UUO Solar Eclipse Talk

Unitarian Universalist Church of Olinda
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***When the Sun Goes Dark*–** be prepared for a total solar eclipse in Kingsville on Monday afternoon, April 8, 2024.

Spring arrived late on last Tuesday evening, and today we celebrate both it and Palm Sunday, while looking forward to Easter Sunday next week and to the total solar eclipse coming to Kingsville on Monday afternoon, April 8, just over a week later. This is a time for thanks and celebrations, with spirits raised in glorious music.

Our opening hymn and alleluia is **#203 *All Creatures of the Earth and Sky*,** with lyrics attributed to St. Francis Assisi (1182-1226) and music arranged centuries later by Ralph Vaughan Williams (1972-1958). In this current time of terrible destruction, displacement, starvation and death, music can raise emotions and lift spirits yearning for peace and an end to violence. Hymn 203 reminds us to celebrate life on Earth, and it will be followed by Hymn 19, which reminds us of the many blessings we can now claim now as our own right here on planet Earth in Ruthven and Kingsville, Ontario, Canada.
Hymn of praise: #**19 The Sun that Shines** with bouncy music by David Dawson.

The Earth, Sun, Moon and other planets, together with most comets and asteroids in our solar system, were formed about 4.6 billion years ago. We can sing praises not only for their existence, but also for our ability now in the 21st century to understand them: their formation, existence, and probable fate. We are most closely connected, of course, to the Earth, Sun, and Moon, and their alignment one week after Easter Monday will present us with a rare total eclipse, during which the shadow of our moon will pass over our church, blocking the brilliant rays of the Sun to give us a clear view of our place in the solar system.

Now there are many moons in our solar system (including 95 for Jupiter and 145 for Saturn) as recognized by the International Astronomical Union (IAU), but our moon is special, not only because it is ours—it orbits the Earth---, but because of its large size relative to the planet it orbits. Its diameter is 1/4th that of the Earth. The largest moons in our Solar System, Ganymede at Jupiter and Titan at Saturn are actually bigger, but much smaller relative to the size of their host planets.

So how did Earth wind up with such a large moon? After isotope, mass-distribution, and compositional studies of moon and Earth, the most promising theory is that a minor planet we now call **Theia,** which was probably formed at about the same time as the Earth, smacked into us about 4.46 billion years ago (GYA), and while some of it stayed buried, the rest bounced off and much of that formed our moon. The evidence is still being analyzed, but what we have learned so far lends support, and we're still learning more: this is exciting science in action!

JILA and Apollo 11

Since the Sun is about 400 times bigger across that the moon, how can the moon possibly block out most of the solar light reaching us? How can their visual sizes in the sky be so similar? As the Greek mathematicians Aristarchus (c. 310-230 BC) and Hipparchus (c. 190-120 BC) realized, if the Sun is 400 times further away than the moon, they can appear to be the same size in the sky even though the Sun is about 400 times larger in diameter. By using simple geometry, the Greek mathematicians gave the first realistic estimates of their sizes and distances. So how far away is the moon? Roughly 400,000 km, but it varies and is increasing! Also, at the time of the first lunar landing in 1969, there was a bit of uncertainty about its true average value.

As some of you know, before Bobbye and I came to Windsor in the fall of 1969, we spent a couple of years in Boulder, Colorado, where I had a post-doctoral fellowship working at the Joint Institute of Laboratory Astrophysics (JILA). It was a wonderful experience, working with impressive physicists and astronomers and hiking in the mountains among 14,000 – foot peaks. By 1969, our older daughter Evy would sometimes join our hikes on my back. This was also the time of the Apollo-11 mission and the first manned lunar landing on July 16–24, 1969. At that time, as I mentioned, there was some uncertainty about the true distance to the moon. As I recall, there were two likely values of the average distance and these differed by several feet. One of the tasks for astronauts Neil Armstrong and Buzz Aldrin, while Michael Collins orbited the moon in the Command Module, was to set up a retro-reflector array on the lunar surface that could reflect a pulse of laser light right back towards its source. The distance of the moon could then be calculated from the time of travel of the laser pulse. Lasers were first made in 1960, and trying to detect a pulse that had traveled to the moon and back was a challenge. The pulse travelled for about 1.3 seconds each way, and although the outward pulse could be collimated by sending it backwards through a large-diameter reflecting telescope, there would be some inevitable spreading of the light before it returned to Earth. The measurement was successfully made several days after the astronauts returned to Earth, after the astrophysicists reduced the signal noise by shrinking the observation window around the expected arrival time of the reflected pulse! There was extra tension when work was interrupted by a telephone call from then new president Richard Nixon (serving from 1969-1974) who wanted to congratulate and chat with the astronauts while they were on the moon. Bobbye and I did not have a TV set at that time, but we had kindly been invited to the home of Peter Bender, a key physicist involved in the lunar laser experiment, to watch the lunar landing with him and a few colleagues. I remember some of us yelling at the TV set for Nixon to end his chat so that the astronauts could finish their important work on the lunar surface!

Because our moon is relatively large and close, its gravitational interaction is sizeable, creating tides on Earth while its back reaction squeezes and warms the interior of the moon. The same effect heats the volcanoes on Jupiter's moon Io and creates the water geysers on Saturn's moon Enceladus. The meditation hymn: **#1068 Rising Green** by our friends Carolyn McDade, the composer, and Jim Scott, the arranger, speaks of the tides caused by the moon and the interconnectedness of nature as the warmth of Spring causes sap to rise in the oak trees. The hymn also speaks of the "open skies where the stars forever have lain." But even stars are not forever! Our Sun, as mentioned, has existed for about 4.6 billion years so far but is continually changing. It is now about halfway through its life as a star, and the laser measurements of the moon show that it is gradually receding from the Earth at a rate of about 3.7 cm/year. Its recession is caused by loss of energy and hence orbital speed, to tidal friction.

To sum up this bit of geometry, It's a stunning coincidence that the visual size of the moon today in the sky is so similar to that of the sun. The mean distance from the Earth to the moon is 384,400 km (roughly 30 Earth diameters), but it varies from 363,104 km at perigee (closest approach) to 405,698 at apogee (when furthest away). The Sun is about 400 times further away and about 400 times larger in diameter than the moon. That gives us this coincidence that the Sun and moon appear the about same size in the sky. But the moon-Earth separation is not constant! The moon is leaving us! It's receding from Earth by 3.7 cm every year, as discovered by timing laser pulses bounced back from retroreflectors placed on moon. When the moon is near perigee in its orbit about Earth, its apparent size is largest and we can get the longest total eclipses, but at apogee, its visual size is too small to fully cover the sun and we can see only annular ("ring of fire") eclipses. (Earth is in an elliptical orbit around the Sun. It reaches perihelion in its orbit in early January, and that is when the solar day is its longest.)

In roughly a billion years, the moon, because of its recession, will be too far away from Earth to ever fully eclipse the Sun. There will then be no more total solar eclipses! Only annular and partial ones, so don't miss this one! (OK, you will have chances to see other total solar eclipses, but not here for almost the next century!)

Here is a link to eclipse map that shows the path of totality this year. You can expand the scale of the map, and by clicking on a place you can get times of the eclipse as seen from that location: https://www.timeanddate.com/eclipse/map/2024-april-8

Note for example that at the beach in Colchester south of Harrow, the time of totality is 1m 33 s from 3:13:32 to 3:15.05 pm EDT, whereas on the beach at Kingsville Park there should be 1 m 49 s of totality, and at Point Pelee, the duration stretches to 2 m 54 s. At our UUO church, a duration of 1m 36s is predicted, lasting from 3:13:54 to 3:15:30 pm EDT.

The choral part of Beethoven's 9th symphony (the Chorale symphony: Ode to Joy) is the source of three hymns in Singing the Living Tradition hymnal: #21, 143, and 327. The lyrics used in our principal hymn: **#143 Not in Vain the Distance Beacons** are by Alfred Lord Tennyson Tennyson/Beethoven.

Total solar eclipses are favorite times to study the corona or plasma "atmosphere" of the sun. The eclipse blocks the blinding brightness of the photosphere and lets us study the sun spots and flares near the solar surface or photosphere. During totality, when the entire solar disc is in shadow, you should be able to see the planets Venus, Jupiter, and Saturn, perhaps a few bright stars, and the large corona, a solar "atmosphere" of charged plasma. There is still much to learn about solar flares and sunspots, solar activity first observed by Galileo in 1610 that occurs mainly in cycles of 11 and 22 years, and about coronal mass ejections that can strike the planets and light up auroras on Earth and other planets. The peak of sunspot activity seemed to have occurred earlier than expected this year. Is this a permanent shift in the sunspot cycle? Time will tell. Eddington's measurement of the deflection of light by the Sun during the 1919 eclipse, confirmed Einstein's general theory of relativity and demonstrated a way to measure the masses of distant black holes and galaxies as well as to focus on distant objects by using the bending of light paths as a gravitational lens. The corona is the Sun's "atmosphere", but it is ionized with temperatures of up to 2 Million degrees C! How does it get so hot? Magnetic turbulence is probably the cause of some heating but the details need more study. Be sure to look for the corona during totality. Also note the temperature drop during the eclipse and see the

behavour of plants and animals as they prepare for what appears to be an early nightfall.More things to study!

Safety precautions! It is essential that you protect your vision! Your eyes are sensitive and can be permanently damaged by only a few seconds of bright sunlight. Our eyes lack pain sensors so you won't feel the damage until it is too late! I have ISO-12321-2 approved solar eclipse glasses that can be used to view the sun safely at all times, and you are welcome to take a few pair, but you'll want to take them off briefly during totality in order to see the corona and the stars and planets. Closely supervise any children or use a pinhole camera or other means to project the solar image for safe viewing. It's fun to use the holes in a colander to produce an array of multiple solar images. Experiment, observe, and learn, but be sure to safeguard your eyes by putting your solar eclipse glasses back on as the Sun reappears after totality.

Traffic and weather notes: Judging from historical trends, the weather during the eclipse on April 8 has a 60 to 70% probability of being cloudy and overcast. Should we be lucky and skies are clear, traffic may be unusually heavy. Please give yourself enough time to get safely to and from your chosen observation spot. Traffic authorities here have had little experience with total eclipses and do not know how congested the roads may become. You do want to be in the band of totality since the difference between a total eclipse and a partial one with 99% coverage is huge, but the area of totality is quite large along the north shore of Lake Erie and the local population density is generally modest. Ontario won't see another total eclipse until 2099. I send wishes of good luck and clear skies!

Our closing Hymn: **#163 For the Earth forever Turning** by K. Oler celebrates the spinning of the Earth, which brings us night and day! OK, maybe it won't spin quite forever, but for billions of years at least and probably longer than the sun will shine!

Thanks for joining us today and please attend our Easter Service with Rev. Janet Brigham Turowski next Sunday.

Other references:

Link to University article about local astronomer Steve Pellarin and his talks about the eclipse:

https://www.uwindsor.ca/dailynews/2024-03-15/essex-county-will-experience-total-solar-eclipse-april-8

A useful National Geographic video on solar eclipses: https://www.youtube.com/watch?v=cxrLRbkOwKs