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Solar Eclipse Activities

Ideas for activities to do during the Solar Eclipse on the Morning of March 20th, 2015

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Solar Eclipse Activities

Introduction

Here is a selection of activities suitable for the partial solar eclipse on Friday 20th March, 2015.

This booklet contains details about…

- Safety!
- Day & Night, Seasons & Orbits
- How eclipses work
- Solar eclipse glasses
- Pin-hole cameras
- Binocular projections
- Solar telescopes & filters
- Details of this eclipse
- Future eclipses
- Glossary

Note that all the experiments mentioned here can also be used to see sun spots – Not just for eclipses!

Safety!

Before anything else – never look directly at the Sun! This can be dramatically demonstrated (with safety precautions) using a magnifying glass and paper in the school playground (and a bucket of water…). The human eye contains a lens that focus' light onto the retina at the back of the eye. If you look at the Sun without using a solar filter, you will literally burn the back of your eyes and will go blind.

This document suggests many ways to safely enjoy a solar eclipse.

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Day & Night, Seasons & Orbits

Equipment List

- Inflatable Earth, Sun and Moon from a set of inflatable planets.
- Spot light or bright torch.

Activity: Earths' Orbit

- With two volunteers holding the Earth and the Sun, demonstrate how the Earth goes around the Sun and discuss the how long this takes (a year).
- Show how the Earth's daily rotation on its (tilted) axis gives us day and night. It can be effective to use the torch to act as the Sun shining on the surface of the Earth, by having a third volunteer stand by the Sun and point it toward Earth with the classroom lights turned off.

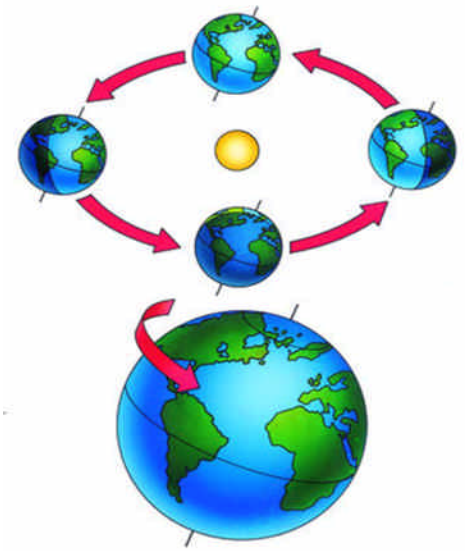
Activity: Seasons

- The earth is tilted on its axis (by 23°), which is why the Earth experiences seasons. During the Earth's yearly orbit of the Sun, for part of the time the North Pole is tilted toward the Sun, giving a northern summer. Six months later it is tilted away, giving it a northern winter. Summer in the north coincides with winter in the south.
- The varying temperatures of the seasons are most effectively demonstrated using a torch or spot light. Shine the light directly downwards to show the intensity of the light. Now tilt the light to show that when the light shines over a larger area it is less intense. This is essentially what is happening in winter – the Earth is tilted away, and so instead of being directly beneath the Sun, the Sun-light is spread over a larger area. In addition, since the Sun is above the horizon for longer, it has more time to warm up that part of the planet.

Activity: Scaled model

- Ask three volunteers to hole the Earth, Sun and the Moon, and a fourth standing by the Sun with a torch to act as the light from the Sun.

- Discuss the scale of the Sun in relation to the Earth. Ask the class to guess how big the Earth would be (to scale) if the Sun was actually the size of the inflatable Sun, and at what distance it would orbit. The Earth would be approximately 0.7cm across and would orbit around 100m away – this shows that there is a lot of space in space! Show the class a ~7mm ball bearing (or a ball of Blu-tack) and let them know that the Earth fits into the Sun just over a million times.



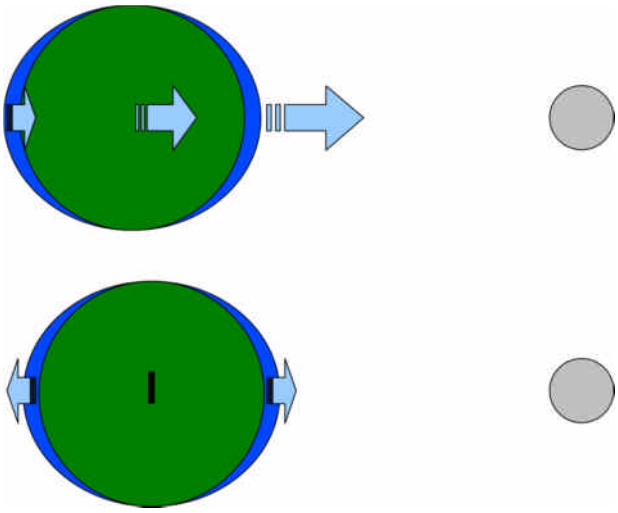
- Earth is approximately four times the size of the moon, separation is 30x earths diameter (you can do this to scale)

- Using the inflatable Earth, the Moon would be the size of a tennis ball and 10m away.

Activity: Lunar Orbit

- The Moon orbits the Earth every month – hence the name. To be exact, the synodic orbital period is 29.5 days.
- Moon orbits the Earth 12 times a year (once every 29.5 days), with 11 days left over. So each month gets an extra day. However ancient people couldn't agree on which months got extra days, and that's why our calendar is a mess.
- The Moon's "day" length (time to rotate once) is also 29.5 days, so this means the same side of the Moon always faces the earth. This is not coincidence, but a minimum energy configuration – all the moons and planets in the solar system are slowing their rotation to get geosynchronous lock with the body they orbit.
- Talk about how the Moon reflects light from the Sun, and doesn't radiate light itself. Move the Moon around the Earth in order to show how the phases of the moon happen. The torch may be useful here if you can make the classroom dark.
- The far side of the Moon is sometimes called the dark side of the Moon. This is wrong, half the time it's the light side! It's just that we never see it because the same side is always facing us.

Activity: Tides



- The gravitational pull of the Moon and the Sun causes the tides – the Moon dominates this (~70%) compared to the Sun (~30%). As the Moon's gravitational force pulls on the water of the oceans it causes 'bulges' in the ocean on both sides of the planet. Think of the Moon pulling on water on the same side by a lot, pulling on the Earth a bit, and "leaving behind" the water on the far side. It is the differential (rate of change in) forces that cause the tides, not force alone (see diagram). Throughout the day as the Earth rotates beneath the Moon, the water 'bulges' in different parts of the planet. This is why we get two tides per day, and not just one.

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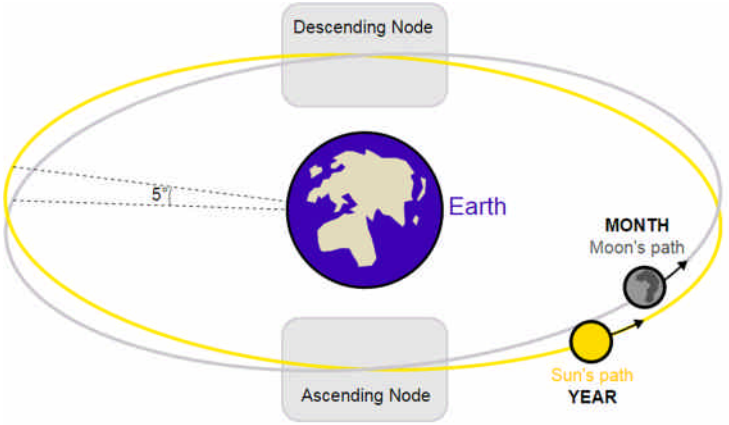
How Eclipses Work

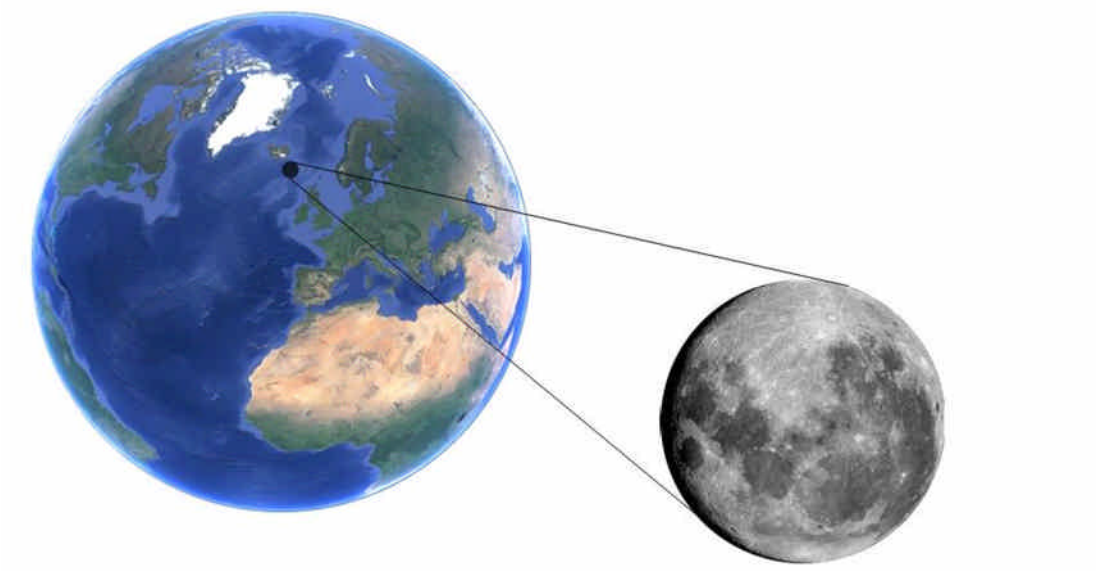
Equipment List

- Inflatable Earth, Sun and Moon from a set of inflatable planets.
- Tennis ball (or anything approximate a quarter of the size of the Earth)
- Spot light or bright torch.



Definitions

- A **Total Solar Eclipse** occurs when the Moon exactly passes across the face of the Sun, and covers the entire Sun (due to it being closer than average on its elliptical orbit)
- An **Annular Solar Eclipse** occurs when the Moon passes directly in front of the Sun, but does not completely cover the Sun because it is slightly more distant on its orbit (and so has a smaller angular diameter than the Sun). This occurs 60% of the time.
- A **Partial Solar Eclipse** occurs when the Moon passes in front of the Sun, but slightly off to one side and so the Sun is not completely covered.



- **Lunar eclipses** occur when the Moon passes through the Earth's shadow.

- Either can be demonstrated using a lamp and tennis ball, and (with practice) you can form a well-focused shadow to demonstrate either the shadow of the Earth for a lunar eclipse, or how localised a solar eclipse is, by making a shadow on either the inflatable Earth or a piece of paper for clarity.
- The width of the total solar eclipse path is less than 250km, although a partial eclipse can be seen from a much larger area (~3,200km either side of the path of totality).
- Eclipses do not occur every month. The orbit of the Moon around the Earth is tilted by 5 degrees, and so the Moon usually passes just above or below the Sun at New Moon for a solar eclipse, or just above or below the Earth's shadow for a lunar eclipse.
- The Earth-Sun separation also varies during the year, but this has a smaller effect on tide height. On average, the Moon appears to be slightly smaller than the Sun as seen from Earth, so the majority (about 60%) of central eclipses are annular. It is only when the Moon is closer to Earth than average (near its perigee) that a total eclipse occurs.

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Solar Eclipse Glasses

Activity

Solar eclipse glasses can safely allow people to observe the eclipse. Note that *you must ALWAYS check for damage to the glasses before using them, to avoid blindness.*

We have a limited number of free eclipse glasses to handout to schools. If you would like up to 5 pairs. Please send a self addressed envelope to Dr Darren Baskill, Physics & Astronomy, University of Sussex, BN1 9QH.

Pin Hole cameras

Equipment List

- Card or a paper plate – just add a small hole with a sharp pencil
- Anything with holes – a colander, scarf, etc. In fact, the more unusual the better!

Activity

A simple, novel and safe way to view the eclipse is through using the pin-hole camera technique – put a hole in an item, and an image of the sun can be projected onto white paper. A huge range of items can be used – anything with small holes!

The following photographs show such examples:

- School child with a hole made by a pencil through paper, and the image of the (crescent Sun) is projected onto another sheet of paper.
- Three holes made in the bottom of a coffee cup project three images of the crescent Sun onto a wall.
- A scarf full of holes between the threads projects hundreds of images of the Sun onto the ground
- A Panama hat casts images of the Sun onto this lady's shoulder

- Fingers can be crossed to form tiny holes between them…
- …forming multiple images of the Sun when projected!
- The gaps between leaves on a tree act as natural pin holes.

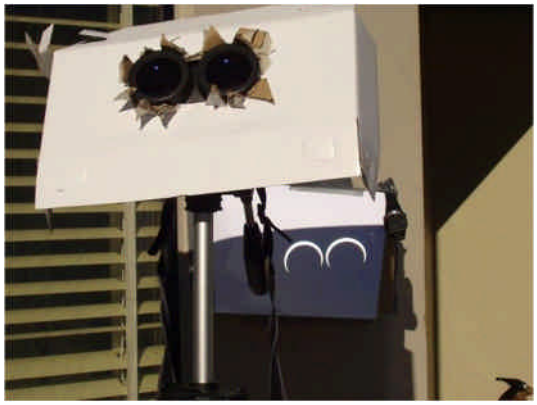





Binocular projections

Equipment List

- Binoculars
- Tripod
- Card
- Magnet and iron filings



Activity

Binoculars can be used to project high-resolution images of the Sun onto a background – useful for both observing the eclipse and viewing sunspots. A tripod is recommended to make life easier.

Take care that the binoculars are not pointing at the Sun for too long, as this may damage them. This should not be a problem if the binoculars are on a static mount, which does not track the Sun. The Earth rotates such that the Sun appears to move across the sky by its own diameter (0.5 degrees) in just 2 minutes, so the binoculars will need to be repointed every few minutes to follow the Sun which could damage the binoculars if they are not filtered.

If you use this method, please USE EXTREME CAUTION to prevent anyone trying to look through the binoculars – something which would lead to instant blindness.

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Solar telescopes and filters

Equipment List

- Cardboard box solar telescope
- Solar filters to fit a wide range of telescopes and binoculars
- Hydrogen alpha telescope

Activity

The Sun is the only star we can examine in detail (due to its proximity), and the only star visible during school lessons, so it may be worth buying equipment for observing sun spots and solar flares on any day, and not just for the eclipse.

Filters fit over the end of any telescope or pair of binoculars, and reduce the intensity of the Sun by a factor of ~100,000 times, making it safe observe the Sun. Cardboard solar telescopes use a simple lens and mirror arrangement to project an image of the Sun on the inside of the box, as pictured. Both are ideal for viewing sun spots.

A sun spot is a region of the sun that is cooler, and so appears darker, that the rest. They are caused by the magnetic field of the solar popping out and back into the Sun. By observing sunspots frequently, students can work out how quickly the Sun rotates –once every 25 days at the equator, and once every 35 days at the poles. Sun spots can change shape dramatically over hours and days.

Left: Sun spots through a 8" Newtonian telescope (£750) with an Orion solar filter (£120)
Middle: View through a Coronado SolarMax 40 H-alpha solar telescope (~£1500)
Right: View with the SOHO space telescope (~£730M)

A hydrogen-alpha telescope filters out light by only allowing a very narrow wavelength of light through. Only the primary (red) light from hydrogen gas is allowed through, with all other colours blocked – which is how the telescope reduces the intensity of the Sun by a factor of 1 million. Using such a telescope allows you to see prominences of gas bursting out from within the Sun along the magnetic field lines that can visibly change within an hour.

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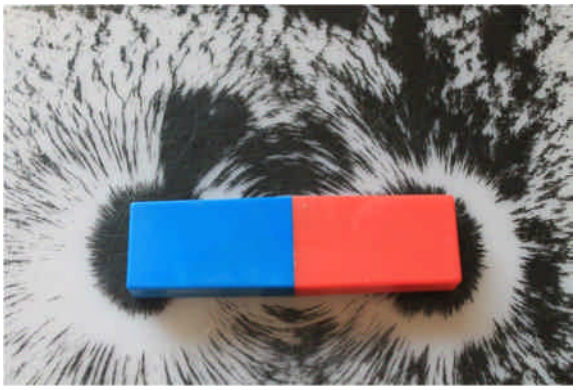
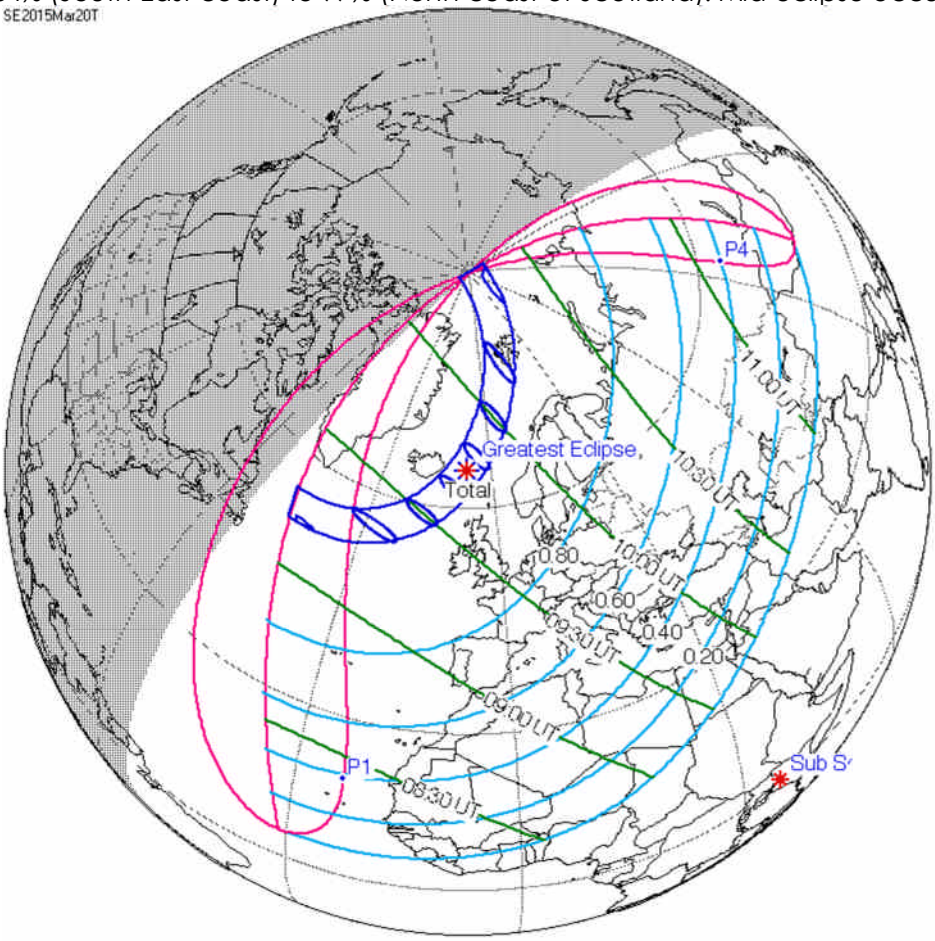
It is worth comparing what can be seen through the telescope, with a magnet and iron-filings in the classroom (right) – both scales show magnetic fields with loop structures.



Example prices of equipment are…:
- Lightec (cardboard) Solar Projection Telescope: £50 from Green-witch.com
- Solar filters: £70-£170 from http://www.scsastro.co.uk/category/solar-viewing (filters for a large range of binocular and telescope sizes)
- Hydrogen Alpha Solar telescopes (e.g. the Coronado range): £700-£7000 http://www.rothervalleyoptics.co.uk/solar-telescopes.html

Details of this eclipse

The eclipse will last from 08:26am to 10:41 over the UK, where the Moon will cover the Sun by between 84% (South-East coast) to 97% (North coast of Scotland). Mid eclipse occurs at 09:31.



Live feeds of the eclipse will be available on the internet, including (weather and technology permitting!) from the University of Sussex – visit **http://www.sussex.ac.uk/physics/outreach** on the day.

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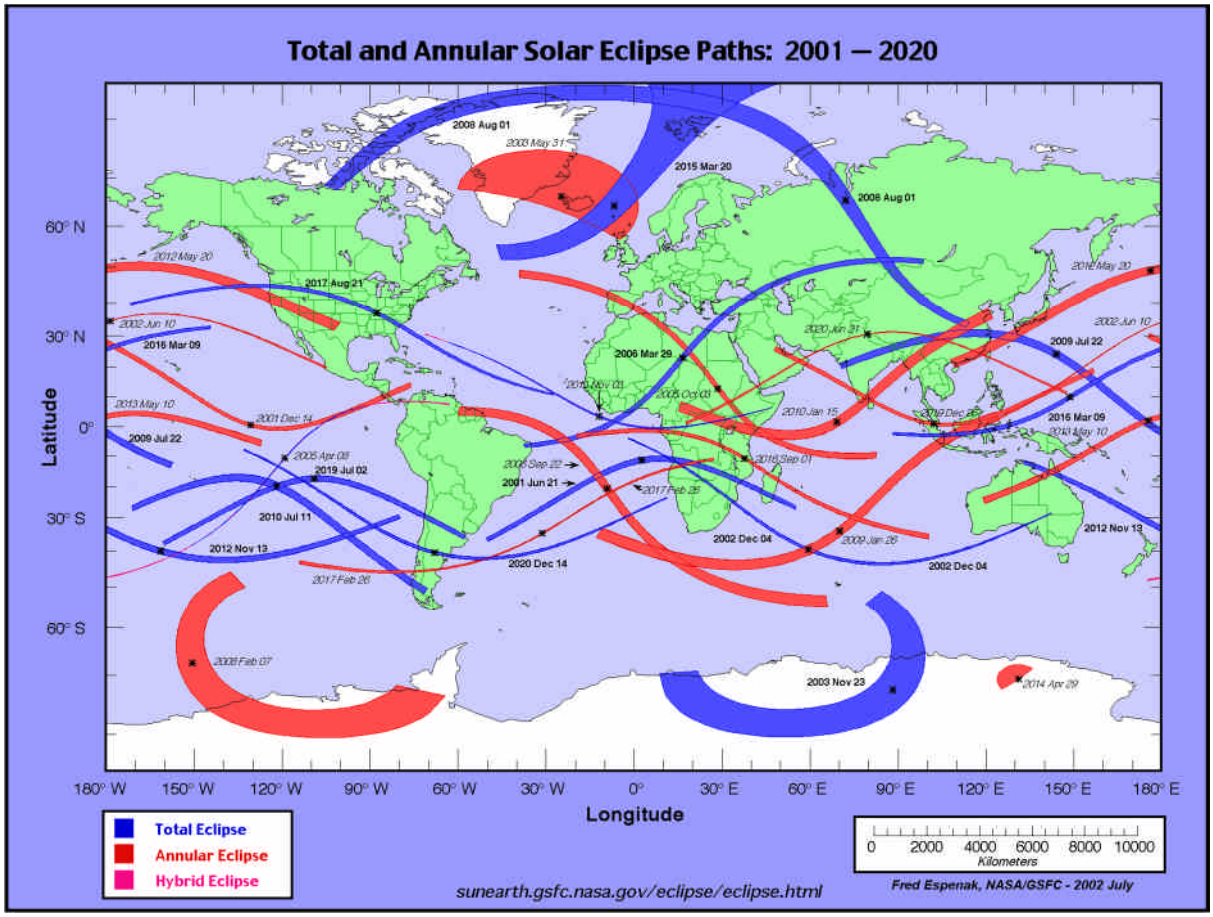
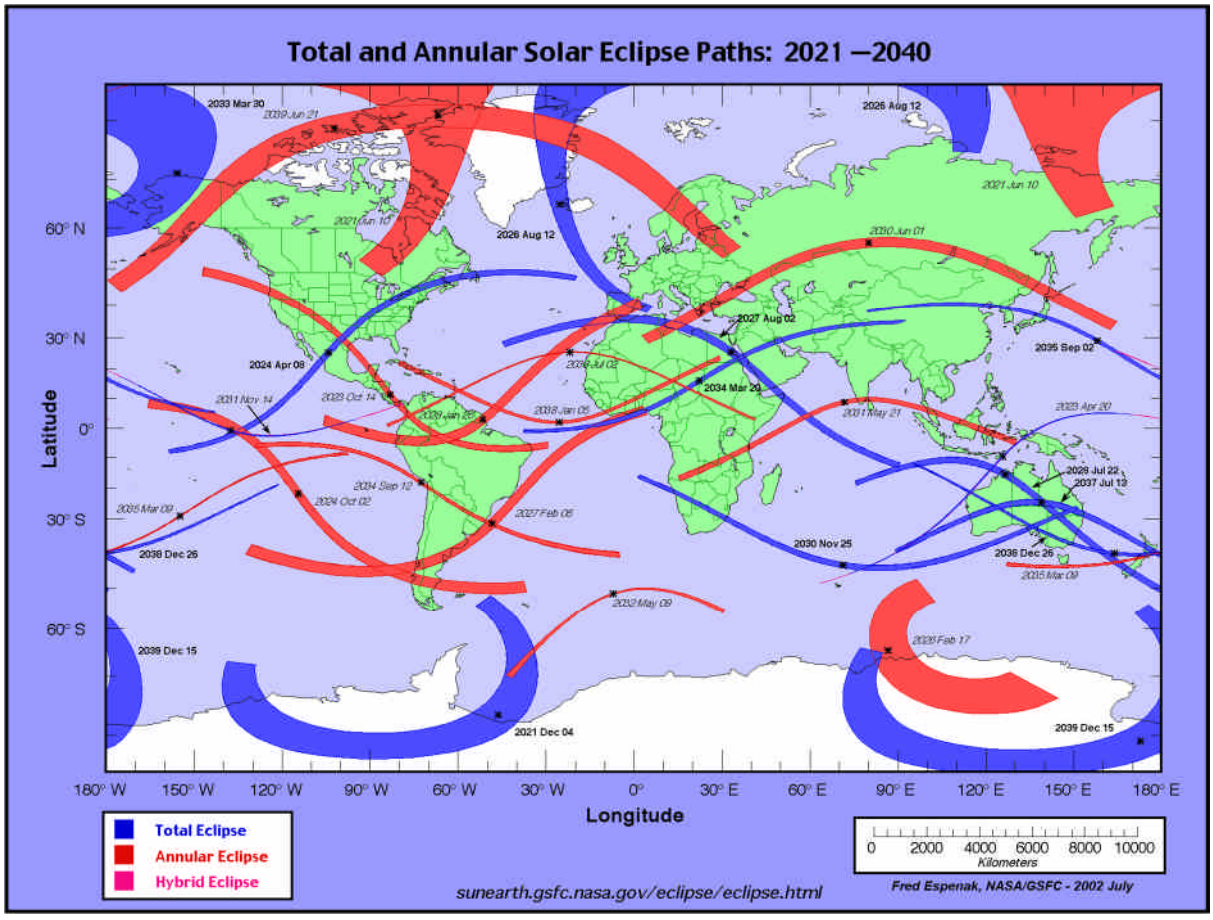
Future Eclipses

The next two solar eclipses are both total - one visible through Indonesia on 9th March, 2016, and the next crosses the USA on the 21st August, 2017.

Partial solar eclipses can be seen within ~3,000 miles of any of the eclipse paths shown on the maps below.




Total and Annular Solar Eclipse Paths: 2021 –2040
2033 Mar 30
2039 Jun 21
2026 Aug 12
2021 Jun 10
2030 Jun 01
2027 Aug 02
2024 Apr 08
2035 Sep 02
2034 Mar 20
2031 May 21
2023 Apr 20
2029 Jul 22
2037 Jul 13
2028 Nov 25
2036 Dec 26
2025 Mar 29
2032 May 09
2039 Feb 17
2039 Dec 15
2021 Dec 04
60° N
30° N
0°
30° S
60° S
Latitude
180° W
150° W
120° W
90° W
60° W
30° W
0°
30° E
60° E
90° E
120° E
150° E
180° E
Longitude
Total Eclipse
Annular Eclipse
Hybrid Eclipse
0 2000 4000 6000 8000 10000
Kilometers
sunearth.gsfc.nasa.gov/eclipse/eclipse.html
Fred Espenak, NASA/GSFC - 2002 July

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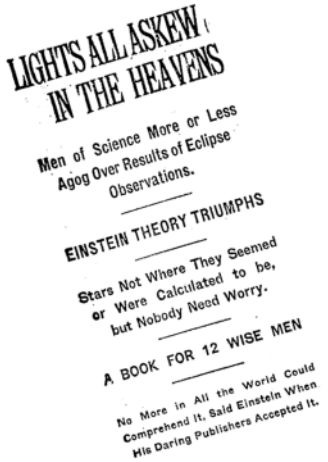
Glossary

- **Total Solar Eclipses** occur when the Moon exactly passes across the face of the Sun, and covers the entire Sun (due to it being closer than average on its elliptical orbit)
- **Annular Solar Eclipses** occur when the Moon passes directly in front of the Sun, but does not completely cover the Sun because it is slightly more distant on its orbit (and so has a smaller angular diameter than the Sun). This occurs 60% of the time.
- **Partial Solar Eclipses** occur when the Moon passes in front of the Sun, but slightly off to one side and so the Sun is not completely covered.
- **Lunar eclipses** occur when the Moon passes through the Earth's shadow.

- **Totality** – The moment when the Moon completely blocks out the Sun, which can last for a maximum of 7 minutes 30 seconds. Both the Earth and Moon orbit their parent body in ellipses. The closer the Moon is to the Earth, and the further the Earth is from the Sun, the longer a total eclipse will last. During totality, the solar corona is visible.
- **Solar Corona** – The plasma that is being emitted by the Sun. Because it is much fainter than the Sun itself, the corona is only visible during an total solar eclipse (with the exception of using a coronagraph instrument).
- **Baily's Beads** – Just before or after totality, this is the effect of sunlight shining down multiple valleys on the edge of the Moon towards the Earth. They are visible for only a few seconds as a couple of points of light along the edge of the Moon.
- **Diamond Ring** – this is just one, brightly shining, Baily's Bead.

- **Eclipse glasses** – A cheap and safe way to view an eclipse. The eclipse glasses film makes the Sun appear a million times fainter.
- **Pin hole camera** – A small hole in material (e.g. card) such that an image is formed through it like a lens, and can be projected. No lens is needed. Since only a small amount of light can get through the pin hole, the image projected is much fainter. However, this is not an issue when projecting an image of the very bright Sun.
- **Solar telescope** – A telescope with a specialised filter on the end that makes the image of the Sun much fainter (approximately, a million times fainter), such that it is safe to observe the Sun. The filters work by only allowing a very narrow wavelength of light to pass through. For H-alpha telescopes, the Sun appears red, as only red light from hydrogen plasma in the Sun is allowed to pass through. For Calcium-K solar telescopes, only blue light is allowed through, and so the Sun appears blue.


LIGHTS ALL ASKEW IN THE HEAVENS

Men of Science More or Less Agog Over Results of Eclipse Observations.

EINSTEIN THEORY TRIUMPHS

Stars Not Where They Seemed or Were Calculated to be, but Nobody Need Worry.

A BOOK FOR 12 WISE MEN

No More in All the World Could Comprehend It, Said Einstein When His Daring Publishers Accepted It.

Through observing the total solar eclipse of May 29, 1919, Eddington was able to confirm Einstein's theory of general relativity. The result was featured on the front page of newspapers around the world and made Einstein famous!