Eclipse of the Sun

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A partial solar eclipse would have been visible for all the residents of the state of Florida if the weather permitted it and we would have been sitting on the first row to participate in a unique spectacle, but the sky was not clement and the clouds spoiled the moment. Hopefully cameras were branched all over the United States and through part of the world to diffuse the event. We were not going to lose the opportunity to enjoy an eclipse and admire the rare phenomenon, from Mexico to Maine and Connecticut. The media was present to follow the trajectory of the sun, from the Southwest (Texas) to Northeast (Maine) of the country.

I wonder if the kids were allowed to observe it because, they may have to apparently wait for another 20 years before observing another solar eclipse. I put my deception aside and sat down in front of the television screen to observe Mother Nature with regrets in mind that I should have been able to plan better my week and stay in Maine after my last assignment. In Florida, few clouds will at time, stop Floridians from appreciating a partial solar eclipse. We will not be able to observe a full path to totality.

If you missed the eclipse of the 8th of April 2024, you can rely on the beautiful images produced by different media to enjoy and live fully the moment: a total eclipse that blocked out the sun and sent millions in the USA into temporary darkness. Remember that you will have to wait for a while before being able to witness another one. A total solar eclipse happens nearly every year but the odd that you find yourself under one's totality is estimated to be less than a lifetime. It seems that the next similar event visible from the naked eye in the USA, will be in Mach 2033 but, to see it, you will have to travel to Alaska.

Why do we have a solar eclipse? In a wide definition, a "Solar eclipse" occurs when the moon passes between the Earth and the Sun, obscuring a small part or the totality. It is expected that such alignment be seen every six months but when the moon's orbital plan become closest to the plane of earth's orbit, the eclipse is said "total", meaning that the disc of the Sun is fully obscured by the Moon. In a "partial" or an "annular" eclipse, only part of the Sun is obscured. Such eclipses can be only seen in relatively small areas around the world while it exists also a" Lunar eclipse" which can be observed from anywhere during the night on Earth. One may remember that a solar eclipse occurs somewhere on Earth every 18 months on average but also recurs at any given place only once around every year (360 days) or 410 years.

A Partial Solar eclipse where the Moon partially obstruct the Sun

A Total solar eclipse where the Moon passes between Earth and the Sun with a diamond's ring effect..

A total eclipse is rarer because it requires a more precise alignment between the Moon and the Sun. In anyway, it is a natural phenomenon. This does not stop ancient or modern cultures to attribute to solar eclipses some supernatural importance rendering them to be of good or bad omens. Astronomers started to be interested in eclipses around the 4th Century BC and this is when the Chinese started predicting them with accuracy around the world. One needed to develop some viewing techniques in order to avoid damaging the eyes. Special glasses are available for any viewer interested in chasing eclipses all over the world. The name of “umbraphile” is given to these chasers of eclipses.

Around every 18 months, a total eclipse is seen somewhere and the dark silhouette of the Moon, completely obscure the bright light of the Sun to form a “corona”. An annular eclipse occurs once every two years when the Sun and the Moon are exactly in line with Earth but the apparent size of the moon is smaller than the sun forming a “ring” or an “annulus” around the moon. A hybrid eclipse (annular/total) is intermediary between the total and the annular. At certain time, on earth, it may be seen as a total or as an annular. This combined form hybrid has a rarer occurrence.

Twice a year, a partial eclipse may be seen when the Sun and the Moon are not exactly in line with Earth allowing the Earth and Moon to partially obscure the Sun forming an “umbra” especially if they are seen from the polar regions. Some of those eclipses can be only seen as partial eclipse because it will never intersect Earth’s polar surface. An annular eclipse can only occur when the Sun has a larger apparent size than the Moon.

The Sun distance from Earth is about 400 times the Moon’s distance and the Sun’s diameter is about 400 times the Moon’s diameter and because these ratios are approximatively the same, the SUN and MOON seen from Earth, appear to be approximatively, the same size. Earth orbits around the Sun while the Moon orbit around Earth. An eclipse that occurs when the Moon is near Earth (perigee) can be a total Eclipse because the Moon will appear large enough to cover the Sun disk (photosphere)… Conversely, an eclipse that occurs when the moon is farthest from Earth (apogee) can be only “annular because the Moon will appear to be smaller.” Lastly, in the hybrid eclipse”, the magnitude changes and the eclipse appear either “total” at certain locations close to the midpoint but, at other locations, because the Earth is further away from the moon, it will appear “annular”.

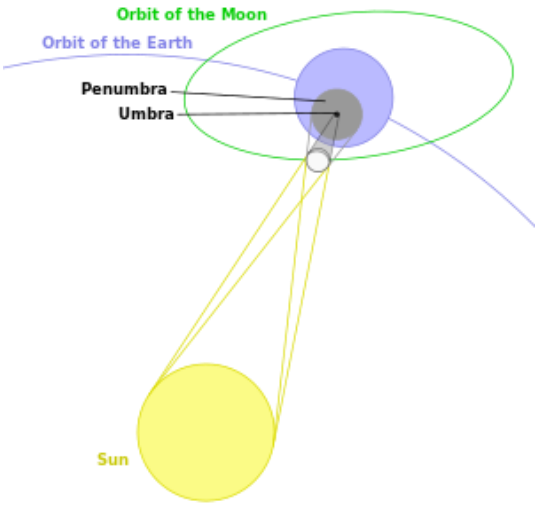
A lunar eclipse occurs when the Sun casts Earth’s shadows onto the Moon. In such event, the Earth must be physically between the Sun and the Moon. With all three bodies lying on the same plan of orbit. A lunate eclipse can only occur during a full moon and when the Moon passes through all or a portion of Earth’s shadow.

Earth’s orbit around the Sun is elliptical while Earth’s distance from the Sun, also varies throughout the year. The size of the sun will also play a role especially when Earth is at its farthest distance to the Sun (July) to produce a total eclipse… while the closest distance to the Sun (January), favor an “annular” eclipse.

The term “central eclipse” is used unequivocally for any eclipse… total or annular or hybrid but in fact the central eclipse is seen when the central line of the umbra touches Earth’s surface. In a “total eclipse”, astronomers will differentiate different contacts:

1- the first contact is when the Moon’s edge or limb is exactly tangential to the Sun’s limb.
2- Second contact: Baily’s Beads are lights shining on the surface of the Moon and the diamond ring effect where almost the entire disc is covered.
3- Totality: The Moon obscures the entire disc of the Sun and only the solar corona is covered.
4- Third contact: Moon’s shadow is moving away, with a diamond ring.
5- Fourth contact where the training edge of the Moon cease to overlap the solar disk.

Geometry of a total eclipse



Alignment of the Sun, Moon, and Earth during a solar eclipse. The dark gray region between the Moon and Earth is the “umbra” where the Sun is completely obscured by the Moon. The small area where the umbra touches Earth's surface is where a total eclipse can be seen. The larger light gray area is the “penumbra”, in which a partial eclipse can be seen. An observer in the “antubra”, the area of shadow beyond the umbra, will see an annular eclipse.

The Moon’s orbit around Earth, is inclined at an angle of just over 5 degrees to the plane of Earth's orbit around the Sun (the ecliptic). A solar eclipse can occur only when a new moon occurs close to one of the points (known as nodes) where the Moon's orbit crosses the ecliptic. The Moon is also elliptical. The moon apparent size varies with its distance from Earth and this distance will force an annular or a total eclipse.

We saw also the way the distances play a role. The closer the Earth is to the Sun, the more chances to see either a central or an annular eclipse but when the Earth is further to the Moon, it will appear smaller than the Sun, a central eclipse or an annular eclipse will be seen, but when the Moon is closer to Earth (perigee), a total eclipse is expected. is closer to Earth but an annular eclipse when the is a total eclipse when the moon.

The moon orbits Earth during more than 27.3 days (sidereal month) while Earth has revolved around the Sun, making during that time a new moon and to follow a (synodic month) of 29.5 days corresponding to the lunar month. The moon crosses in an ecliptic way through the ascending node due to the action of the Sun's gravity on the Moon motion with a complete circuit of 18.6 years through the descending nodes. This period of the Moon ecliptic motion through the nodes is shorter than sidereal month and is called the nodical or draconic month (8.85 years) while a new moon follows an arc of 180 degrees for a period of 6 months (173.3 days). This means that in any given year, there is two solar eclipses and sometimes as many as five. These eclipses can occur only when the Sun is within 15 to 18 degrees of a node and are often central but rarely partial.

Earth is also rotating from west to east at 28 km/min at the Equator while the Moon also is moving at 61 km/min. The umbra or the antubra almost always appears to be moving in a west to east direction. They may show width up to 160 km width setting Besselian elements used to predict partial, annular or total eclipse. These elements can also determine the exact shape of the umbra's shadow on the Earth surface et a what longitude on earth the shadow falls. One can also determine the duration of the solar eclipse. The following factors determine the duration of a total eclipse like the position of the moon (at the perigee), Earth further away (aphellon) from the Sun, the midpoint of the eclipse being close to Earth's equator where the velocity is greatest. The longest eclipse calculated will be seen on July 16, 2186 for 7 minutes 29 seconds over northern Guyana.

Earth revolves around the Sun and results in the revolution of the lunar nodes which causes the eclipse season each six months at a new moon phase and also a lunar

eclipse can occur at the full moon phase. A total solar eclipse is a rare event which may be seen each 18 months on average. Hundreds of millions years in the past, the Moon was closer to Earth and appeared larger and every solar eclipse were either total or partial but never annular. In the future, the Moon will be too far away to fully cover the Sun and no eclipse will occur.

The oldest recorded solar eclipse was recorded on a clay tablet at Ugarit (Syria) in possibly in 1375 or 1223 BC. An Assyrian text mention a solar eclipse on Jube 15, 763 BC. The Chinese King Zhong Kang beheaded two astronomers His and Ho who failed to predict an eclipse 4000 years ago. Records of solar eclipse in 993 and 1094 as well as lunar eclipses in 1001 and 1002 reported by Yanus in Cairo. Eclipses have been interpreted as a disruption of the natural order and many groups have judged them to be of a bad omen. Many have spiritual explanations for solar or lunar eclipses in order to justify such inexplicable phenomena. Some have seen “Darkness and Spiritual renewal”.

The Greek Herodotus mentioned that Thales of Miletus predicted an eclipse during the battle between Meded and the Lydians, forcing both sides to put down their weapons and declare Peace. (Medes vs Lydians). He also reported another eclipse during the second Persian invasion of Greece in August 1, 477 BC not matching the date of the invasion. Astronomer Shi Shen described in the 4th Century BC, and predicted eclipses relative to the positions of the Moon and the Sun. Attempts at establishing the exact date of “Good Friday” by assuming that the darkness described at Jesus crucifixion was due to a solar eclipse, were not conclusive… more “Good Friday” was recorded at Passover which is held at the time of a full Moon. The darkness which lasted almost 3 hours while the upper limit of any solar eclipse is less than 8 minutes. Muhammad himself denied that an eclipse has to do anything with the death of his son.

We started observing solar eclipse by looking directly at the photosphere of the Sun (bright disc of the Sun) but even for just a few seconds, permanent damages to the retina of the eye can happen. Indeed, you may become blind because the retina has no sensitivity to pain. Effects will appear after and can produce irreversible blindness. Binocular, telescope or optical camera viewer are recommended to observe the sun during an eclipse. Viewing the sun during any solar eclipse requires special eye protection or indirect viewing methods to avoid eye damage. The safest way to view the Sun’s disk, is by indirect projection or by pinhole camera.

I would like to mention the way Religion has influenced scientific ideas. We have seen the way they tried to link the crucifixion of Jesus with the total eclipse which followed days after. Scientists have proven that such phenomenon can last a maximum of seven to 8 hours but never days. Although, Christians believe that this Eclipse phenomenon heralds the second coming of Christ and the end of times, when Jesus will return to Earth for judgement. Others in the Islam religion, believe that it is time to turn to God and pray. In the Judaism, it is written in the Talmud that a total eclipse is “an ill omen for the world”. In the Hinduism, also many legends refer to eclipses as bad omens. In Buddhism, an eclipse is seen as an occasion to encourage spiritual practices.

For others, an eclipse seems to elicit primal fear, mixed with euphoria and a sense of relief, once the sun reappears in the sky. In general, it is a curiosity that one would not

like to miss. Even if many may still believe that it is a sign of bad omen with the idea to observe the sun being eaten out… by demons or dragons or wolves etc. Years ago, I was vacationing in Mexico and while visiting the town of Tulum, I was attending a show presented by the native Indians. Two groups were playing a game similar to a mixture of basketball and soccer, but it was the object of the game to win. The winner would then be sacrificed in the name of his king, in a supreme honor. This special game was played during a solar eclipse and the winner was sacrificed for his king. What a token of love to give up self for the love of his king.

Life has many ways to attract your attention. Certainly, a phenomenon like an eclipse, leaves in you a sense of respect for mother Nature, mixed with the fear of the extra-ordinary and the unknown, in a feeling of surprise and amazement that you only can experience when witnessing such wonderful and natural event.

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