La Société Guernesiaise Astronomy Section

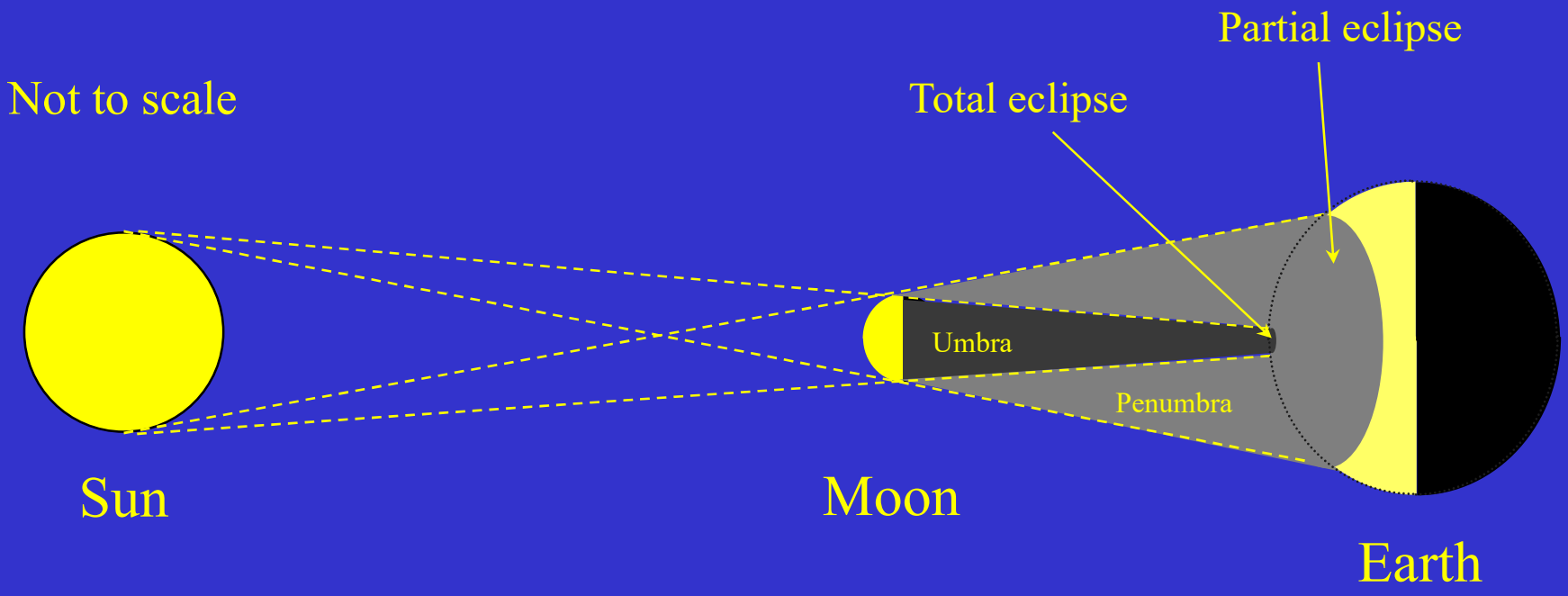
Eclipses of the Sun and Moon

Why they happen, when they happen, and how to observe them safely

David Le Conte

The geometry of a solar eclipse

The Moon passes in front of the Sun, blocking it out either totally or partially.

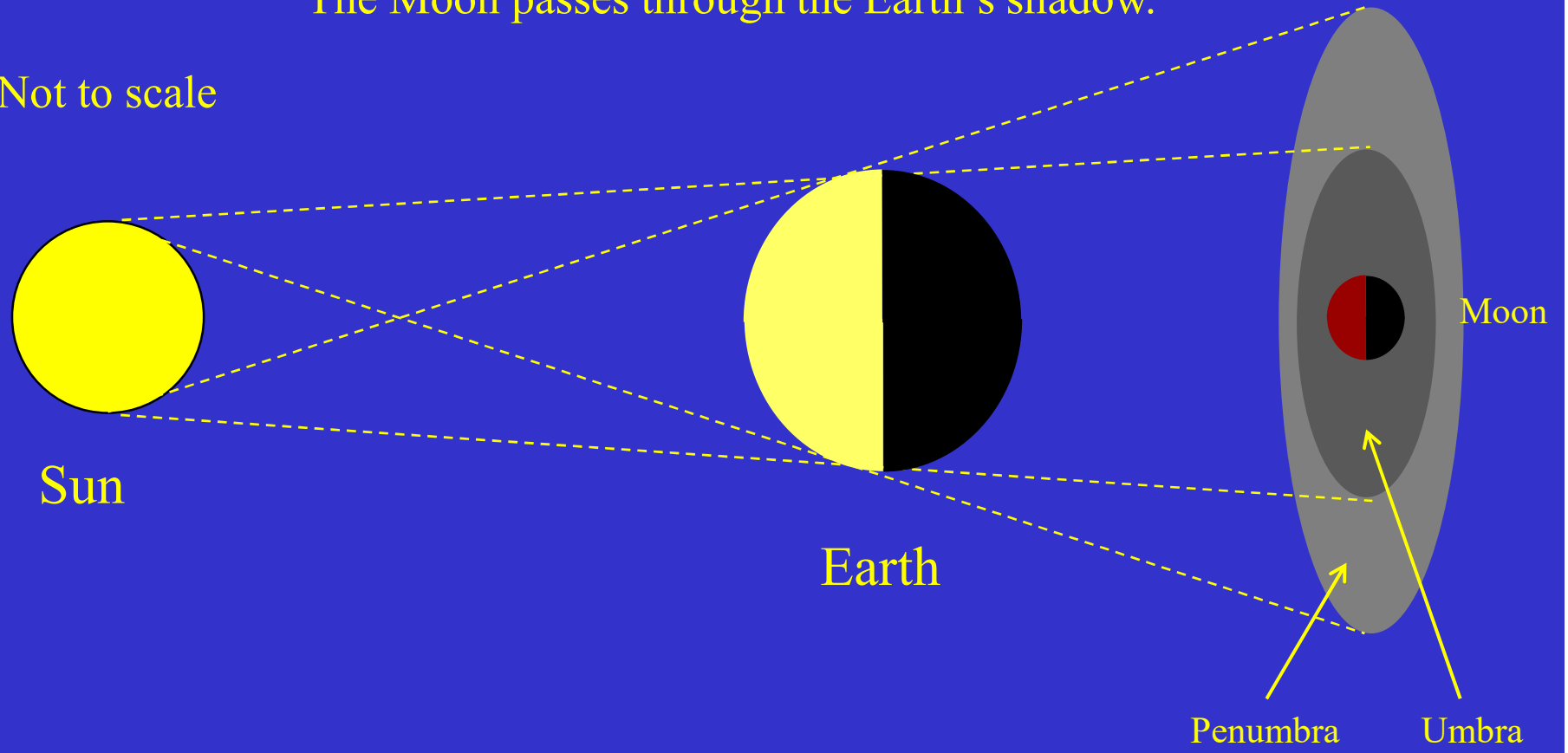


You have to be within the umbra to see the Sun totally eclipsed.
That is within the small spot (typically about 150km, 100 miles wide) on the Earth.
The spot moves rapidly, so totality lasts only a matter of minutes.
For hundreds of miles either side, within the penumbra, there is a partial eclipse.

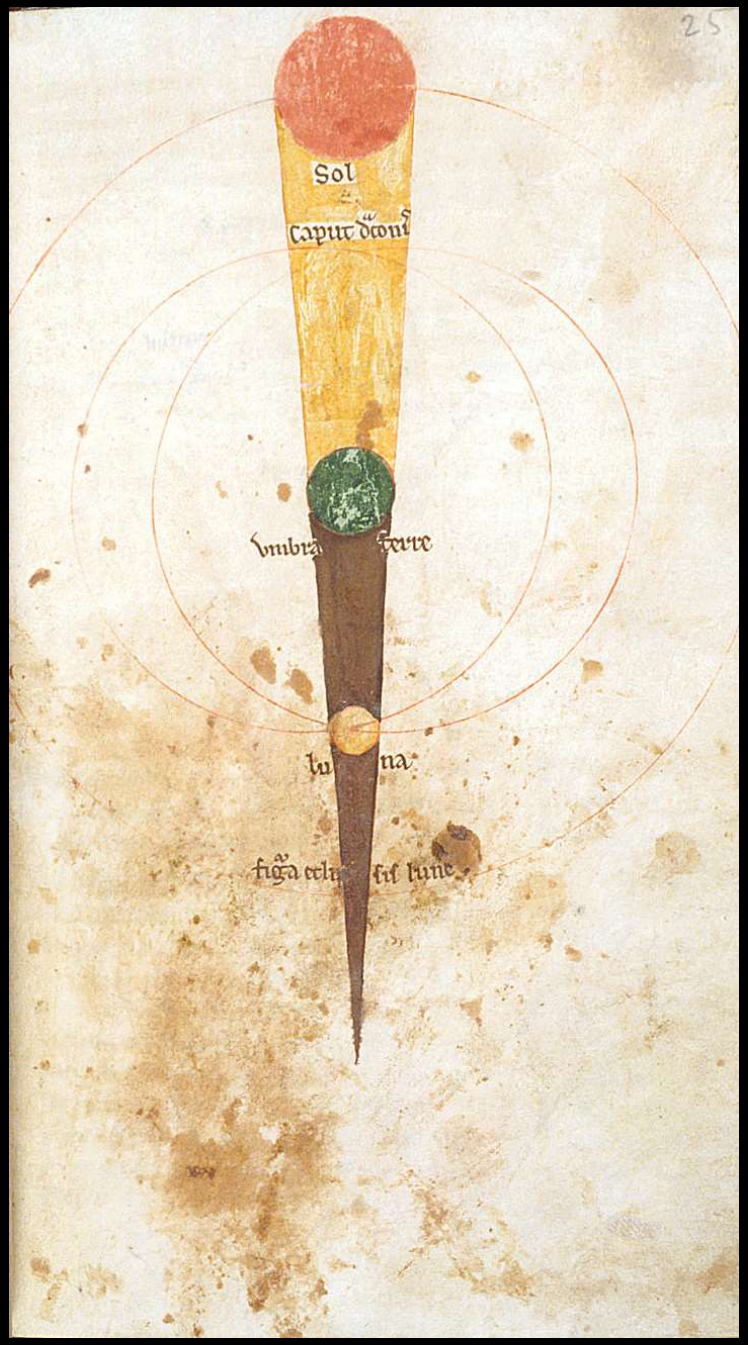
The geometry of a lunar eclipse

The Moon passes through the Earth's shadow.

Not to scale



At the Moon's distance the umbra is about 2.5 times the diameter of the Moon.
If the Moon passes completely through the umbra it is totally eclipsed.
If it passes partially through the umbra then it is partially eclipsed.
As it passes through the penumbra it is only dimly eclipsed.
Lunar eclipses are visible from anywhere on the night side of the Earth.



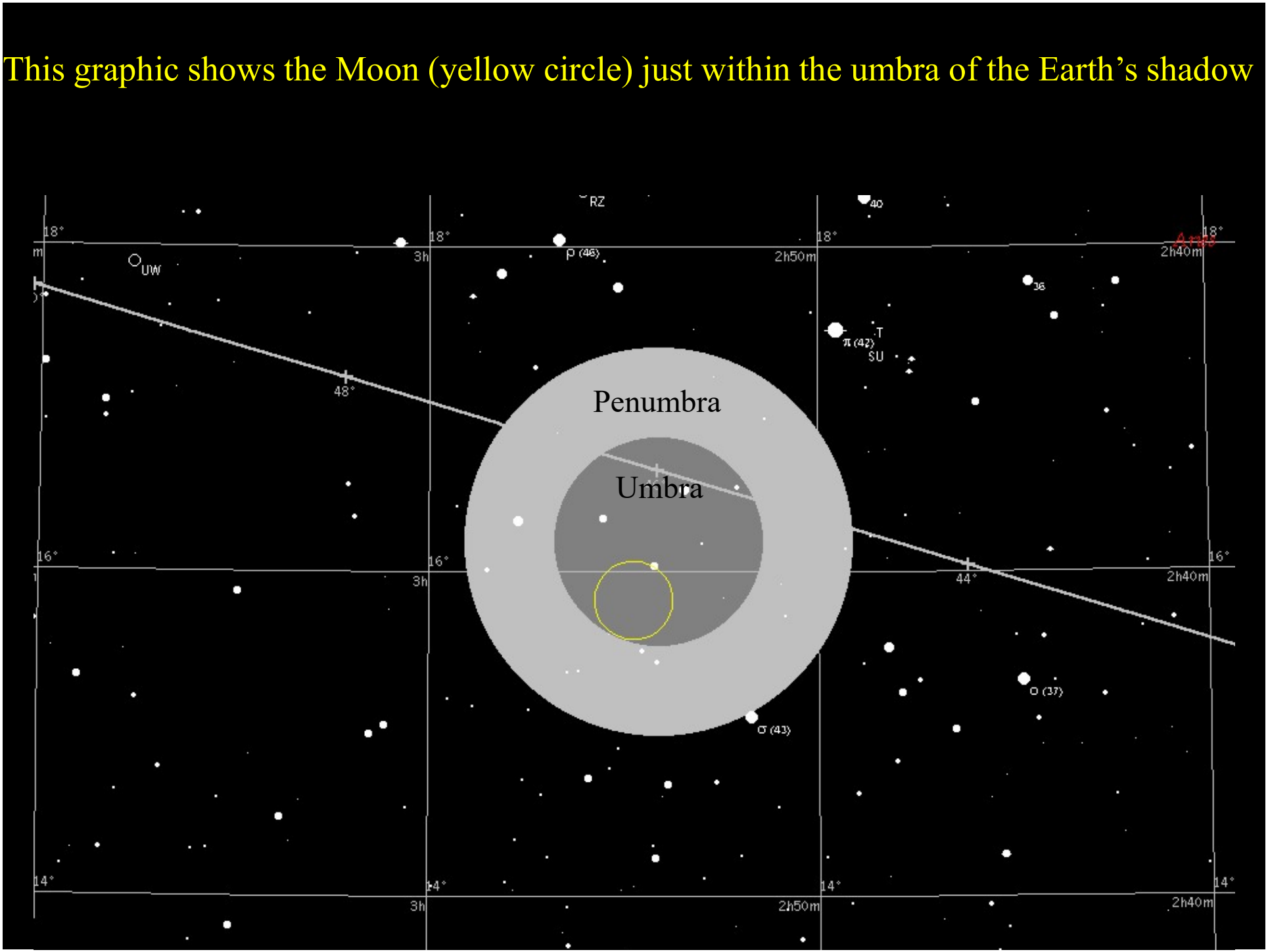
The causes of eclipses were well understood by ancient peoples. The Greek Anaxagoras (c500 BC) reasoned that the Earth was round because of the shape of its shadow on the Moon during a lunar eclipse.

Diagram of a lunar eclipse.
Johannes de Sacro Bosco.

England, 13th century.

British Library

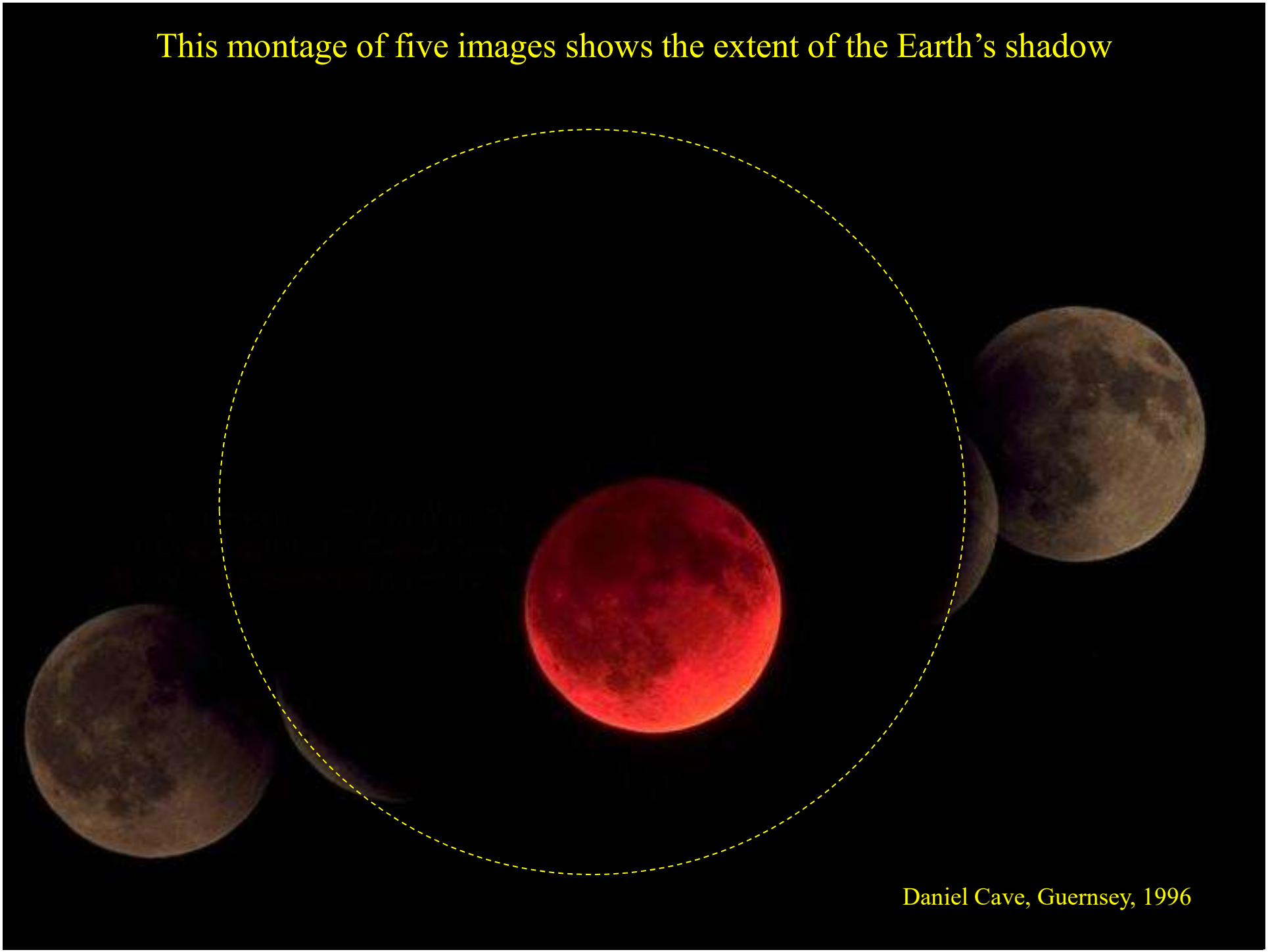
This graphic shows the Moon (yellow circle) just within the umbra of the Earth's shadow



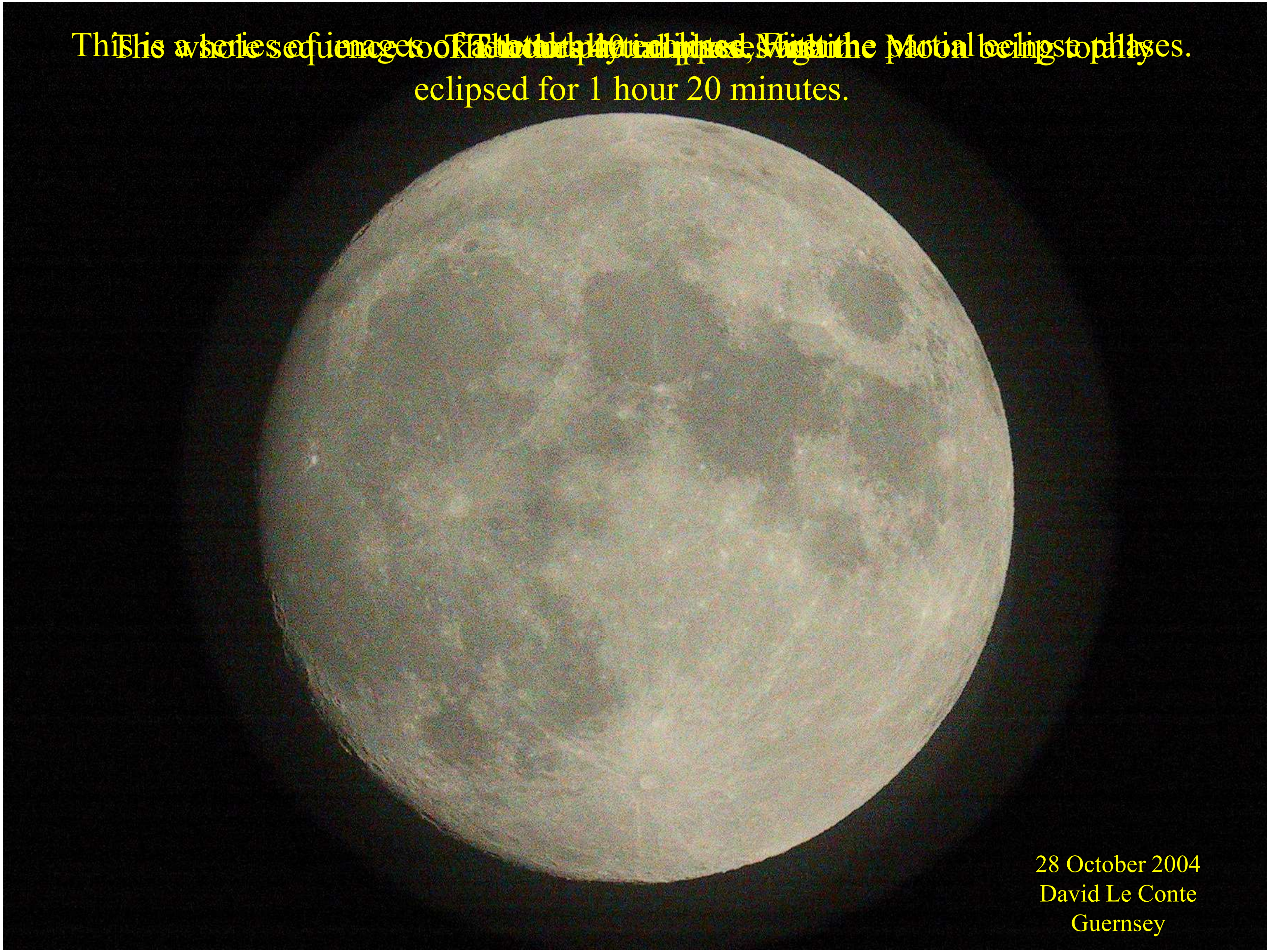
When the Moon is totally eclipsed it often has a deep red colour.
This is caused by sunlight being refracted (bent) by the Earth's atmosphere and falling onto the Moon.

Total lunar eclipse
28 October 2014
David Le Conte

This montage of five images shows the extent of the Earth's shadow



Daniel Cave, Guernsey, 1996


This is a series of images … phases.
The whole sequence took … with the Moon being totally
eclipsed for 1 hour 20 minutes.
28 October 2004
David Le Conte
Guernsey

Here's another sequence of a total lunar eclipse

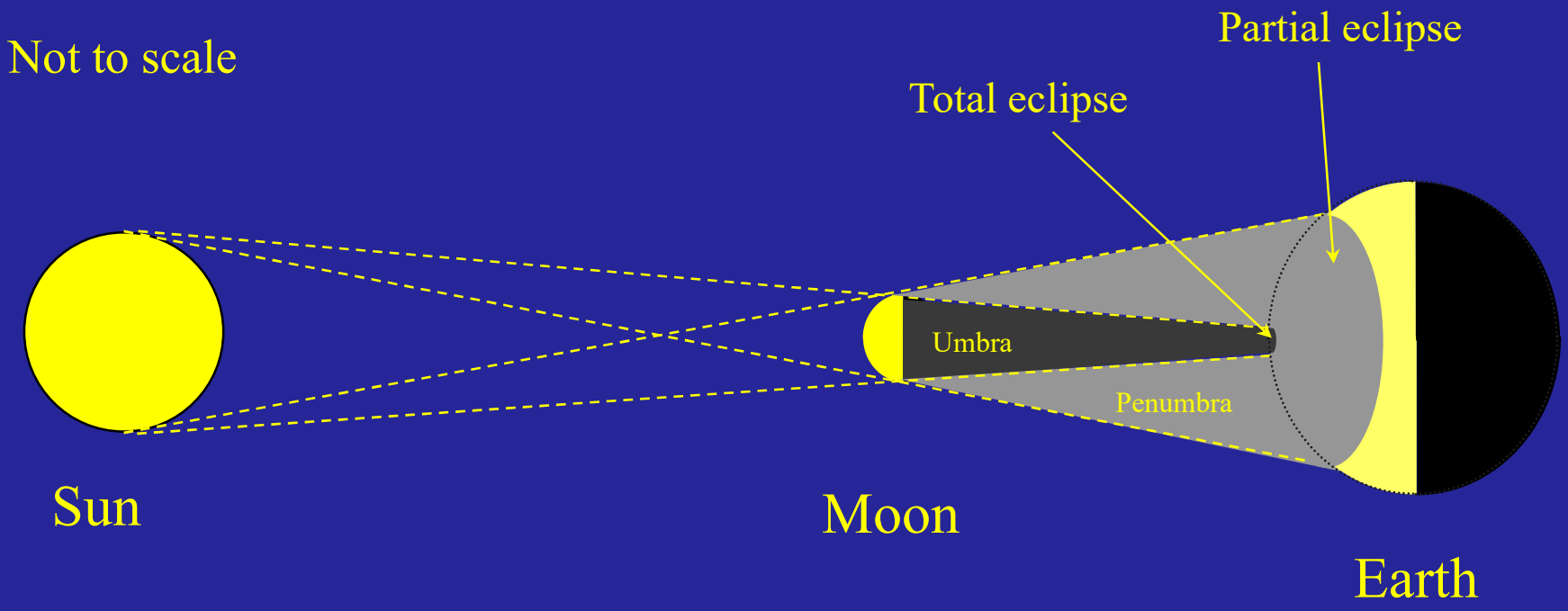
Jean Dean, Guernsey, 28 September 2015

Having foreground objects can produce an impressive picture

Jean Dean, Guernsey, 28 September 2015

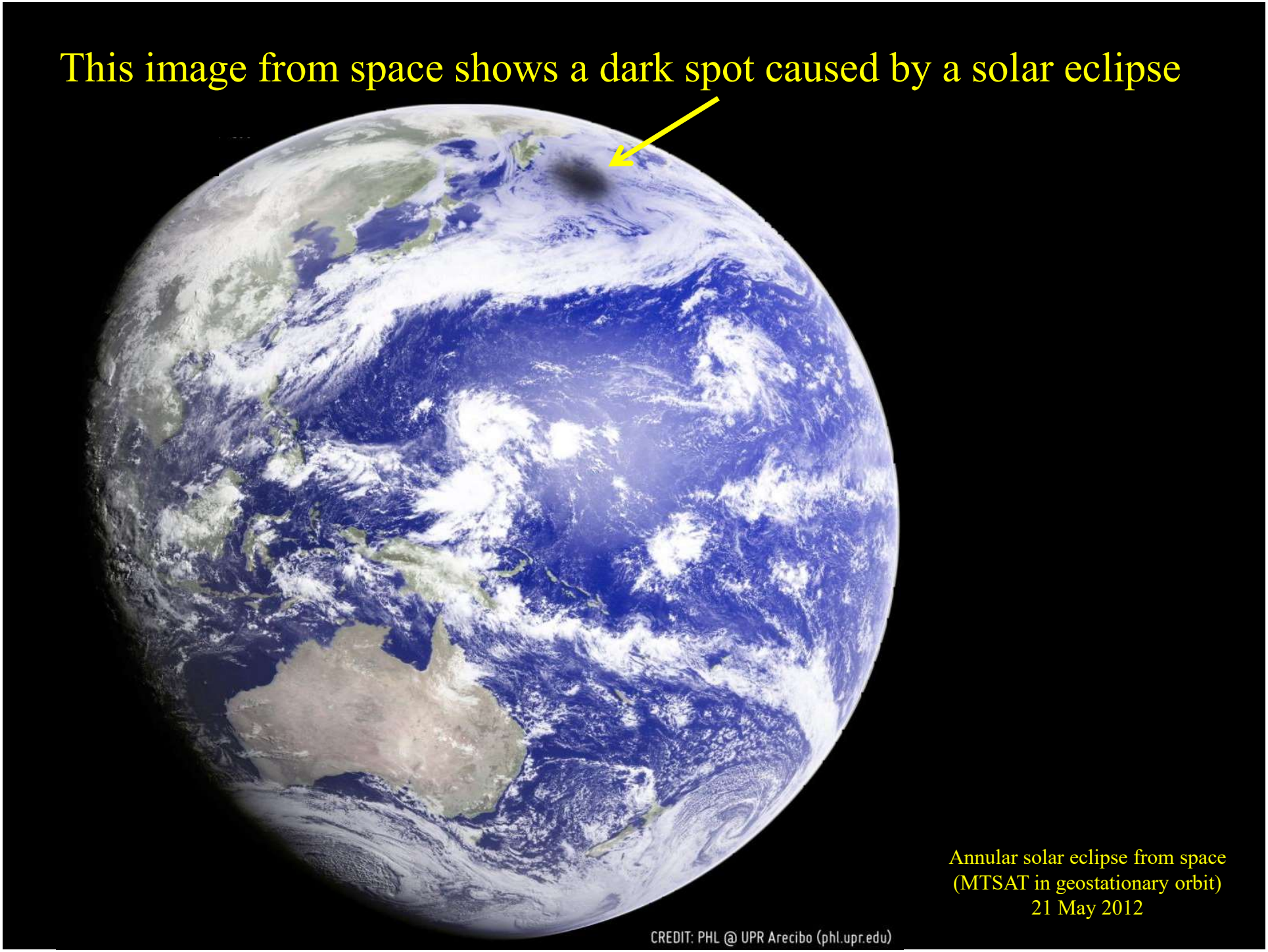
Jean Dean, Guernsey, 28 September 2015

Now let's have a look at solar eclipses



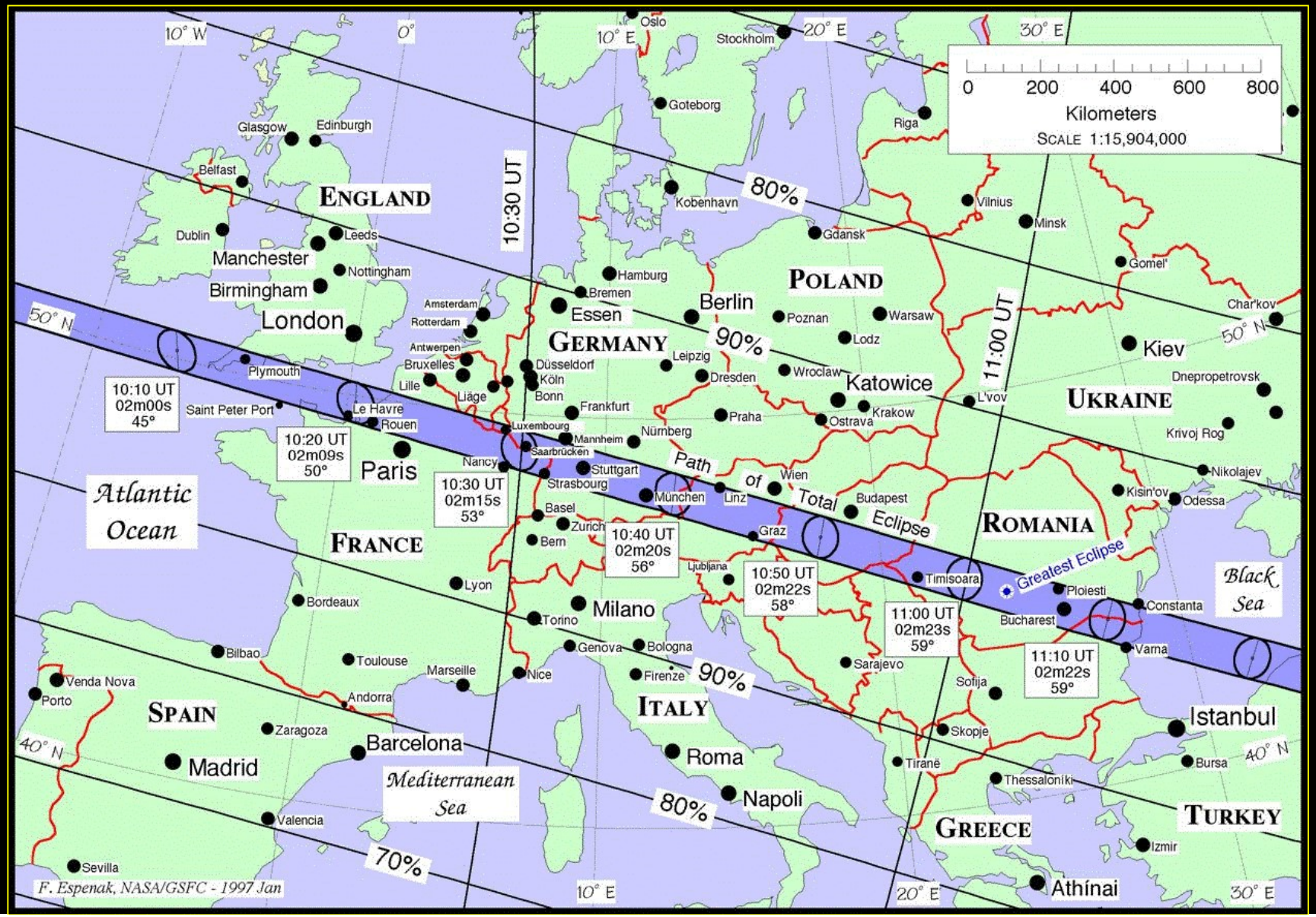
Remember that they happen when the Moon passes directly in front of the Sun, the total eclipse only being visible from a relatively small spot on the Earth.

This image from space shows a dark spot caused by a solar eclipse

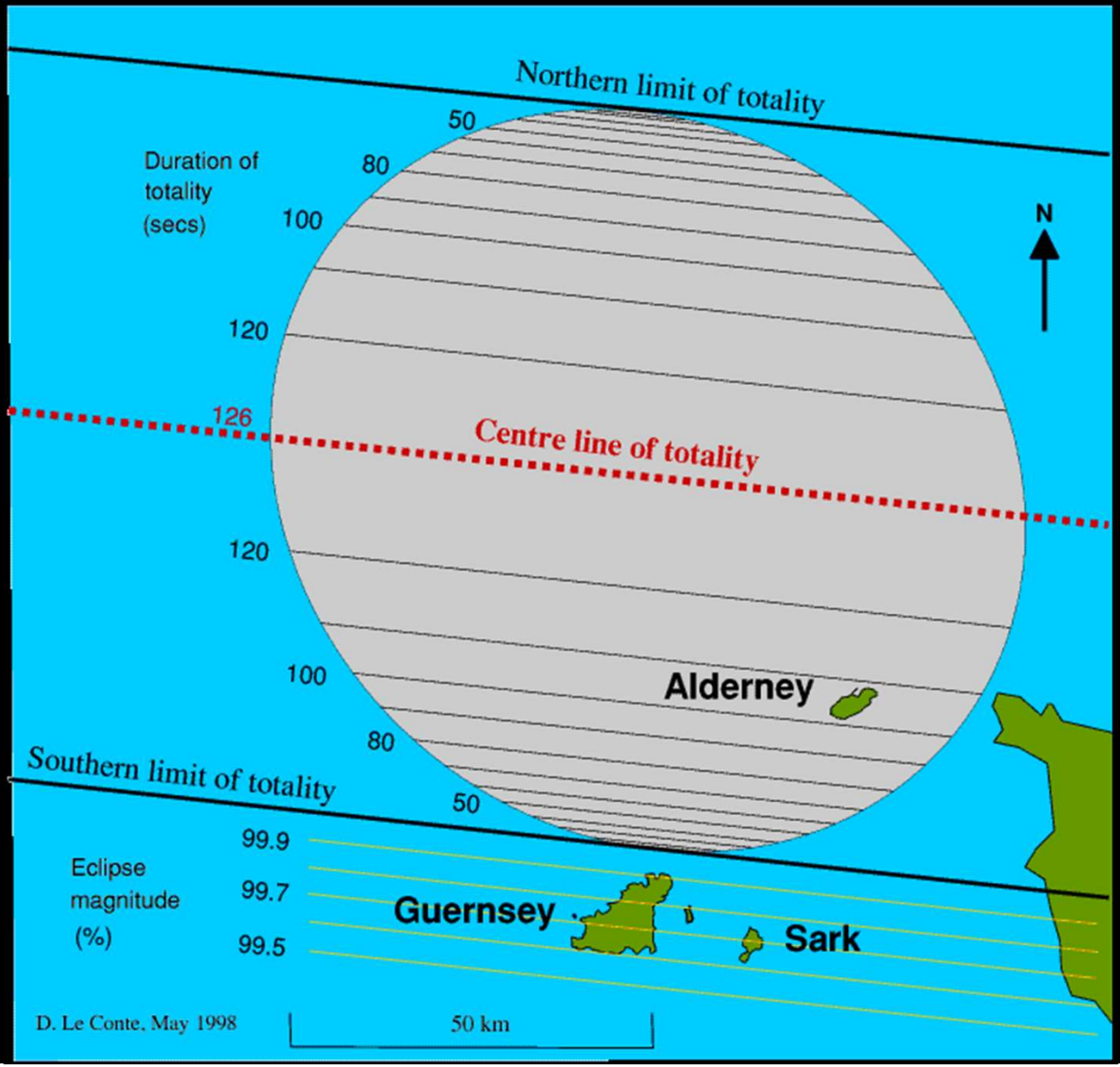


Annular solar eclipse from space
(MTSAT in geostationary orbit)
21 May 2012

The spot moves rapidly across the surface of the Earth. Here is the path of the 11 August 1999 eclipse. The total eclipse band is shown in dark blue. Either side of it the Sun was partially eclipsed.



As it passed across the English Channel its speed was over 3000 kph (1900 mph) from west to east. At the centre line totality lasted just 126 seconds!



WARNING

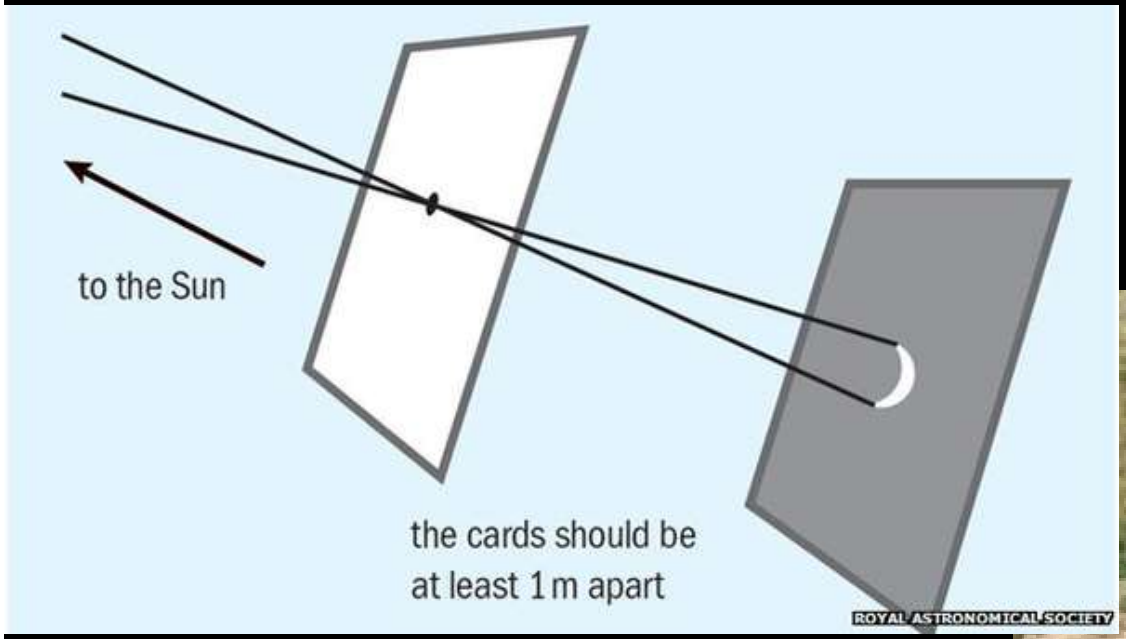
It is dangerous to look directly at the Sun, especially with any optical instrument such as binoculars or a telescope. Blindness can result. Only specialised equipment or projection methods should be used.

One of the easiest ways for non-telescopic viewing is to use special approved eclipse glasses.

Put the glasses on before looking at the Sun.

Welders goggles with filters rated 14 or higher are also safe.

Another method is pinhole projection. Make a small hole in a piece of card and hold it with your back to the Sun so that an image of the Sun is projected onto another piece of white card about a metre away. Do not look through the hole!



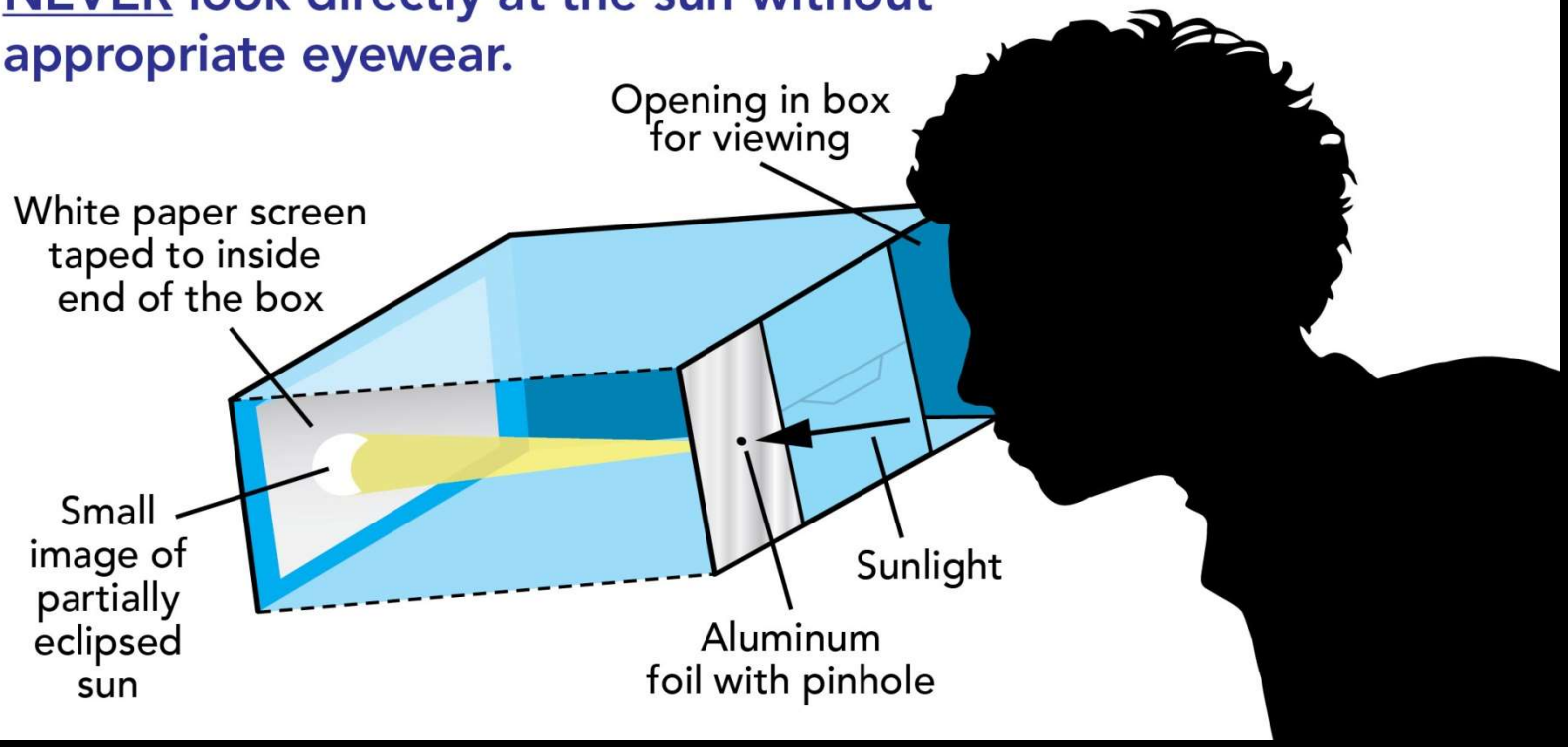
You can make the image easier to see by using a box, such as a cereal box to make a simple eclipse projector

MAKE YOUR OWN ECLIPSE PROJECTOR

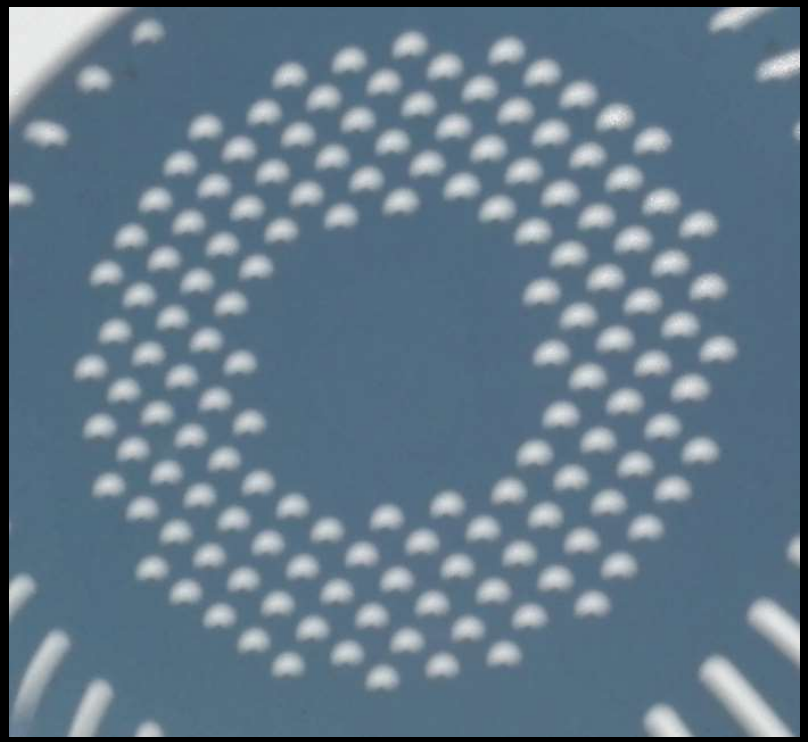
You can make this simple eclipse projector with almost any cardboard box, paper, tape and foil.

The longer the distance from the pinhole to screen, the larger the image of the sun will be.

NEVER look directly at the sun without appropriate eyewear.

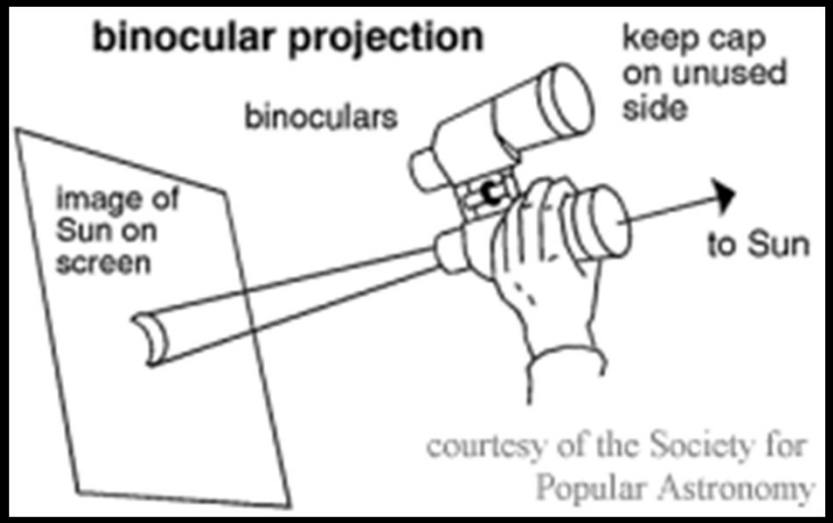


Anything with a hole in it can be used, even a hat! Here a kitchen colander produces multiple solar images during an eclipse.



You don’t even need any equipment at all if there are trees around. The gaps between leaves form pinhole images of the Sun on the ground, and these become crescent-shaped during a solar eclipse.

Larger, detailed images can be obtained by projecting sunlight through binoculars or a refracting telescope.



In all these projection methods you stand with your <u>back</u> to the Sun.

No filters that you wear should be used for looking through telescopes, binoculars or cameras.

For these, special optical filters which fit over the front of the instrument's main lens are needed.

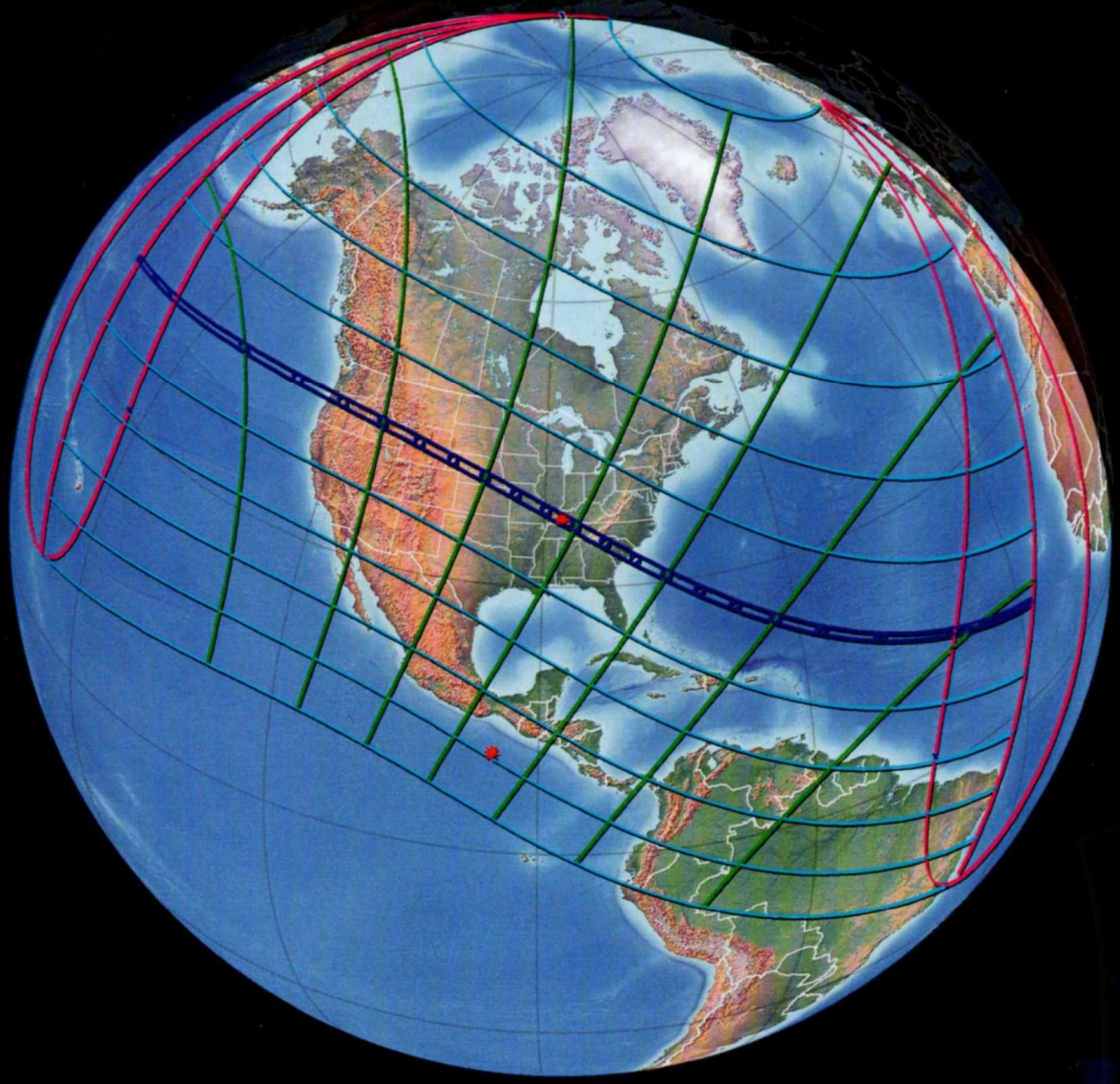
All these methods are fully described at

www.mreclipse.com/Totality3/TotalityCh11.html

Here is a partial solar eclipse taken with an 11-inch reflecting telescope with a proper filter.

David Le Conte, Guernsey
12 October 1996

In 2017 a major solar eclipse passed right across the United States.

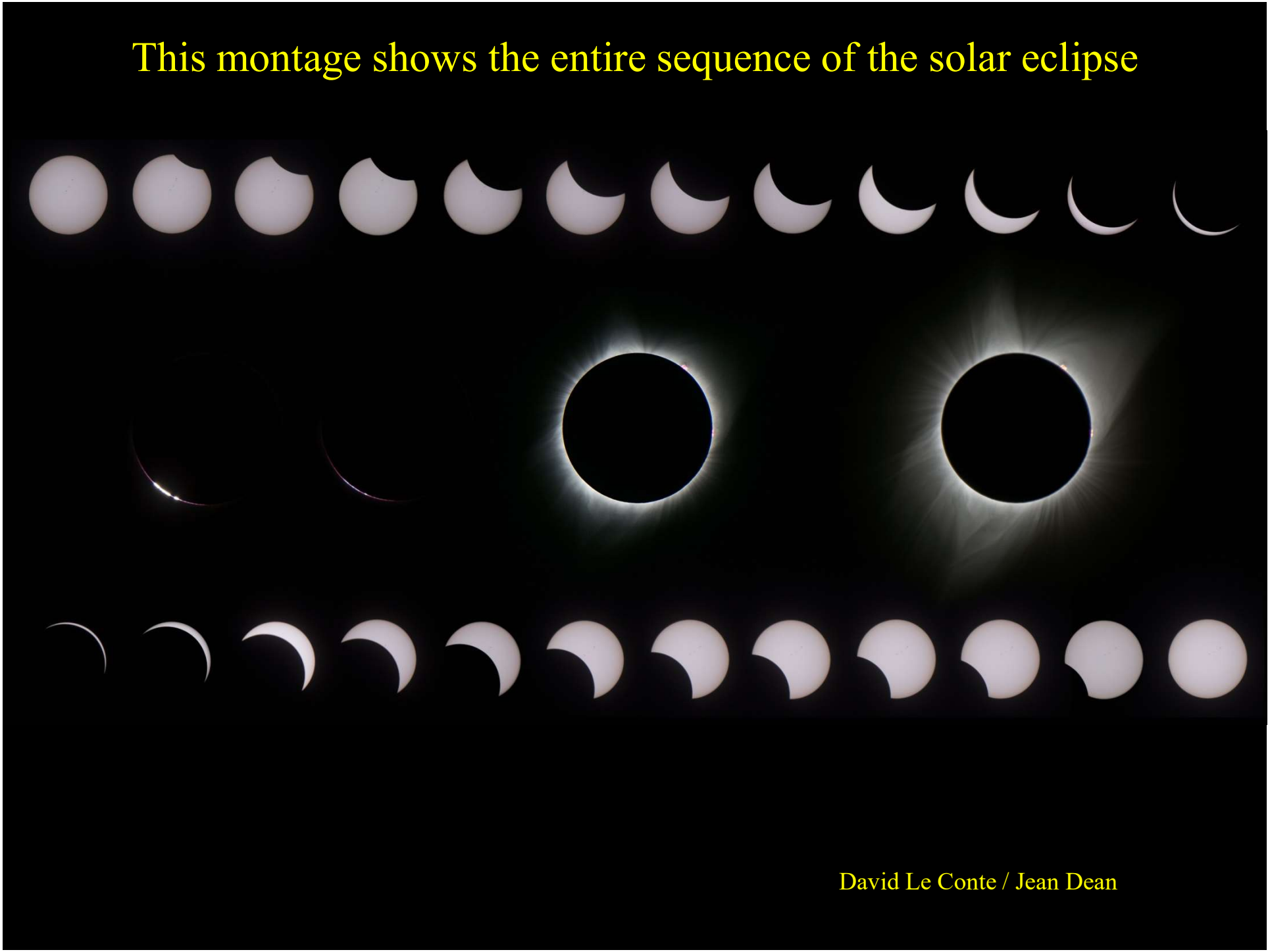


The appearance of the corona is affected by the Sun's magnetic field

David Le Conte / Jean Dean

Click to continue

This montage shows the entire sequence of the solar eclipse



David Le Conte / Jean Dean

As totality approaches things start getting really exciting. The sky gets noticeably darker, shadows sharpen, it will feel cooler, animals may start acting strangely, there may possibly be a wind, and bright planets and stars may become visible.

In the last couple of minutes before totality look out for ‘shadow bands’ – rippling bands seen on the light ground surface or a white sheet. They are caused by light from the thin crescent Sun affected by turbulence in the Earth’s atmosphere.

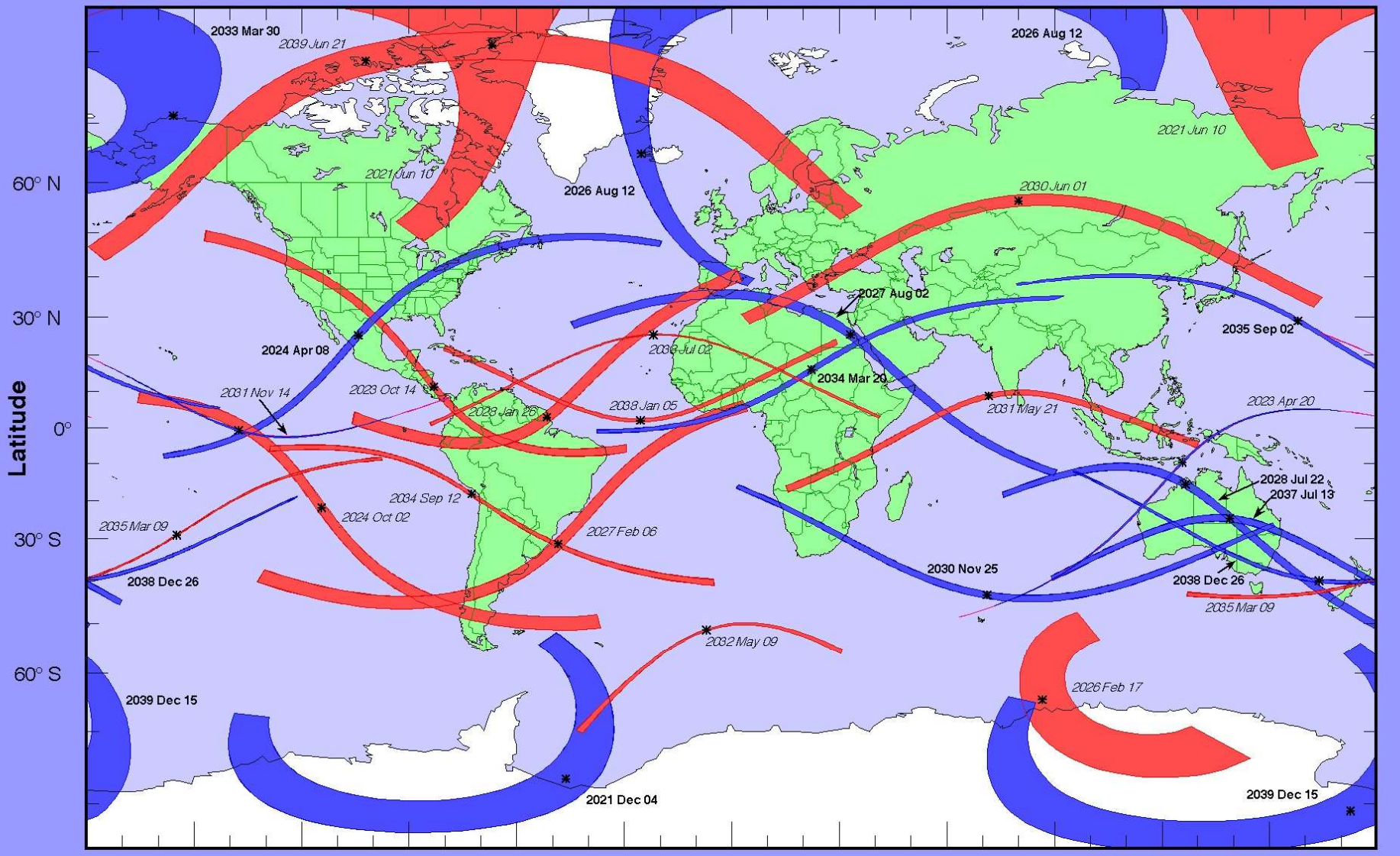
In the 30 seconds or so before totality look towards the west. You may see the Moon’s shadow racing towards you!

If you have eclipse glasses you must use them during the partial phases of the eclipse. But in order to see the solar corona you must remove them during the few minutes of totality, using them again as soon as the Sun starts reappearing.

During totality note that all of the horizon appears to have the colours of sunset – a 360º twilight!

The longest totality can last is 7½ minutes, but most are only 2-4 minutes!

Total and Annular Solar Eclipse Paths: 2021 –2040

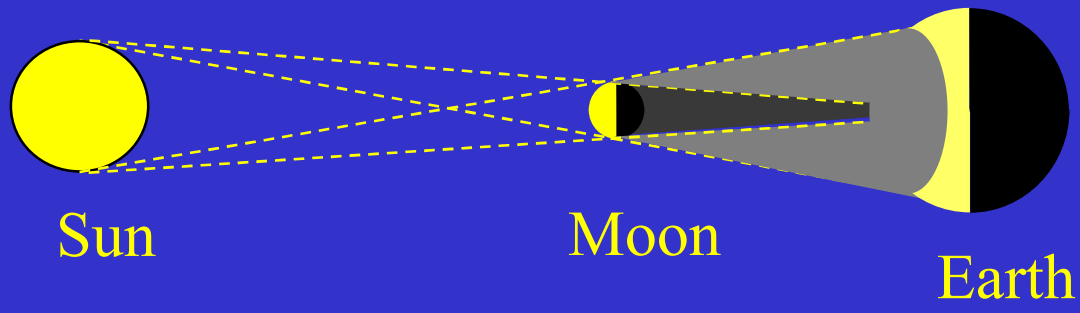


Total Eclipse
Annular Eclipse
Hybrid Eclipse

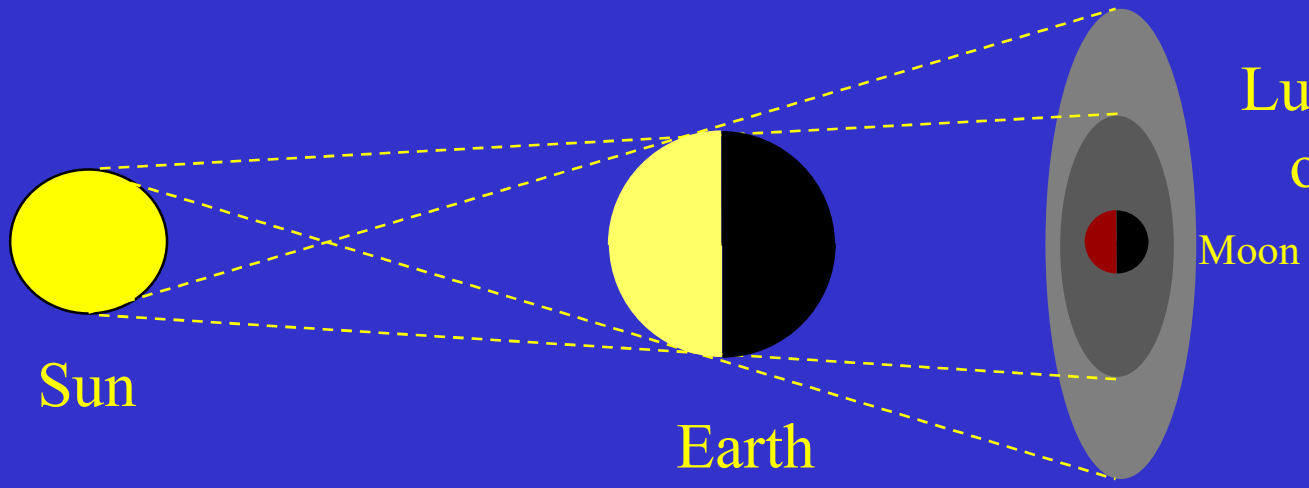
Annular (from 'annulus' = ring) eclipses occur when the Moon is further away from the Earth than average, and a ring of sunlight appears around the Moon at maximum eclipse.

0 2000 4000 6000 8000 10000
Kilometers

Fred Espenak, NASA/GSFC - 2002 July



Solar eclipses can only occur at New Moon.

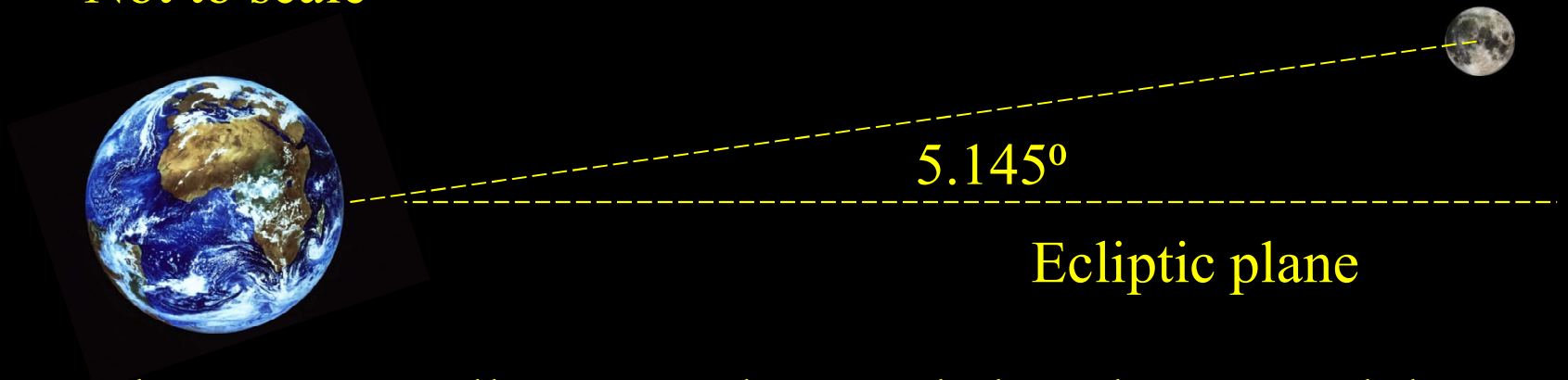


Lunar eclipses can only occur at Full Moon.

So why aren't there eclipses at every New and Full Moon?

The answer is that the Moon's orbit is inclined at just over 5^{o} to the plane of the Earth's orbit around the Sun (called the 'Ecliptic').

Not to scale



So the Moon usually passes above or below the Sun and the Earth's shadow. Only rarely do they line up to cause an eclipse.

The pattern of eclipses repeats every 18 years, 11 days, 8 hours (a period called the Saros).

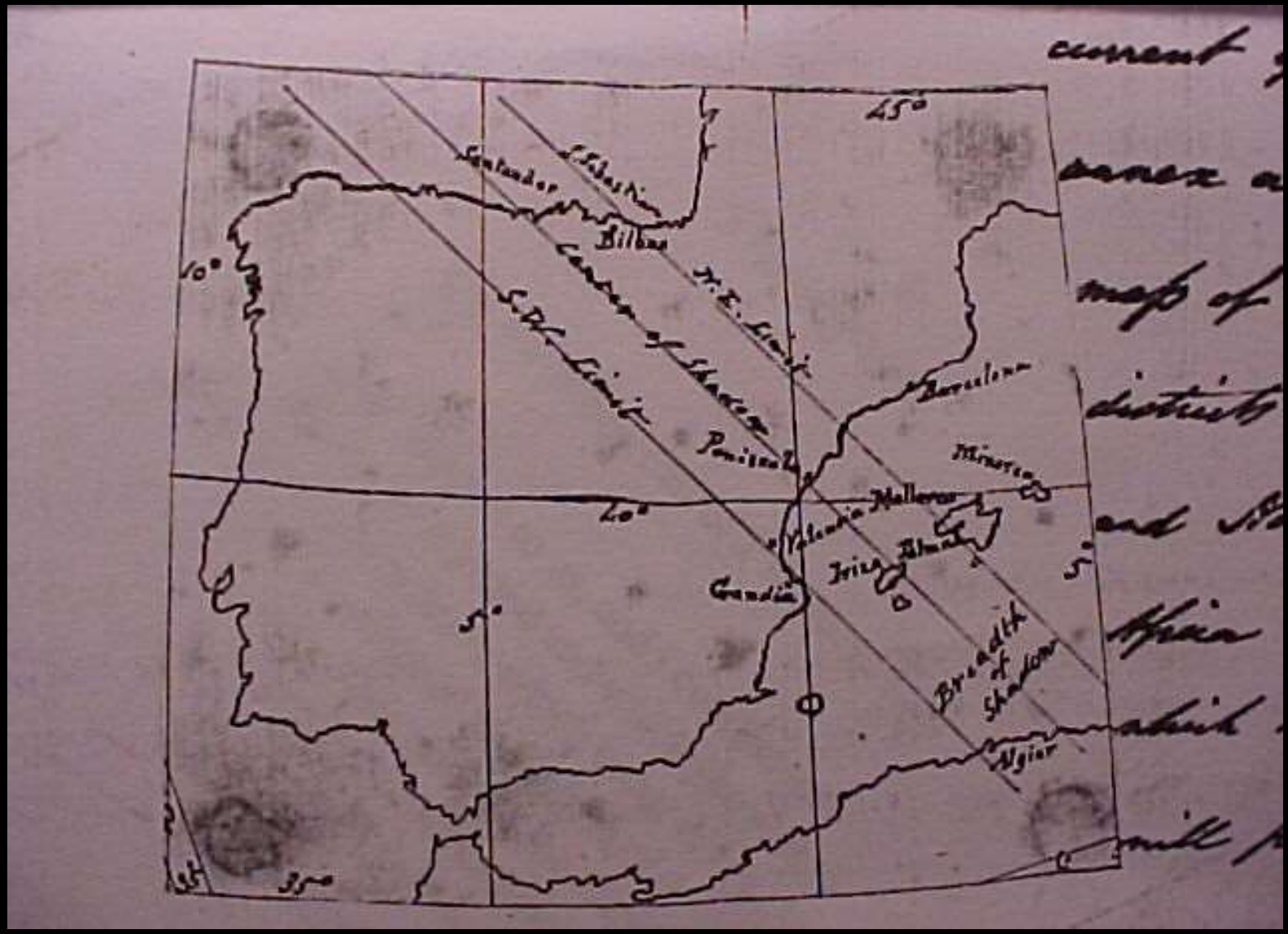
There are between 2 and 5 solar eclipses (not necessarily total) every year, and between 0 and 3 lunar eclipses (ignoring penumbral eclipses).

Some Guernsey connections with historic solar eclipses.

In 1858 Guernseyman Thomas Lukis Mansell took the first known astronomical photographs in Guernsey – of a solar eclipse.

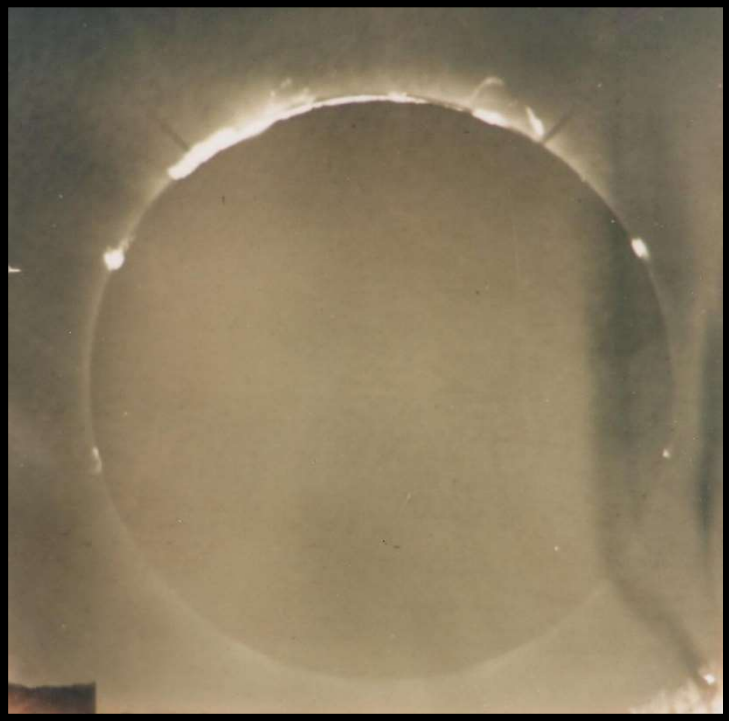
In 1860 there was a total solar eclipse in the north of Spain.

Here is the Astronomer Royal's plan of the eclipse path.



Guernseyman Warren De La Rue was on the Astronomer Royal's eclipse expedition …

… and took the first scientific pictures of an eclipse, which showed that the prominences were part of the Sun.



In 1870 Guernsey artist Paul Jacob Naftel was invited to join the Royal Astronomical Society's eclipse expedition to southern Spain …

… and painted the scene to show the details of the corona and the colours of the landscape.

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