Eclipses, Occults, and Transits – Oh My!

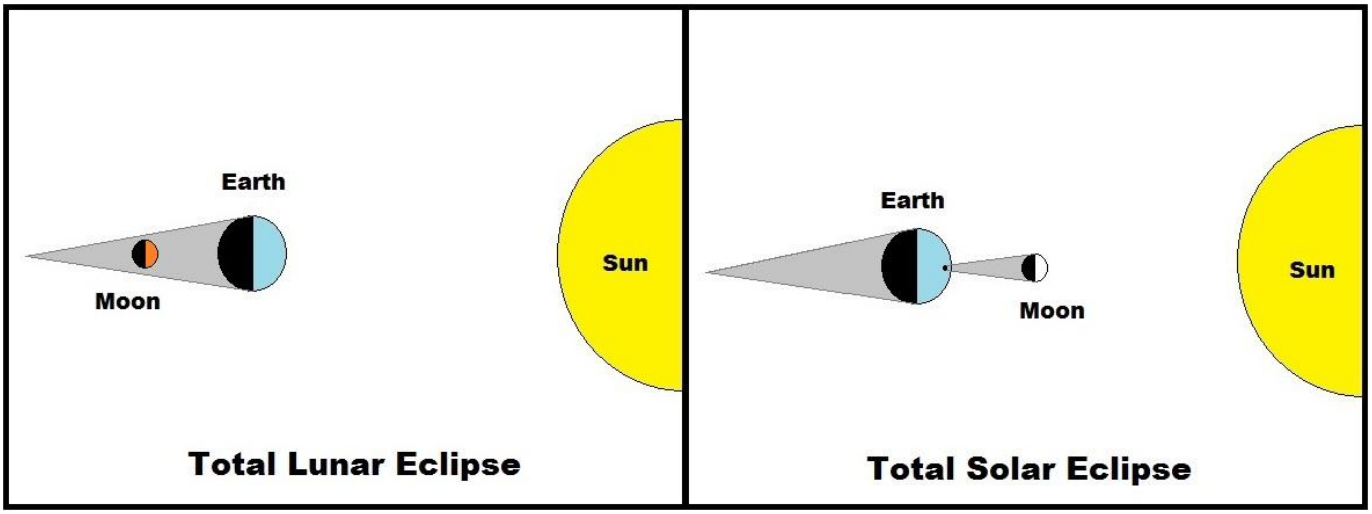
Winter 2014-2015

I often hear that astronomers are not particularly adept at delivering information to the general public. Actually, I don't totally disagree with this assessment, but I do think we should cut them a bit of slack. Astronomy is an ancient science, rich in history, discovery, technology, and unfortunately, jargon. Sometimes, the techno-babble actually gets in the way of our ability to just appreciate and enjoy the simple beauty of a celestial event. Who knew? And, while many of the very best astronomers in the world have spent years, even decades, growing their knowledge and improving their skills, public speaking in an outreach environment may not always be their strong suit.

In this newsletter, we are going to tackle three related terms that don't always convey the majesty and wonder of their visual astronomical events. We'll be reviewing ***eclipses, occults*** and ***transits***. I'll provide technical definitions for those with a "high GF" (I'm an amateur astronomer too, after all). At the same time I'll provide context and background so we can understand their significance and what they teach us about the universe. When we combine the technical with the wondrous, we'll know why these cosmic happenings attract us in a way that's "kinda now, kinda wow, sort of sexy, and kinda POW!" It's why, when people see them in a telescope, they say, "That is so cool!"

At the end of this newsletter, as usual, I'll throw out there some of the celestial happenings that are coming up in the next few months. Many of these events are examples of the high end astronomy that is going on right now, in some of the best observatories on the planet. All of them though are cosmic eye-candy that everyone, even a professional astronomer, can visually appreciate.

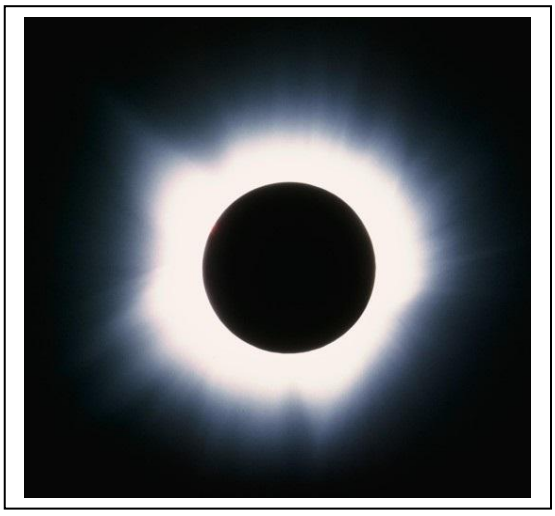
We start with a diagram from way, way back, when the newsletter was young. Below, from spring 2008's "***Celestial Dances***", is a side-by-side depiction of lunar and solar "eclipses" – our first term.



Here is a quick review of what most of my readers already know. The "lunar" version of a total eclipse happens when the *Full Moon* enters into the shadow of the Earth. Everyone on the "night side" of our planet can look into the sky and see the blood-red moon characteristic of these events. The "solar" version, on the other hand, happens during the day (I'm betting you knew that). Only those lucky Earthlings standing in the small circle of the Moon's shadow see *totality*. A chunk of the population near the lunar shadow would be perfectly positioned to view a *partial solar eclipse*. The rest of us, unfortunately, would see nothing at all.

An examination of the above images shows that a lunar eclipse is caused by Earth's shadow falling on the disk of the full moon. A solar eclipse is caused by the moon itself actually obscuring the disk of the Sun. Why are both of these events called an eclipse? Our perspective from one case to the other is completely 180-degrees different. What gives with this sloppy language; isn't it confusing?

Well, if you look at the ***general definition***, you'll find that the noun "eclipse" is defined as "any obscuration of light". While this explanation is neither technically helpful nor awe-inspiring, both the lunar and solar versions have been viewed with wonder over the centuries; and eclipses in a variety of forms have been important both scientifically and culturally.



Above left is a lunar eclipse in progress, while the right image is a total solar eclipse at the absolute peak. These images are at different scales – the moon and the sun in our skies appear nearly identical in size –but these scales showcase the scientific value. Notice the subtle curvature of the dark shadow on the moon? So did ancient Greeks who used the information to postulate that the Earth was round. In the right side image, it's not the eclipse itself that attracted scientists not long ago. It was the corona, a part of the solar atmosphere that could only be seen and studied when the brightness of the sun was blocked out by the disk of the new moon.

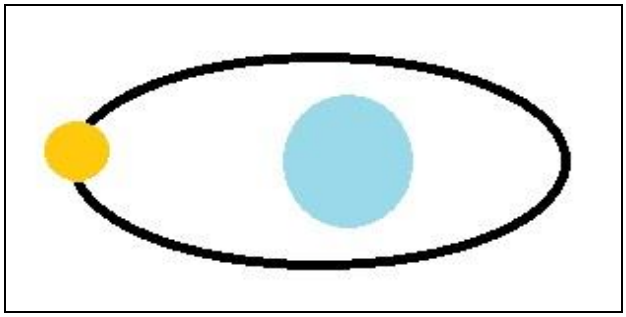
Eclipses of the sun and moon no longer provide the wealth of science they once did, but there was a time that a ship's captain used his knowledge of a lunar eclipse to save his crew. When Christopher Columbus' crew was stranded on the island of Jamaica, the initially pleasant natives grew weary of providing sustenance to slackers for trinkets and toys. With rescue still months away, Columbus concocted a plan and consulted his almanac for the exact timing of a pending lunar eclipse.

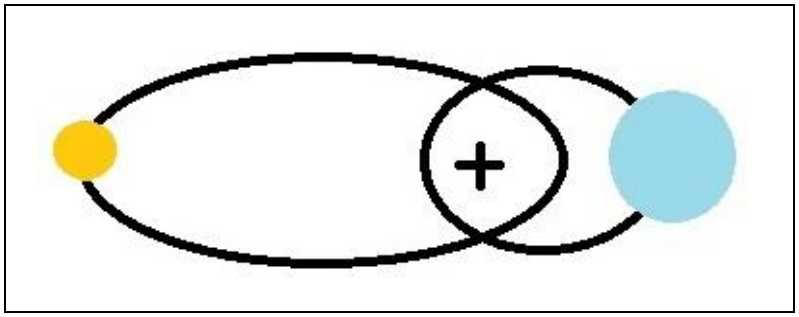
Putting his plan in play, Chris called a meeting with the chief and let him know that the gods were most unhappy with the tribe's lack of support. He pointed out that in three nights the moon would be taken from the sky, and God's anger would be clear. At the appointed time, not only did the moon fade from view, but it turned blood red! Surely, the gods were furious - the natives were horrified.

Columbus the showman retired to his quarters to "consult the gods" and to inform them that the tribe had seen the error of their ways. He reappeared only minutes before the end of totality to announce that all would now be restored. The moon immediately began to recover its splendor, and Chris and his men had no further troubles with their newly repentant hosts.

While eclipses of our own sun and moon are now more show and legend than science, there are similar cosmic happenings that still provide valuable information to astronomers. Eclipses of stars other than our own sun are in fact pushing the very limits of astronomy. This is also where our other terms come into play. If we accept the earlier definition that an eclipse is any obscuration of light, then both occults and transits are eclipses of either the lunar or solar variety. The only differences are in the relative sizes of the celestial bodies involved, and possibly in the observer's point of view. Here are some illustrative examples.

Studies have shown that approximately two-thirds of the stars in the sky have partners…not planets necessarily, but partner stars. Our own Sun is the odd duck in the universe…it is a loner. Now, in a ***binary star system***, both bodies have mass and gravity, and that means that the two suns will orbit each other, or more specifically, they will orbit their center of gravity as shown below.





The drawing at left shows a small yellow star orbiting a larger blue star. However, as all stars have mass and gravity the pair would actually orbit their common center, as in the drawing at right. If the two stars had the same mass, they would orbit a point centrally located between them. In this case, the blue star is more massive, and so the system's center of mass is proportionately closer to the blue partner.

If we take the concept of binary stars, and assume that the plane of their orbits is oriented to be aligned with Earth, then the two stars would appear to be moving back and forth as they orbit each other. From our perspective, sometimes the small yellow star would appear in front, as it *transits* across the face of the larger blue star, while at other times, the more massive blue partner would totally *occult* the smaller yellow star. This is known as an ***"eclipsing binary"***, and it tells astronomers a great deal. Measuring the changes in their motion and combined light tells us about stellar masses, and allows us to more closely estimate the distances to stellar systems in other galaxies – a vast improvement from previous ***"standard candle"*** measuring systems.

This idea of an eclipsing binary also shows the difference between a transit and an occultation. When a smaller body, *or its shadow*, moves across the face of an apparently larger body, it is called a transit. When a relatively larger body totally blocks the light from a smaller object – whether the apparently smaller body is a star, a planet, or even an asteroid – it occults the smaller object. There are good examples of where both of these events are used in today's astronomy.

Possibly the most famous example of a discovery arising from an occult is the rings of Uranus. While rings were reported around the seventh planet in 1789 by Herschel himself, the actual discovery is generally accepted from a study in 1977 using the Kuiper Airborne Observatory. At that time, astronomers were watching as Uranus occulted a star, hoping to use that data to learn more about the planet's atmosphere - another example of the method's usefulness. Their data showed that as the star approached the planet, its light flickered five times. The five flickers appeared again as the star exited from behind the planet. Their conclusion was that Uranus had five rings which caused the

stellar light to flicker five times; a hypothesis that was confirmed in 1986 when the Voyager-2 space craft actually imaged the Uranian ring system. Additional rings were discovered in later years.

The rings of Uranus were discovered in great part by a "perfect storm" of chance occurrences. First, Uranus is tilted nearly on its side, so that there are times when, from our Earthly perspective, the planetary system looks more like a target with a large blue-green "bulls eye" in the middle.
In this Hubble image from 2005, the rings are nearly edge-on. It would have been nearly impossible to make the same discovery using stellar occultation given this orientation of the ring system.
Similar techniques using stellar occults have been used to identify rings – or parts of rings – around Neptune.

Having reviewed eclipses and occults, we can now look at transits which have become an even more useful tool to cutting edge astronomy as time and technical sophistication have advanced. Even in my last newsletter ***"A New Day"*** from fall 2014, I hinted at this new capability. Without the ability to "see" an actual planet orbiting its host star, telescopes like the space-based Kepler depended on the gravitational tug-of-war that goes on between the two bodies to give up their secret existence. With the new telescopes and observatories that are here or in development, actual imaging is now possible. Not only will this allow the transiting planet to be seen, but elements of its atmosphere can be analyzed for the telltale signs of advanced civilization. This is an area where I believe the greatest scientific discoveries of all time will be made – and it may yet happen in my lifetime.

Now for a couple events that are coming up – and the first is yet another comet. Comet C/2012 Q2 Lovejoy is now visible in binoculars as it travels from Lepus to Taurus. Until early February, the comet will likely dim, but it can be found roughly between Perseus and Pegasus as it moves on a path from Taurus to Andromeda.

Next up is a relatively rare triple transit right here in our own solar system. As Jupiter reaches toward opposition in early February, transits of its Galilean Moons become more frequent. In fact, the brightness of Jupiter and its moons makes it very difficult to see the moons themselves. These transits typically involve the shadows of the moons that are cast onto the disk of Jupiter. The inky black shadows are much easier to see, though sharp-eyed observers can watch the moons transit as well. On the night of January 23, at about 11:30pm Tucson time, the three Jovian moons Io, Calisto, and Europa will simultaneously cast their shadows onto Jupiter. The transit of all three will only last about 30 minutes, and then there will be only two. Triple transits such as this occur only rarely, happening only every few years.

And now, a follow-up on the news I announced in my fall newsletter. The new website for Astronomy Adventures Arizona is up and running, and available to visitors. You can now find out about the astronomy observing services I offer at www.AstronomyAdventuresAZ.com. I will be updating my site regularly with new information and more offerings for customers, so please be sure to visit and let me know what you think. If you would like to schedule your own Astronomy Adventure in Arizona, be sure to contact me by email or phone. I would love to help you with a customized observing session, or even to help you find and obtain that perfect telescope to advance your astronomy passion.

Finally, I am going to include some information as attachments with this newsletter for you who have been readers for so long. First, I'm sending along a 2015 Calendar commemorating Fay – my new 16" SCT reflector. On the calendar, I list monthly sunsets and moon phases – perfect for creating your own astronomy activities and events. If you choose to print the calendar out, there is ample room on there for your own personal notes, to keep track of all your 2015 "don't miss this activities"!

I am also going to send along a sample of my newly completed brochure for Astronomy Adventures Arizona. On it there is a 10% discount coupon that you can use for any observing session scheduled through me. Just print out the brochure and cut off the coupon, send it to me when you are ready to schedule an event. And again, your comments and suggestions would also be appreciated. As new events are scheduled, I will post them on the calendar that can be viewed on my website's "Links and App's" page. I'd love to see your event included on there!

Take Care Everyone and Have a Great Spring and a Happy 2015,

Chuck Dugan
Astronomy Adventures Arizona
520-419-6343
ChuckD@AstronomyAdventuresAZ.com