Apparent sizes, or "It was this big!"

by Bob Riddle

This past year, a couple of astronomical events occurred that were sensationalized to the point that they may actually have done more harm than good in trying to increase the general public's understanding of them. I am specifically thinking about the "super Moon" of last May and the naked-eye viewing of the Venus transit the following month. My concern as an educator is that without enough accurate information about these or any science-related events, they could be completely misunderstood or become "Is that all there is?" moments. The latter are often followed by a sense of letdown that may decrease the understanding of and interest in science-related events and, by extension, science in general.

Measuring 15° from the Moon

Super Moon

Last May, according to news media, the rising full Moon of May 5[would be the biggest ever—"huge" was one word I heard quite a bit. So what is a "super Moon," how "super" was this full Moon, and how significant was the event? A super Moon is a full Moon that occurs very near to its time of perigee, the closest the Moon comes to the Earth for that particular orbit, or month. By definition, "very close" would be when the Moon is less than 10% of its orbital period from the time of perigee. Use the data in Figure 1 to compare the full Moon and perigee dates, with the perigee distances, and with the angular sizes for 2012. Even though the exact times for perigee are not given, by comparing the May 5distance with other dates and distances, you will see that there could have been several super Moons in 2012. In fact, each year there are from four to six occurrences when the full Moon and perigee are close enough to be considered a super Moon; the full Moon closest to the time for perigee is the super Moon for that year. So a super Moon is not that unique nor, perhaps, worthy of the media hype this past one received, since we can have a super Moon ever year.

Carry this analysis further by comparing dates for full Moon and perigee, and you'll find a pattern in the regularity of super Moon events. How? There are two regular time periods, or cycles, involved in the pattern for super Moons. First, the time period between each full Moon, the synodic month, is approximately 29.53 days; second, the time period between each perigee, the anomalistic month, is approximately 27.55 days. With a two-day difference between these, there is obviously not a super Moon every month. However, with a ratio of 14 synodic months to 15 perigee periods,

FIGURE 1 Moon-to-Earth distances and apparent full Moon sizes for 2012

Month	Date of full Moon	Date of new Moon	Date of lunar apogee	Date of lunar perigee	Angular size at full Moon
January	January 9	January 23	January 2 (404,578 km) January 30 (404,323 km)	January 17 (369,886 km)	31'
February	February 7	February 21	February 27 (404, 862 km)	February 11 (367,922 km)	31'
March	March 8	March 22	March 26 (405,776 km)	March 10 (362,400 km)	32'
April	April 6	April 21	April 22 (406,419 km)*	April 7 (358,314 km)	33'
May	May 5**	May 20	May 19 (406,448 km)	May 6 (356,955 km)*	33'
June	June 4	June 19	June 16 (405,787 km)	June 3 (358,484 km)*	33'
July	July 3	July 19	July 13 (404,779 km)	July 1 (362,366 km) July 29 (367,315 km)	32'
August	August 2 August 31	August 17	August 10 (404,123 km)	August 23 (369,768 km)	31' 31'
September	September 30	September 16	September 7 (404,294 km)	September 19 (365,752 km)	30'
October	October 29	October 15	October 5 (405,160 km)	October 17 (360,672 km)	29'
November	November 28***	November 13	November 1 (406,050 km) November 28 (406,362 km)	November 14 (357,361 km)*	29'
December	December 28	December 13	December 25 (406, 098 km)	December 12 (357,075 km)*	29'

* large tides ** largest full Moon *** smallest full Moon

the closest of the super Moons to perigee for that year will occur about every 14 months. Because of this ratio relationship between these two cycles, 14 full Moons after last May's full Moon, the next full Moon coming closest to the time of perigee will occur. This will be the full Moon of June 23, 2013 (356,991 km/ [221,824 mi.]), which will be followed 14 months later by the full Moon of August 10, 2014 (356,896 km [221,765 mi.]), which is followed by September 28, 2015 (356,877 km [221,753 mi.]), and so on.

So what did the super Moon of May 5 look like as it rose? Was it as huge as it was predicted to be, or as I heard many people describe it the next day? The short answer is no. The Moon may have appeared larger than usual to some, but the larger-appearing rising, or setting, full Moon is actually a result of an optical illusion having to do with the full Moon against the background of the horizon. Once the Moon is higher up and viewers don't have the horizon as a visual reference, the Moon appears smaller, but there is no actual change in size. For example, during a recent late night drive home on a long, eastward-facing stretch of highway, my wife and I observed an extremely large-appearing full Moon over the highway and just above the horizon. A few minutes later, as the road angled toward the west and the horizon, and the Moon was shifted to an expanse of empty pasture, the Moon appeared noticeably smaller. As my wife commented, the key word here is "appears" because the Moon did not actually physically shrink in size.

To demonstrate how a full Moon near the horizon is actually the same size as the full Moon higher above

the horizon, look at the rising full Moon through a toilet-paper or paper-towel tube. Wait a few hours until the full Moon is higher above the horizon and again look at the full Moon through the tube. They are both the same apparent size when viewed through the tube. Interestingly, the rising Moon, regardless of the phase, is actually smaller in the sky because it is farther away by about 1.5% than when at its highest altitude above the horizon.

Two weeks after the May 5 super Moon, as Moon phases go, we had new Moon. This particular one may be well remembered for occurring at a point in its orbit that placed it between the Earth and the Sun enough to cause a total solar eclipse. However, a total solar eclipse did not occur. Instead there was what is called an *annular solar eclipse*, a situation where at mid-eclipse the disk of the Moon does not completely cover the disk of the Sun. This happened as a result of the elliptical shape of the Moon's orbit and timing. This new Moon was the opposite of the super Moon and so was at about the farthest the Moon could be from the Earth near the time for apogee. Because of this, the Moon, with a smaller-than-average angular diameter of approximately 30', was unable to cover the Sun, with an approximate angular diameter of 32'. This new Moon, by the way, could have been called a "super-mini Moon."

Angular measurements

Figure 1 also shows the approximate angular size of the full Moon as measured in arc-minutes. Angular size in astronomy is measured using a familiar system of degrees, minutes, and seconds. However, because the sky appears as a curved surface, angles between objects or the object's diameter are sometimes prefaced with *arc*. For example, the hand held out at arm's length, as shown in Figure 2 spans approximately 20–25°, a fist is 10°, and the little finger is approximately 1° in width. The field of view for a 7 x 35 binoculars is about 7°, while the average angular size, or diameter, of the full Moon is around 30' (arc-minutes); the Sun also has an average angular size, or diameter, of 30'. Venus ranges from about 1' (1 arc-minute = 60 arc-seconds) at inferior conjunction, to about 10" (arc-seconds) at superior conjunction. If the Big Dipper is visible, look at the two pointer stars. They are approximately 5° apart and about 30° away from them is the Pole star, Polaris—the North Star. The altitude in degrees that the North Star is above your northern horizon is the same as your latitude. Knowledge of angular size in observational astronomy is very useful; for example, the observer would be able to determine how close an object will be to another celestial object, or if both could be seen within the field of view of binoculars or a telescope eyepiece.

Spread the word

There are probably other instances that could come to mind where science-related information is not presented in an entirely accurate way, whether by intent or from a lack of understanding of the topic. With regard to the "super" Moon, there is no doubt that more people, including our students, became excited, more aware, and participated in these events in part due to the media attention. But how many come away thinking they actually saw a huge "super" Moon, when in fact the Moon's apparent size was due to an illusion? Or how many people thought their naked-eye view of the Venus transit last June would be like the pictures shown online, in print, or on TV? Or that Mars could be as large as the full Moon? Or that eggs (and only eggs) balance on the equinox? As educators, we must ensure that information about events like these is accurate. Think of these moments as teaching opportunities; a way to take advantage of them could be to have your students prepare displays, presentations, or demonstrations that not only would promote an event, but also provide accurate information.

World Space Week

This is the 55th anniversary of the launch and orbit of the Russian satellite Sputnik 1. During October of each year, there is a global celebration of space flight that begins on the October 4 anniversary of the launch of Sputnik 1 in 1957 and ends on the October 10 anniversary of the signing of the first space treaty, the *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies* (see Resources).

October

2	Venus near Regulus
4	Jupiter begins retrograde motion
	Mercury near Saturn
	Moon at Apogee: 405,160 km (251,754 mi.)

	Waning gibbous Moon near Aldebaran
	Waning gibbous Moon near the Pleiades
4–10	World Space Week
5	Waning gibbous Moon near Jupiter
6	Waning gibbous Moon near 1 Ceres
8	Last quarter Moon
12	Waning crescent Moon near Venus
15	Dwarf planet Eris at opposition
	New Moon
17	Moon at Perigee: 360,672 km (224,111 mi.)
	Waxing crescent Moon near Mercury
18	Waxing crescent Moon near Mars
20	Astronomy Day
	Mars near Antares
	Orionid meteor shower peak
21	First quarter Moon
23	Sun enters astrological sign of Scorpio
25	Saturn in solar conjunction
26	Mercury at eastern elongation
29	Full Moon
30	Sun enters the astronomical sign of Libra
31	Waning gibbous Moon near Aldebaran and Jupiter

Visible planets

Mercury will be visible all month, but will be low above the western horizon at sunset.

Venus will be very visible, shining above the eastern horizon at sunrise.

Mars will be visible over the southwestern horizon at sunset and set one to two hours after the Sun.

Jupiter will rise after sunset and will be visible all night this month.

Saturn will be visible, but low over the western horizon at sunset by the end of the first week and will be too close to the Sun to be easily seen. Saturn will reappear in about a month as a "morning planet."

Resources

Cassini at Saturn—*http://saturn.jpl.nasa.gov*

Getting an angle on the Sun and Moon—*http://spacemath.gsfc.nasa.gov/weekly/6Page32.pdf*

Lunar perigee and apogee calculator—*http://fourmilab.ch/earthview/pacalc.html*

Questions for students

1. How do we know that every 14 months there will be a "super Moon"? What is the relationship between the synodic month and the anomalistic month?

   During the time that it takes 14 full Moons to occur, there will be 15 perigees. 14 x 29.53 days (synodic month) = 413.42 days; 15 x 27.55 days (anomalistic month) = 413.25 days.

2. Based on data from 2012 in Figure 1, what is the average angular size or diameter of the full Moon, and how could these different sizes be explained?

   The average angular diameter of the full Moon is 31' (arc-minutes). The different sizes show that the Moon is at different distances from the Earth at full Moon—an indication that the Moon's orbital shape is not circular but elliptical.

3. Use your answer to Question 2 and the Sun's apparent angular diameter to explain how we can have both a total eclipse as well as an annular eclipse.

   The Moon follows an orbit that is more elliptical than circular, so there will be times with a solar eclipse at new Moon when the Moon is either farther or closer to us. When closer, the Moon's apparent angular diameter may be larger than the Sun's, giving us a total solar eclipse. On the other hand, when the new Moon is farther away, its apparent angular diameter will be less than the Sun's, giving us the annular eclipse.

NASA image of the day: Sputnik 1—*www.nasa.gov/multimedia/imagegallery/image_feature_924.html*

Orionids meteor shower—*http://meteorshowersonline.com/orionids.html*

Outer space treaty—*www.state.gov/t/isn/5181.htm*

Riddle, B. 2009. Urban legends. *Science Scope* 33 (4): 58–61.

Riddle, B. 2012. March Mars madness. *Science Scope* 35 (7): 90–93.

U.S. Naval Observatory: Data services—*http://aa.usno.navy.mil/data*

World Space Week—*www.worldspaceweek.org*

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