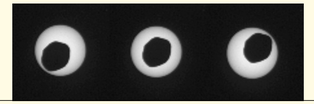

Curiosity rover captured Mars' moon, Phobos, eclipsing the sun on August 20, 2013. *Credit – NASA/JPL-Caltech/Malin Space Science Systems/Texas A&M Univ.*

More than a Fleeting Straight Line: How Eclipses, Transits and Occultations can help to reveal the Physics of the Universe

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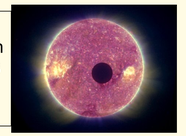
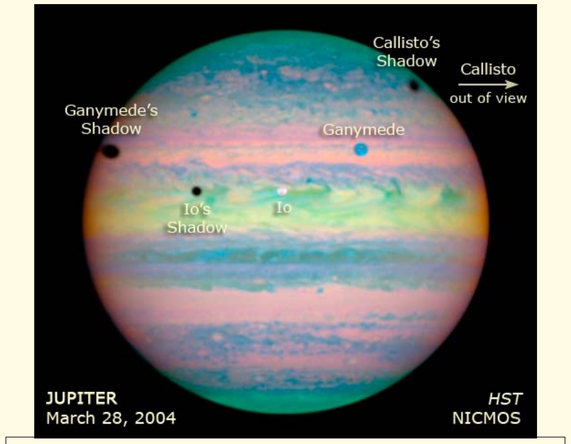


Earth's moon transits across the sun as seen by NASA's STEREO-B on March 25, 2007. *Credit - NASA*

Scientific concepts associated with eclipses, transits and occultations that can help us learn about the solar system, our galaxy and beyond. I have divided these into three categories below. Each of the lists is not exhaustive and is meant to be a starting point for exploring astrophysical phenomena.

1. Solar and Lunar Eclipses

a. What are solar and lunar eclipses and why do they occur? What are the different types of solar and lunar eclipses? How often do they occur and why?
b. One can introduce moon phases, and discuss the moon phases needed for solar and lunar eclipses.
c. One can discuss angular size versus actual size of objects, umbral and penumbral shadows.
d. The shape of Earth's shadow on the moon during a lunar eclipse helps us know what is the shape of Earth.
e. One can discuss how moon phases are caused, and why they are not caused by Earth's shadow falling on the moon.
f. Explaining why we see total and annular solar eclipses leads into the fact that the moon's orbit is not a perfect circle. This can lead to the introduction of different types of orbits, Kepler's Laws and gravity. One can discuss orbits of stars within our galaxy and orbits near a black hole too.
g. One can discuss why eclipses do not occur at every new and full moon.
h. One can discuss the precession of the nodes of the Moon's orbit and how this affects the frequency of eclipses. One can discuss precession of Earth's rotation axis and other objects and orbits.
i. How many people on Earth are able to see solar and lunar eclipses and why?
j. One can introduce tides and angular momentum, and explain why the moon shows the same face to us and also whether total solar eclipses will continue to occur in the future.



A rare triple eclipse on Jupiter seen by the Hubble Space Telescope's Near Infrared Camera. *Credit – NASA, E. Karkoschka*

1. Solar and Lunar Eclipses (continued)

k. When viewing the sun's projected image, one can ask why the image moves. This leads to discussing Earth's rotation and why objects rise and set. If sunspots are present, one can compare sunspot diameters to Earth's diameter, one can discuss the sunspot cycle, magnetic fields, other solar activity and space weather.
l. One can discuss the layers of the sun's atmosphere when viewing white light and H-alpha images of the sun as well as the absorption spectrum of the sun.

2. Phenomena unique to total solar eclipses:

a. viewing Baily's beads and the diamond ring
b. viewing the totally eclipsed sun and its corona with the naked eye during totality
c. shadow bands
d. how behavior of animals changes during totality
e. how the ambient temperature changes during totality

3. Other three-body alignments:

a. Solar eclipses seen from Mars or by space missions studying the sun or other spacecraft
b. Transits of Mercury and Venus, transits of moons of Jupiter and Saturn across their parent planets, occultations of distant solar system objects by the moon or other closer solar system objects
c. Occultation of stars by solar system objects
d. Finding planets around other stars (exoplanets) using the transit method
e. Determining radii of transiting exoplanets and the chemical composition of their atmospheres
f. Eclipsing binary stars
g. Gravitational lensing of stars during a solar eclipse
h. Gravitational lensing due to stellar mass black holes within our galaxy, using gravitational lensing to find planets around other stars
i. Gravitational lensing involving clusters of galaxies

Poster presented at the American Astronomical Society's Solar Eclipse Planning Workshop, 8, 9 April 2022, held virtually.