	34°

- The events are earlier the further west and south you are.
- To find global circumstances and animations of the Earth for locations across the globe, visit <http://astro.ukho.gov.uk/eclipse/0112015>.
- To find the exact viewing conditions and watch an animation of what to expect the solar eclipse to look like where you live, visit <http://www.timeanddate.com/eclipse/solar/2015-march-20>.

What you'll see (cont.)

the sky goes dark for a few minutes. For us, although at maximum the Sun will be a thin crescent, it will still seem like daylight, though maybe slightly eerie. If you didn't know there was an eclipse in progress you might just think there was cloud dimming the sunlight. If it is cloudy anyway, you might hardly notice any difference at all.

But if it's clear, when you look at shadows in the landscape, particularly at maximum eclipse, you may see that they will have an odd shape, being sharper in one direction than another. Small chinks of light will appear crescent-shaped. Usually people notice these in the shadows under trees, but in March there are fewer trees with leaves on so they won't be as easy to spot.

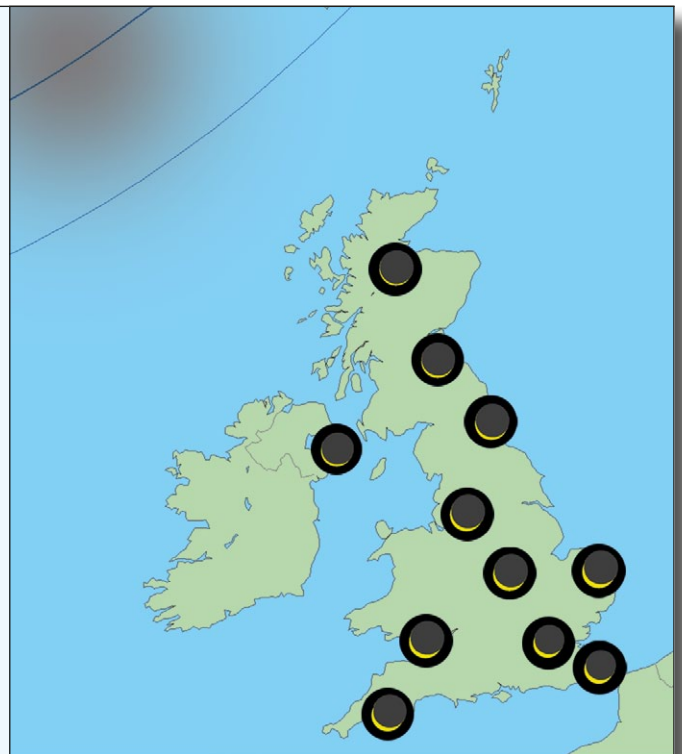
"You may notice that there are dark spots on the Sun: sunspots"

If you have a telescope and are projecting the image (see section 3), or are viewing it using a safe solar filter, you may notice that there are dark spots on the Sun: sunspots. These are places where the Sun's magnetic field restricts its light output. Although sunspots look black, they are still part of the Sun and if the Moon's disc happens to cross one you could notice that the Moon's disc is darker than the sunspot.

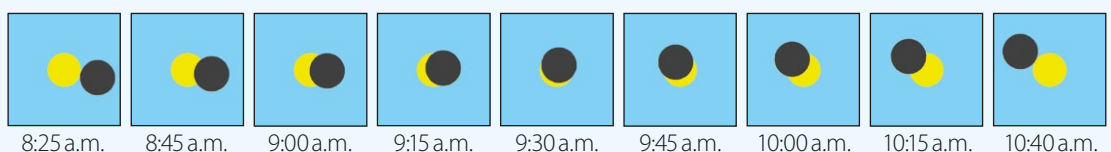
Also look at the edge of the Moon (known as the limb) and you might see that it isn't completely smooth, as you can see mountains or valleys on the limb silhouetted against the Sun. But you'll probably see a lot of shimmering at the limb, which is caused by turbulence in our own atmosphere rather than anything astronomical. ●

Across the UK

The diagram on the right shows the maximum phase of the eclipse from various locations in the UK. Scotland will witness a larger eclipse than the south of England. This is because the track of totality crosses the North Atlantic to the northwest of the UK, as indicated by the thicker blue line and shadow in the top left.



From London



These diagrams show how the eclipse progresses as the Moon moves from right to left across the Sun, as viewed from London. Timings are approximate.

3: View using household items

Danger!

How NOT to view a solar eclipse: with your eyes! *Viewing a solar eclipse is potentially hazardous and should only be attempted with caution. You should never, ever – under any circumstances – look directly at the Sun!* And no matter what anyone says, sunglasses will not provide adequate protection for your eyes. The only exception to this rule is the brief period of totality when the Sun is completely covered – but no-one in the UK will be able to see this on 20 March 2015.

Viewing an eclipse is dangerous because the Sun's photosphere emits very hot infrared radiation and high-energy

ultraviolet radiation. These types of radiation can burn your skin and hence they will do similar damage to your eyes if you look directly at the Sun. You only need to look at the Sun for a few seconds for your eyes to become permanently damaged.

In the same way, you should never look at the Sun through binoculars, a telescope or any other direct method. Astronomers use special solar telescopes or filters to view the Sun directly, but most of us do not have access to these types of equipment.

However, there are things we can get hold of easily – or even make – that are safe to use, as suggested below. ●

Eclipse viewers

If you are able to find a pair of eclipse viewers or shades then that is a safe and enjoyable way to view the eclipse directly. Eclipse viewers are made of card with special material inlaid, and you hold them up to the eclipse to view it. If you manage to get hold of a viewer, you should check it for damage such as holes or scratches, as only undamaged filters are safe to use.

Eclipse shades are a bit like the 3D card glasses you used to get at the cinema, but they have special dark material in them to cut down the Sun's light by 100,000 times.

Never use material that just looks dark, such as bin liner or gift wrap. Even though



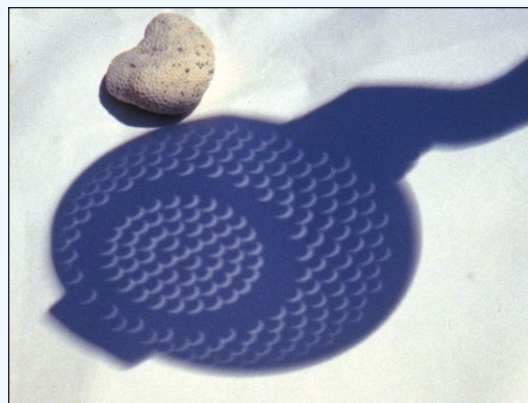
it cuts down the visible light, it might not cut out the dangerous infrared light, so you could still do permanent damage to your eyes.

Don't look up at the Sun then hold up the viewer – put the viewer to your eyes before you look at the Sun!

For more information on how to obtain eclipse shades, see section 4.

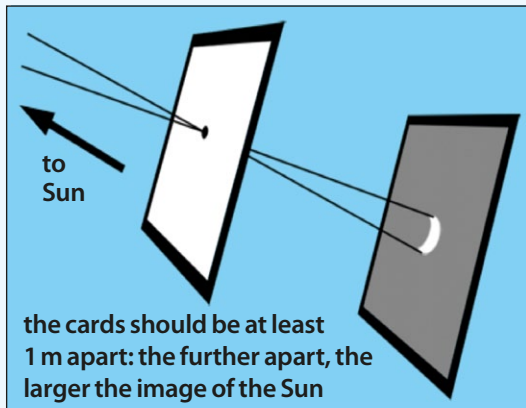
Colanders

By far the simplest way to view an eclipse is to use an item you normally find in the kitchen: a colander. Stand with your back to the Sun and hold the colander in one hand and a piece of paper in the other. Hold the colander between the Sun and the paper and watch as you safely observe many images of the eclipse on one piece of paper!



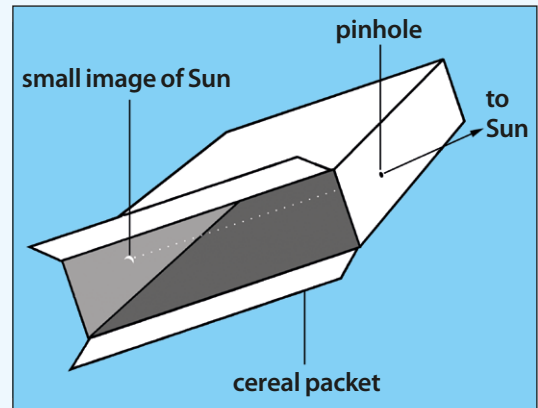
NIGEL LEWIS/GALAXY

Pinhole viewers



A simple yet safe way to view the solar eclipse is by making a pinhole viewer.

Pinholes allow light through them, and can create an image like a lens. All you need for this are two pieces of white card. Poke a small hole in one piece of card using a compass or a similar tool. Stand with your back to the Sun. Hold both cards up, with the one with the pinhole closer to the Sun. The light through the pinhole can be projected on to the other



piece of card, allowing the eclipse to be viewed safely.

An alternative to this is to use a cereal box or similar. Make a pinhole in one edge. Point this towards the Sun and you'll see a tiny image of the Sun projected on to the inside of the packet. Put white paper or card on the inside to make it easier to see.

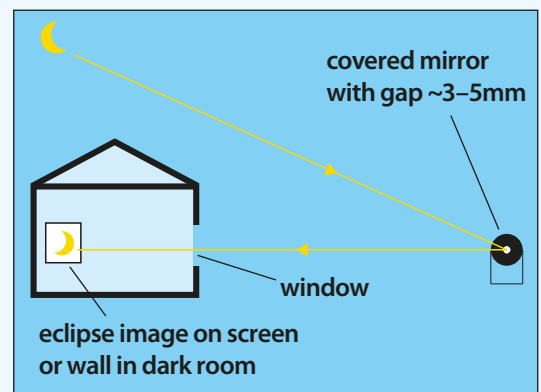
Never look through the pinhole at the Sun, but only at the projected image.

Mirrors

A small mirror, such as a make-up mirror, can be used to reflect the image of the eclipse onto a white wall. Do not use a magnifying mirror. Do not look into the mirror at the eclipse as this is just as dangerous as looking directly at the Sun.

Cover the mirror with paper in which you have made a hole no more than 5 mm across. Stand with your back to the eclipse. Use the mirror to reflect an image of the Sun onto a light-coloured wall, being careful not to reflect the sunlight into anyone's eyes.

This works well when you are about 5 m away from the wall. The smaller the mirror and the further away the wall, the sharper the image you should get. Experimenting with the distances



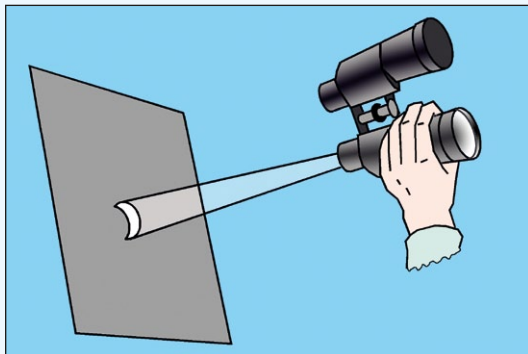
and mirror size should make the image brighter. To make the image clearer to see, use an indoor wall in a house and reflect the image in through a window.

Notice that the shape of the hole – even a triangle – still gives a circular disc of the Sun.

Did You Know?

There was an annular eclipse visible from the north of Scotland in 2003. On that occasion, early morning mist spoiled the view for many.

Projection using binoculars or a telescope



A pair of binoculars can stand in for a pinhole. Cover one eyepiece with the lens cap, then when the binoculars are pointed at the Sun you should see its image projected onto the plain card. Use the focus wheel to sharpen the image. This method works best if both the card and binoculars are mounted on a tripod.

Never, ever, look directly into the binoculars while they are pointed at the Sun.

You can use a telescope in the same way. If it has an aperture (lens or mirror size) larger than about 50 mm, it may come with a cap that reduces its aperture to this size for safety. But while this method is safe for humans, unless you are careful it can damage your valuable binoculars or telescope. This is because the Sun's light is focused on the inside of the eyepiece, which could contain plastic parts. If the



ROBIN SCAGELL/GALAXY

Sun drifts out of the field of view, it might melt the inside of the eyepiece! So take great care, or use an old eyepiece (many older eyepieces used metal rather than plastic).

An alternative is to completely cover the top end of the telescope with suitable solar film, such as Baader AstroSolar. This is available in A4 sheets which you can cut to fit. As long as the material fully covers the top end, with no chance of the filter being dislodged and no chinks in the holder, it is perfectly safe to view the partial eclipse through the telescope.

This is also the material to use if you want to photograph the eclipse through a telephoto lens. An alternative is to photograph the projected view with an ordinary camera or even your phone camera.

Did You Know?

An eclipse of the Moon occurs when the Moon passes through the shadow of the Earth. Unlike a solar eclipse, this only happens at night, and it can be seen from anywhere on Earth where the Moon is visible. The next total lunar eclipse visible from the UK will be in the early morning of 28 September 2015.

4: Resources and websites

Resources for teachers

Primary resources

- **Role-play a solar eclipse**
www.ras.org.uk/education-and-careers/for-schools-and-teachers/2554-solar-eclipse-role-play
- **Paper model of a solar eclipse**
sunearthday.nasa.gov/2008eclipse/materials/My_solar_eclipse.pdf
- **Write a newspaper article**
www.ras.org.uk/education-and-careers/for-schools-and-teachers/2555-solar-eclipse-newspaper-article

Secondary resources

- **Solar eclipse worksheet (years 7–9)**
www.ras.org.uk/education-and-careers/for-schools-and-teachers/2556-solar-eclipse-worksheet-years-7-9
- **The maths of a solar eclipse (year 10–11)**
www.ras.org.uk/education-and-careers/for-schools-and-teachers/2557-the-maths-of-a-solar-eclipse-year-10-11

Eclipses in general and the 20 March 2015 eclipse

- **Royal Astronomical Society**
www.ras.org.uk/education-and-careers/for-everyone/2558-solar-eclipses
- **Eclipse Calculator: select your town**
www.timeanddate.com/eclipse/in/uk/london?iso=20150320
- **UK Hydrographic Office: the eclipse of 20 March 2015**
astro.ukho.gov.uk/eclipse/0112015
- **The eclipse of 20 March 2015**
www.solareclipse2015.org.uk/chasing-the-shadow/about-the-eclipse
- **Sheridan Williams: topical and historical eclipse information**
www.clock-tower.com/eclipse.htm
- **European Space Agency: general eclipse information**
www.esa.int/Our_Activities/Space_Science/What_is_an_eclipse
- **HM Nautical Almanac Office: solar and lunar eclipses**
www.eclipse.org.uk

Make an eclipse viewer

- **The Exploratorium in San Francisco, USA, gives simple ways of viewing the Sun**
www.exploratorium.edu/eclipse/how.html
- **Construct your own eclipse viewer**
www.scholastic.com/browse/subarticle.jsp?id=2265
- **How to make a shoe-box viewer to safely view the solar eclipse**
www.youtube.com/watch?v=SILKLi1OG4
- **A step-by-step guide to making a cereal box viewer**
hilaroad.com/camp/projects/eclipse_viewer/eclipse_viewer.htm
- **European Space Education Resource Office links to eclipse viewing information**
www.esero.org.uk/news/solar-eclipse-2012

Buy safe eclipse viewers or projectors in the UK

- www.eclipseglasses.co.uk
- www.harrizontelesopes.co.uk/acatalog/Solar_Eclipse_Glasses.html
- www.amazon.co.uk/Eclipse-Glasses-Solar-Shades-Black/dp/B00PZ5K0XI/ref=sr_1_cc_1?s=aps&ie=UTF8&qid=1418390762&sr=1-1-catcorr&keywords=rainbow+symphony+eclipse
- www.telescopehouse.com/acatalog/Eclipse_Viewing_Pack.html
- www.widescreen-centre.co.uk/Products/THE_SOLAR_PROJECTOR.html
- www.britastro.org/solarviewers
- www.firstlightoptics.com/solar-filters/baader-solar-eclipse-observing-glasses.html
- **Or buy them in person from the SPA stand at AstroFest 2015**
europeanastrofest.com

Free eclipse viewers!

- If you are an SPA member, or if you join in January or February 2015, you will automatically receive an eclipse viewer with the magazine in March 2015. See www.popastro.com
- If you print this leaflet out and bring it to the RAS in London before 20 March 2015, the first 100 people will receive a free eclipse viewer. Our address is Burlington House, Piccadilly, London W1J 0BQ.
- If you follow @RAS_outreach and @popastro and tweet to tell us where you'll be viewing the eclipse – using #eclipse2015 – before 15 March 2015, the first 100 tweets will receive a free eclipse viewer. Viewers will be sent out by second-class post and therefore will only be available to UK recipients.

Get yourself on our viewing map!

- Tweet @RAS_outreach and @popastro – using #eclipse2015 – and tell us where you'll be viewing the eclipse. Fill in your details on our interactive map to share where you'll be viewing the eclipse: www.solareclipse.ras.ac.uk

Keep in touch

- If you want to come to the RAS public viewing event on 20 March 2015 or if you just want to know more, join our mailing list by tweeting @RAS_outreach or emailing outreach@ras.org.uk
- Schools can have an eclipse-related school visit by our Education, Outreach and Diversity Officer (and they might even bring some free eclipse viewers with them). Email outreach@ras.org.uk if you are interested in a school visit.

On the day

- Tweet us with photos of you viewing the eclipse! Tweet @RAS_outreach and @popastro – using #eclipse2015 – and send us your photos.
- Come and watch the eclipse with the RAS!

Watch Lucie Green explain safe viewing



The SPA is producing a video starring Lucie Green of BBC TV's *Sky at Night*, in which she shows how to observe the eclipse safely. To view it, keep an eye on the SPA website: www.popastro.com