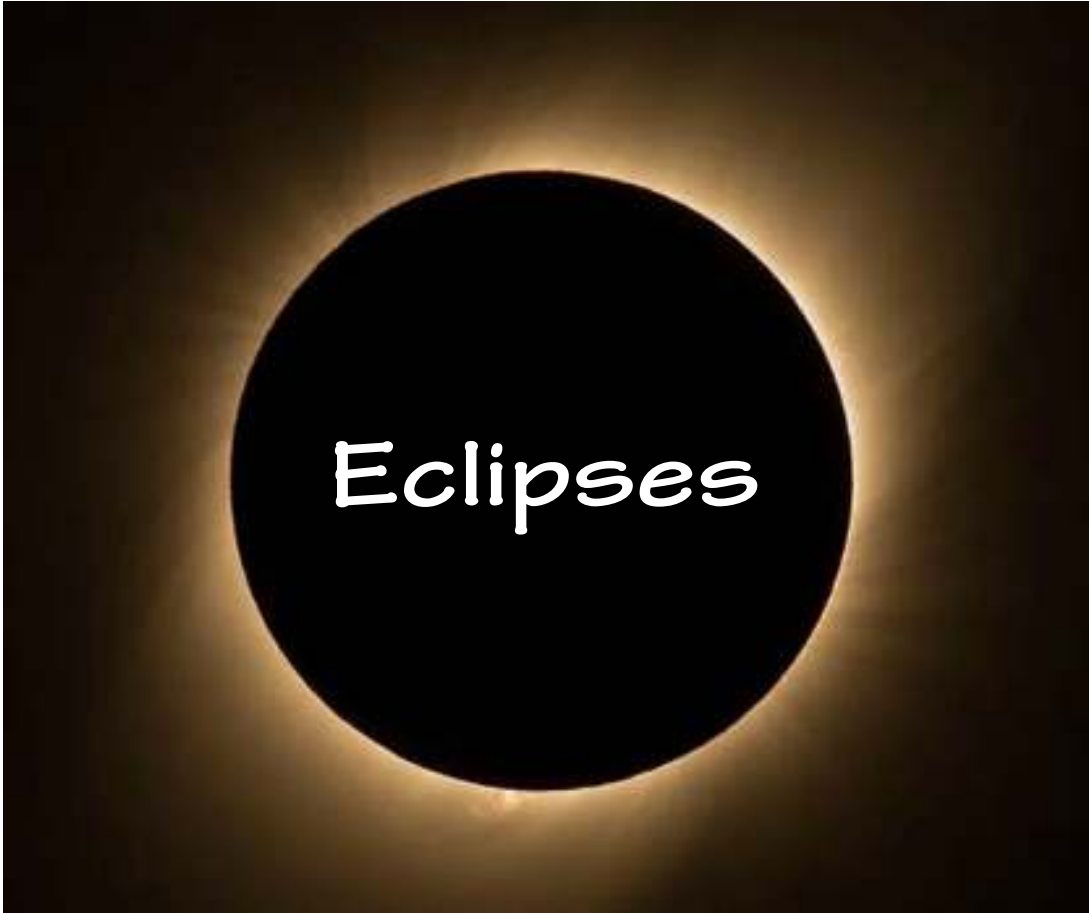


# The Universe in my pocket



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The Moon is 400 times smaller in diameter than the Sun, but it is 400 times

closer to the Earth. That is why the Moon and the Sun have equal apparent sizes.



When the Moon passes in front of the Sun, a solar eclipse occurs. Here is a picture of a partial eclipse.

When the centers of the Moon and the Sun coincide ...



...a total eclipse occurs.

(photo Martin Bernetti/AFP)

When the Moon is further away from the Earth, even if its center coincides with that of the Sun, an annular eclipse occurs. (photo Rehman Abubakr)



There is an extraordinary coincidence of nature: the apparent sizes of the Sun and the Moon are the same.

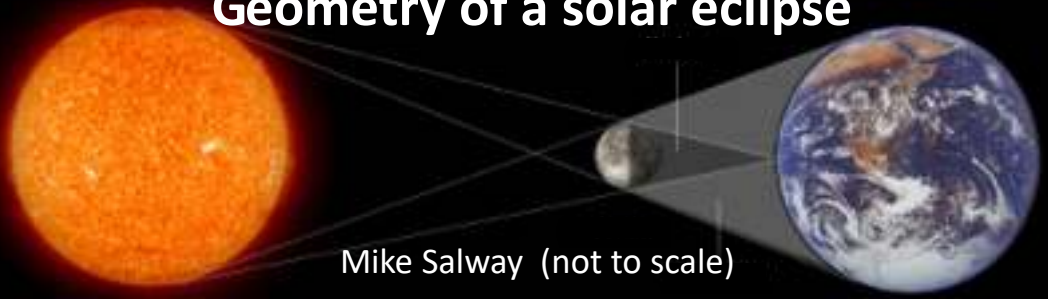
A solar eclipse occurs when the Moon passes in front of the Sun.

During total eclipses the center of the Moon is precisely in front of the center of the Sun, and hence the Moon covers it completely.

When the centers of the Moon and the Sun do not coincide, partial eclipses occur.

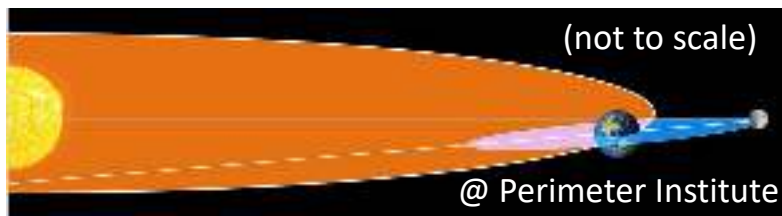
If you have the opportunity to see an eclipse, don't miss it - especially if it is a total eclipse. It is an unforgettable moment, when the sky darkens and you can see the stars in the middle of the day. In the countryside, some surprised animals become mute or prepare to sleep.

# Geometry of a solar eclipse



A Solar Eclipse occurs when the Moon passes in front of the Sun. This can happen only at New Moon, when the Sun, Moon and Earth are aligned. A **total eclipse** can be seen only from a narrow zone of the Earth where the Moon blocks the sunlight entirely. A **partial eclipse** is seen from a much greater zone where the Moon covers only part of the Sun.

The Moon's orbit is tilted with respect to



Earth's orbit around the Sun. As a result the shadow of the Moon passes above or below the Earth during most New Moons, except **twice a year** when it falls on the Earth and an eclipse is seen.

Montage of photos during a solar eclipse. The passage of the Moon in front of the Sun lasts a couple of hours. 4



## How does a solar eclipse occur?

The Earth rotates on its axis, which gives us the impression that the Sun moves across the sky. It's like when we spin around, it seems that it is our environment that moves.

The Moon also appears to travel across the sky. When the apparent paths of the Sun and Moon cross, an eclipse occurs.

For this to happen, the Sun, Moon and Earth must be aligned. When the Moon is between the Sun and the Earth, a solar eclipse occurs. When the Earth is between the Sun and the Moon, a lunar eclipse occurs.

Eclipses of the Sun occur during the so-called New Moon, when the Moon's night side points towards the Earth and therefore we do not see it.



When observing a solar eclipse, it is necessary to wear **certified** glasses.

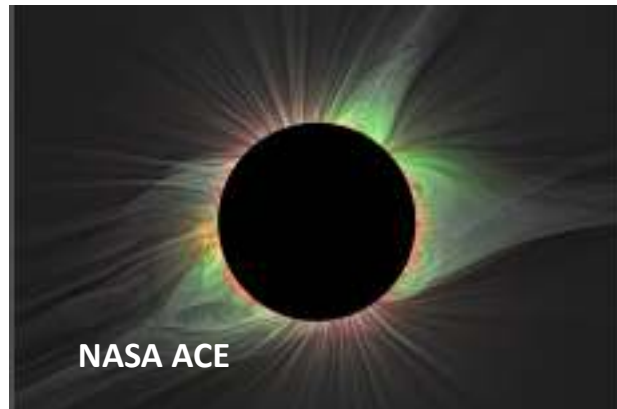
**ISO 12312-2**

which are available at planetariums, in some stores or by remote delivery.

During total solar eclipses, the sky darkens. The solar disk disappears and the solar corona is visible.



The red region surrounding the lunar disk is the chromosphere and the green region is the corona.



## Observing an eclipse

During total solar eclipses the Sun's outer layers, such as the chromosphere and corona, can be observed. They are not seen at other times because they are less bright than the photosphere, the region of the Sun that emits the light we see.

The shape of the corona is always changing because it depends on the continuously changing solar magnetic field. That is why each eclipse is different.

In the darkened sky, planets and stars are visible, almost as if at night.

It is not good to look directly at the Sun because its rays are very intense and can damage your eyes without you realizing it. If you are going to observe a solar eclipse it is important to wear special glasses. You can take them off during totality.



Diagram of a lunar eclipse (the diagram is not to scale). The Sun's rays are blocked by the Earth. Only those that have passed through the Earth's atmosphere at sunset or sunrise reach the Moon. These light rays are red; the blue light has been scattered out.

This is why the Moon looks red during a total eclipse, as shown in the photo to the right.

Photo Sergei Mutovkin



This image shows several photographs of the Moon during a partial lunar eclipse. You can see that the Earth's shadow is round.

Photo: A. Ayiomamitis



# Lunar Eclipses

When the Sun, the Earth and the Moon align, and the Moon passes through the Earth's shadow, a lunar eclipse occurs.

Lunar eclipses occur at full Moon, when the Moon looks round. It turns red because the light that illuminates it passes through the Earth's atmosphere, which scatters the blue light and deflects the red light toward the Moon. The more dust or clouds in the Earth's atmosphere during the eclipse, the redder the Moon will appear.

Unlike a solar eclipse, which can only be seen from a small area of the Earth, a lunar eclipse can be seen from anywhere on the night side of the Earth.

The shadow of the Earth on the Moon is always round, so since ancient times it was known that the Earth is a sphere.



**Upcoming total solar eclipses**

- |                          |                            |                             |
|--------------------------|----------------------------|-----------------------------|
| <b>5</b> April 8, 2024   | <b>8</b> July 22, 2028     | <b>11</b> March 20, 2034    |
| <b>6</b> August 12, 2026 | <b>9</b> November 25, 2030 | <b>12</b> September 2, 2035 |
| <b>7</b> August 2, 2027  | <b>10</b> March 30, 2033   | <b>13</b> July 13, 2037     |
|                          |                            | <b>14</b> December 26, 2038 |
|                          |                            | <b>15</b> December 15, 2039 |



Reproduction of the eclipse tables from a 13th century Mayan Codex.

The sun-eating dog of a Chinese legend.



# Eclipses and humans

In the past people were frightened when there were total eclipses of the Sun. When the Sun was covered and darkness arose, it was feared that the Sun had been extinguished. As there is always misfortune in the world, eclipses used to be interpreted as causing evil.

There are many legends in the world about eclipses. But some civilizations such as the Chinese or the Mayan knew how to predict eclipses in advance. It is said that Christopher Columbus, when he ran aground in Jamaica and the natives refused to provide him with food, threatened to make the moon disappear. He knew what was going to happen because his almanac gave the dates of the eclipses.

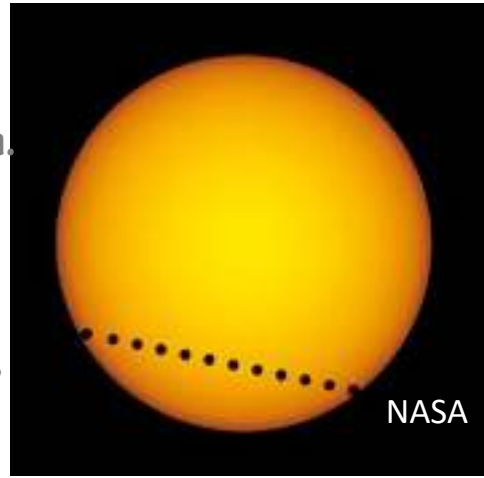
Now the dates of upcoming solar and lunar eclipses can be found on the internet.



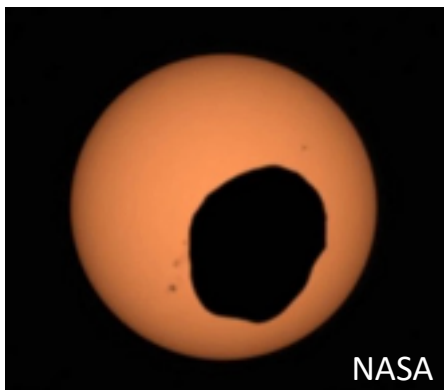
NASA

Photo taken from the Juno spacecraft in orbit around Jupiter. The shadow cast on Jupiter by its satellite Io during a solar eclipse is seen.

Occasionally Venus passes in front of the Sun as seen from Earth. This phenomenon is called a transit, not an eclipse. This photo shows various positions of Venus during a transit.



NASA



NASA

A transit of Phobos, one of the moons of Mars, as seen from the surface of Mars. The shadow is not round because Phobos is not spherical. The photo was taken by the Perseverance Rover, a robotic rover exploring the planet Mars.

# Eclipses and transits

In all the planets of the Solar System that have satellites, eclipses occur when they pass between the Sun and the planet.

Imagine yourself on worlds like Jupiter and Saturn that have more than a hundred satellites: there are eclipses every day!

Eclipses which do not cover the entire Sun, are called transits.

One event that can be seen from Earth is the transit of Venus. It occurs when Venus passes in front of the Sun as seen from Earth.

Thanks to transits, astronomers have discovered thousands of planets outside the Solar System by observing the small dip in light from the star they orbit when they transit (see TUIMP 8).

# Activities during a solar eclipse

**1-** During a partial solar eclipse, any small circular hole will produce an image of the partially eclipsed Sun.



**2-** Cross your fingers above your head, with your back facing the Sun. You will see, in the spaces between your fingers, small images of the partially eclipsed Sun, in the form of a smile.



**3-** Measure the temperature before and during the eclipse. As the Moon blocks the Sun's light, it also blocks its heat.

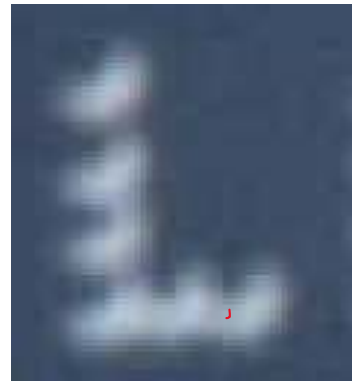


# Activities before an eclipse

**1-** Exend your arm. Your thumb will cover the full Moon. Although your thumb is much smaller than the Moon, it is much closer, so its apparent size is the same.



**2-** Prepare a sheet of paper by punching holes forming the name of the place where you will observe the eclipse as some children did in Zimbabwe.



An image of the partially eclipsed Sun will be produced by each hole.

**3-** Construct a simple model showing motion of the Earth around the Sun and that of the Moon around the Earth.



# The Universe in my pocket No.28

Julieta Fierro and Grażyna Stasińska wrote this booklet in 2023. It was revised by Stan Kurtz. Julieta and Stan work at the National University of Mexico and Grażyna at the Paris Observatory.

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