

## **Measure the moon's size and distance during the next lunar eclipse**

By Ethan Siegel

The moon represents perhaps the first great paradox of the night sky in all of human history. While its angular size is easy to measure with the unaided eye from any location on Earth, ranging from 29.38 arc-minutes ( $0.4897^\circ$ ) to 33.53 arc-minutes ( $0.5588^\circ$ ) as it orbits our world in an ellipse, that doesn't tell us its physical size. From its angular size alone, the moon could just as easily be close and small as it could be distant and enormous.

But we know a few other things, even relying only on naked-eye observations. We know its phases are caused by its geometric configuration with the sun and Earth. We know that the sun must be farther away (and hence, larger) than the moon from the phenomenon of solar eclipses, where the moon passes in front of the sun, blocking its disk as seen from Earth. And we know it undergoes lunar eclipses, where the sun's light is blocked from the moon by Earth.

Lunar eclipses provided the first evidence that Earth was round; the shape of the portion of the shadow that falls on the moon during its partial phase is an arc of a circle. In fact, once we measured the radius of Earth (first accomplished in the 3rd century B.C.E.), now known to be 6,371 km, all it takes is one assumption—that the physical size of Earth's shadow as it falls on the moon is approximately the physical size of Earth—and we can use lunar eclipses to measure both the size of and the distance to the moon!

Simply by knowing Earth's physical size and measuring the ratios of the angular size of its shadow and the angular size of the moon, we can determine the moon's physical size relative to Earth. During a lunar eclipse, Earth's shadow is about 3.5 times larger than the moon, with some slight variations dependent on the moon's point in its orbit. Simply divide Earth's radius by your measurement to figure out the moon's radius!

Even with this primitive method, it's straightforward to get a measurement for the moon's radius that's accurate to within 15% of the actual value: 1,738 km. Now that you've determined its physical size and its angular size, geometry alone enables you to determine how far away it is from Earth. A lunar eclipse is coming up on September 28th, and this supermoon eclipse will last for hours. Use the partial phases to measure the size of and distance to the moon, and see how close you can get!

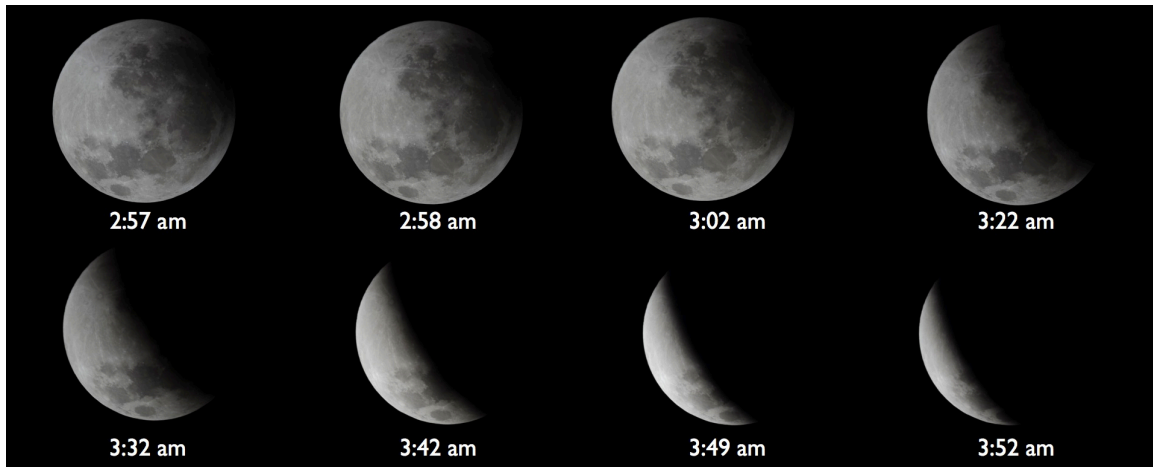


Image credit: Daniel Munizaga (NOAO South/CTIO EPO), using the Cerro Tololo Inter-American Observatory, of an eight-image sequence of the partial phase of a total lunar eclipse.