From the Classroom Astronomer Newsletter, #3, June 16, 2021

Photographing the June 10th Eclipse, or the Sun in General

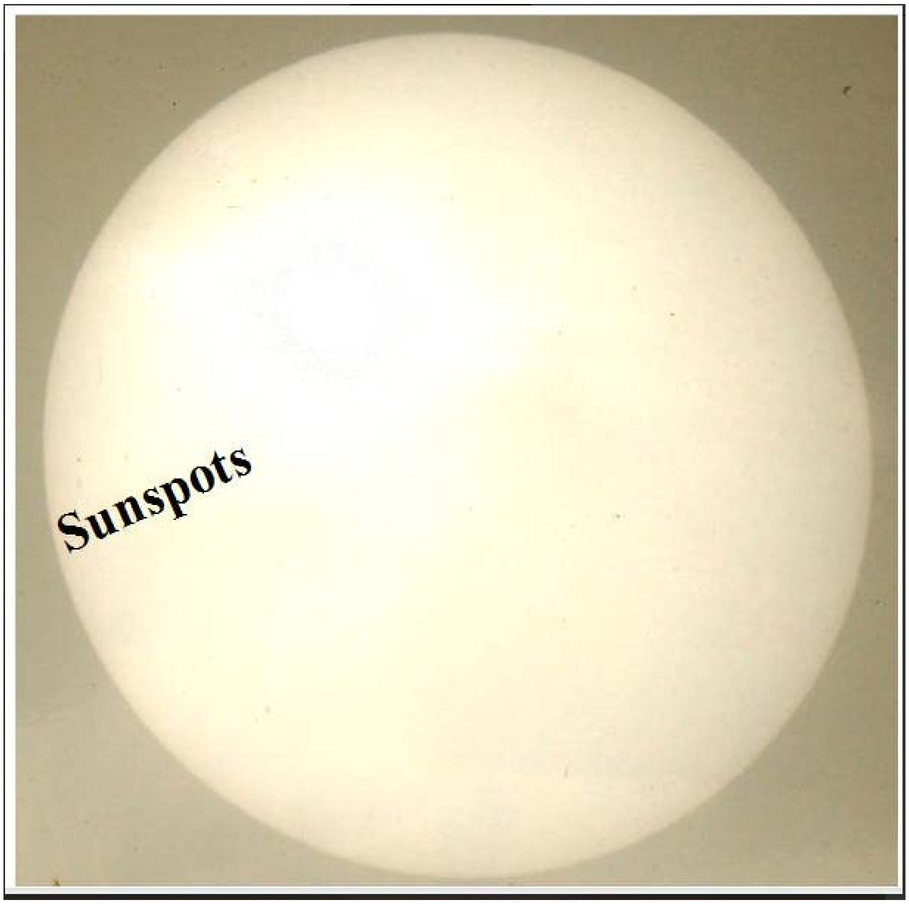
From top left clockwise: The eclipse from Padova, Italy by Dario and Giulia Tiveron, using a Sunspotter device and iPhone; from Perugi by Simonetta Ercoli, Canon EOS 1100D, 200 mm lens, 1/20 sec.; from Nahant Beach, Massachusetts, by Rich Stillman, using an Olympus E-620, zoom at 150mm with 100000 ND solar filter, 1/50 sec.; and a pinhole projection device, photographed with a Canon dSLR from Helsinki, Finland by Dr. Sedeer el-Showk.

Four very different ways to observe a partial eclipse, all photographed within minutes of each other (from a few to less than an hour) according to their UTC times (Universal Coordinated Time, essentially Greenwich Time), but at varying distances from the annular eclipse track through the Arctic. A demonstration of parallax for sure, but geometrically and mathematically more complicated than the usual lunar or solar eclipse parallax problem in which one can determine the distance to the Moon— because there are no right angles from these these locations and views!

The Finland photo is intriguing because of the extra and inadvertent crescents. The pinhole(s) were made through a simple pinhole projection device, a Pringles chip can, attached to a pole by a store-bought wine bottle mesh. But the mesh provided its own set of varying-with-solar-orientation pinholes as well!

The images are simply made onto a piece of paper on a cardboard box that supports the pole in a slot. Ostensibly, if the pole is long enough, and in a dark enough well to provide contrast, one could presumably see sunspots, such as those starting to appear in the new sunspot cycle. (Photo from Sedeer el-Showk).

From the Classroom Astronomer Newsletter, #9, Sept. 16, 2021



- ### What Color is the Sun? Or Any Other Star?

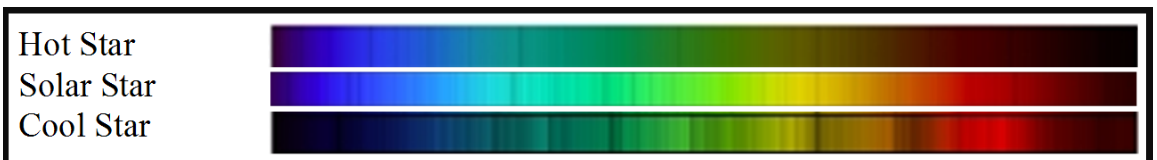
This Teachnique started out as a RAP Sheet piece, reviewing an article well-written by Matt Bobrowsky in the NSTA *Science and Children* magazine. In it, Bobrowsky queries why children always use yellow crayons to draw the Sun on paper when it can be clearly shown that the Sun is white. He uses various experiments to show this, using white paper and lights, and neutral density filters with telescopes, to show the Sun is indeed white, i.e. it has all the colors of the visible spectrum.

And that is the problem. The visible spectrum. And the human eye. We see all those colors. That makes things white. But that doesn't mean we see all the colors equally.

First, our eyes not only see all those colors, but we see them only to a point. After certain wavelengths of color (high and low) we stop seeing them. But more importantly, things that glow from heat do not glow in all the wavelengths equally. There is ALWAYS a peak in some wavelength, i.e. SOME color is always maximum in intensity, more than any other. It may be in the visible spectrum, or it may be so hot to be in the ultraviolet and our eyes will see the maximum in the blue because we don't see UV. Or the object is so cool that the intensity peak is in the infrared and our eyes don't see IR so the peak is in the deep red zone. But if the peak is in between, then the maximum is in one of the visible colors. That doesn't mean the other colors aren't there, it just means one is at maximum intensity. And if the overall light intensity is weak, our eyes tend to see the light source as predominantly that maximum color, whatever it is.

But what if there is too much light? Then, like a photograph, our eyes rather overexpose, and everything seems white. And that is why the Sun appears white. But it isn't. Let's see some other colored stars first to see why.

The only deep red stars in the fall nights are Antares, low in the southern sky in Scorpius, and Arcturus, halfway up due West for those of us in the American South (higher in more northerly latitudes). The former is truly a red giant, spectral class M, Arcturus is more orange, a K star, but it will serve the purpose here. Why do they appear reddish? If you send their light through your telescope and into a prism or diffraction grating, you will see little, if any, blue in your spectrum (rainbow) produced. Look at any of the other stars in the night sky and likely you will see all the colors of the rainbow in their spectra but the peaks will be different. You'll likely see more blue in the bluer stars and weaker red contributions. The *distribution* of the colors is a marker of the star's temperature. Red stars are cooler, blue are hotter. Where does the Sun fit into this?



(Spectra courtesy NOAO)

No, don't look at the Sun with a prism or grating! But it is safe to look at the *reflection* of the Sun's light off a white piece of paper, or poster board, with a simple spectroscope. And the narrower you can make a slit at the front end of a spectroscope, the dimmer the light coming through will be (we'll ignore the fact that it also makes the sun's spectral lines from its chemical elements more visible--that's a story for another time). What will you see as the amount of light comes through with fainter *quantities* of sunlight? That the peak of the Sun's light is somewhere in the yellow to yellow-green part of the spectrum, that the amount of sunlight towards the blue and red ends of the spectrum fade out, even before you get to where the colors fade to black because the eye can not see the UV and IR light beyond violet and red, respectively.

Why does the Sun not appear yellow normally to us? Because our eyes are swamped with too much light to see both the intensity peak in the yellow and the lower intensities elsewhere; it is all just overexposed to appear white. And, we'd go blind if we tried without protection. Furthermore, our species has grown up with the Sun's radiation, so we're used to this.

So that article wasn't entirely correct. The Sun isn't white naturally. It DOES have all the colors of the rainbow, because the rainbow is made by the Sun's light. It appears white because of its sheer overwhelming brightness to the eye. But if the Sun was moved out to the realm of the stars, it would appear as a yellow star, like winter's Capella in Auriga, the brightest of the northern sky's G-type, solar-spectrum stars, or Alpha Centauri in the south.

I do like his end joke. Yes, looking at the Sun through a colander would strain your eyes…..but so would looking at the Sun without it.

From the Classroom Astronomer Newsletter, #12, Nov. 1, 2021

Astronomical Teachniques

* IAU-Shaw: Low Tech Astro—Teach Astronomy During the Day, So Explore The Sun

Astronomy has a bad rap as an expensive hobby, notably because much of its PR comes from expensive magazines showing expensive equipment, such as high-end telescopes, cameras, mounts, and more. Of course, observatories and space-borne satellites don't come cheap either, and are often not available, or at a high cost, to educators, and whose got a budget for this? Furthermore, astronomy is a night time science, right? School is in the day.

There are actually good reasons for daytime astronomy, and a variety of low cost and low tech ways to teach it. A whole session on Low Tech Astronomy Education, and one also on Daytime Astronomy, took place at the virtual IAU-Shaw meeting out of Heidelberg. Here are some of the reasons why and what you can do with day skies, and cloudy budgets.

Daytime astronomy has the advantage, says T. V. Venkateswaran, an Indian astronomy educator, of being easier to organize, of being easier to be inclusive—especially of girls, in cultures where educating girls and other underserved populations can not do night time activities—and easier when there is a risk of less safe conditions for night time activities. There may be less teacher hesitation with daytime activities as well.

Dr. Breezy Flaquer of San Diego State University points out that when working with Hispanic underserved populations, she finds Low Tech approaches "makes science fun, interesting and approachable….and empowering [of students]." It doesn't mean low standards or expectations.

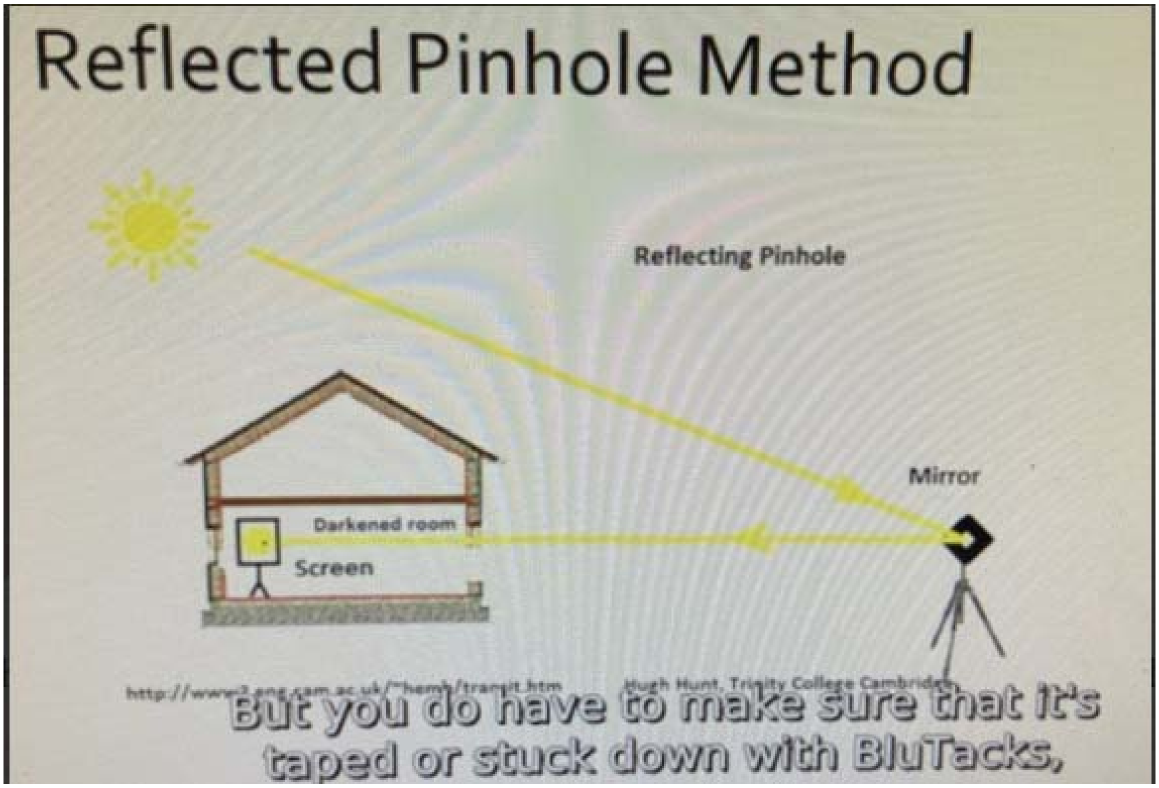
In the day, you have the Sun and the Moon, various motions, and with effort, some other objects if you have telescopes available. Let us stick with the Sun for the moment. There are four ways to explore our own star, two of which are Low Tech, one middling tech, and one Not Your Tech. That last one, if you are in possession of a good Internet connection, you simply go **online** and take a look at images from, say, SOHO, on a daily basis. But that rather defeats the purpose of classroom *exploration* as a starting educational activity.

The middling tech is **using a telescope** to directly observe (SAFELY, by projection, preferably, or with valid safe solar filters) or via pinhole or mirror projection, the last also being known as reflected pinhole, observation. With the former and the proper filtering, you can observe the solar disk in something other than strictly visual light, as in H-alpha light, a narrow-band view in the light of hydrogen in the red part of the spectrum. But that starts falling into not-Low Tech classroom astronomy. Let's stay with Low Tech for now.

A neater view is with **reflected pinhole projection**. Mr. Venkateswaran made balls filled with sand for stability, the ball on a cylindrical stand such as from cardboard or PVC pipes, with a mirror secured to the ball, framed in a circular mask. This projected a Sun image into a classroom or onto a wall. The farther the throw, the greater the size of the image, and no focusing is required. The round reflection acts as a pinhole lens, or in this case, a telescope mirror, and does that focusing work. Any spots that are of naked eye visibility in size will be easily spotted.

Ghanian educator Sarah Abotsi-Masters had a slightly different approach, and an improvement in one regard. Hers was also a framed mirror, but on a tripod, and it gave perhaps a better image reflected into a *darkened* room, though that may be troublesome for some classroom teachers elsewhere, being harder to arrange for all daytime hours.

[Ed. Note—At public eclipse parties, I've made small children's memories by taking women's purse makeup mirrors, already round, and made an eclipse image on their bodies—"Mom! I've been eclipsed!" I am sure they remember that!]



With pinhole observations, you can observe sunspots, do daily counts, do plots by position, and trace their paths caused by solar rotation, determine the time of solar rotation (though accuracy requires long timelines because you'll get different rates if you take only measures using spots near the solar limbs). If you can get the Sun all day in your room, you can determine Earth's rotation period, too.

The last method is **pinhole projection**, the simple hole in a piece of, well, anything. Paper, cardboard, or any household utensil such as a cheese grater or flat strainer. Nature can provide such pinhole images, through leaves on trees, holes in a curtain or shade if properly positioned, and I've had students contest to see who can make the most crescents by overlapping the fingers of their hands.

Only the largest of sunspots will show this way, and not much scientific observations are likely to be possible but as a cheap entry point to solar observation, pinhole projection is as low tech and low cost as you can get.

Beyond this, you enter the realm of telescopic and space-based observations.

One last solar note, Mr. Venkateswaran had one other interesting device, a card with the symbols of all major religions punched in it….cross, Star of David, crescent moon, and more. Held close to paper in the sunlight, they made their silhouettes; move back, they all made pinhole solar images. An interesting object lesson.

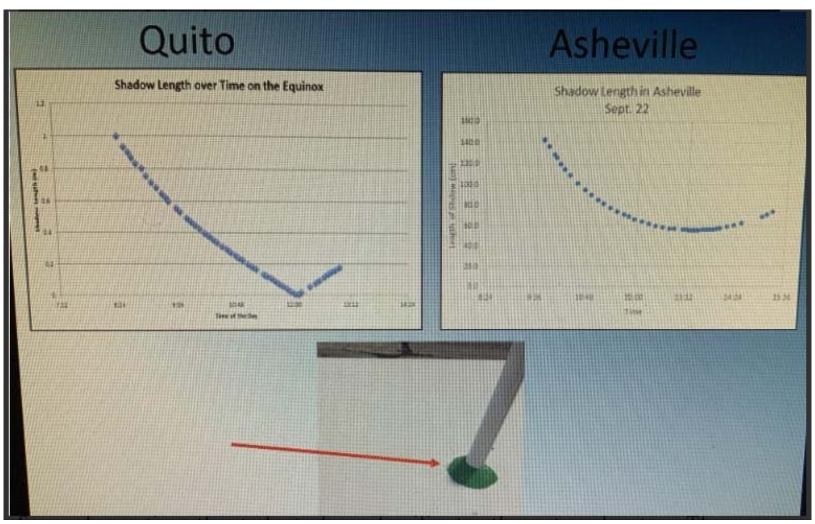
From the Classroom Astronomer Newsletter, #16, Jan. 11, 2022

Astronomical Teachniques

* ASP Notes: Mind Your Beeswax!

First semester college students often need to be transitioned into —- real college students. Dr. Judy Beck, an advisor also in the Department of Physics and Astronomy at the University of North Carolina Asheville, runs such a course for them. These seminars are often something that the professor gets to choose the topic, to do something THEY like that doesn't usually fit into the standard menu card of departmental courses. Several years ago Dr. Beck chose a solar observation course with a multitude of multidisciplinary connections that many other astronomy educators ought to consider.

The Sun is a very relatable topic to students, regardless of their backgrounds! Asheville in 2017 had a total solar eclipse as a motivation but each year since she has about 20 students take her first-year's seminar, now more a Science and Society than just Solar Observing course.



Some observations the students do are familiar to other astro educators. The course connects by Skype with a high school in Quito, Ecuador in time for the Equinox and does gnomon shadow measurements. They plot and compare shadow lengths and angles of altitude over time.

But Beck also connects with the local Cherokee Indian reservation and her students get involved with beeswax. What?? The students have to use solar furnaces (such as those at betterbee.com) that take 'raw' beeswax and melt them into molds created by students using computer-aided design programs and 3-D printed casts, into useful things such as soaps.

As part of the study of bees and wax, they learn about the honey-bees 'waggle dance' that is related to the position of the Sun in the sky, and with the Cherokees they initiate a study of legends of the Sun in other cultures. Gods (Helios and Ra), structures built around solar positions (Stonehenge of course, but also Chaco Canyon and the Mayan temples), events and rituals (Native American Sun dances, for one), and stories.

For more information on her course, email Judy Back at jbeck@unca.edu .

From the Classroom Astronomer Newsletter, #29, June 21, 2022

Hockey, T. Poster presentation at AAS 240. Total Eclipses of the Sun as Depicted in the Modern Popular Novel. **June 2020.**

I'm presuming that this will one day appear in some printed or online journal, knowing Dr. Hockey of the University of Northern Iowa, an esteemed history of astronomy researcher. But continuing in the vein of books using astronomy, and as there are an annular and a total solar pair of eclipses coming up in the next two years, this seems apropos for those looking for books to use in class.

Hockey asks the research question, "Following the total solar eclipses of 1999 and 2017, did the quantity and quality of book length fiction, which includes in its narrative an historical total eclipse of the Sun, increase in the English-speaking world?"

Using the Amazon Kindle library, Hockey filtered out non-relevant books ending up with a list of ten, nine of which he found to be historically accurate in that geographical and scientific accuracy of what was viewed (solar and eclipse phenomena [e.g. corona, shadow bands], viewing techniques and eye safety, environmental effects such as birds chirping, and so on) was spot on in all or most books. All the books were written after 2003, with a spike around 2017. The books were under 300 pages and cost less than $8 each.

Books included *The Eclipse*, by C.J. Petit, *Shooting the Sun* by Max Byrd, *After the Eclipse* by Fran Dorricott and *Illegal Alien* by Robert J. Sawyer.

From the Classroom Astronomer Newsletter, #38, Oct. 29, 2022

Astronomical Teachniques

When The Sun and Moon Look the Same Size, How Big Is a Shadow?

We have two solar eclipses coming up in the USA in the next two years, an annular (ring) eclipse and a total eclipse. The difference comes from the Moon's distance from Earth being not the same each time; in an annular eclipse the Moon is near apogee, its farthest part of its elliptical orbit, and therefore appearing at a smaller apparent size such that it can't quite cover the disk of the Sun. When closer, we get a total eclipse. Here are two things you can do to demonstrate this, one for younger kids, one for older ones.

1. NASA has put up a YouTube demonstrating how to show the effect of why a smaller but closer object (Moon, coin) can cover a bigger, similarly shaped object (Sun, round paper plate). The video is here: https://youtu.be/ygZNa8maTh0

2. Useful for both real solar and lunar eclipse studies, use a tennis ball and a white flat paper or cardboard or similar object (paper plate?) as a screen to project the ball's shadow. Holding the

plate near the ball, say, at both arms outstretched in distance, you immediately see that the shadow has two parts, the deeper umbra in the center and the grayer penumbra around it (as does your personal shadow—kids can be really surprised at that!). The objective is to find the distance where the umbra's end is and the shadow is now all penumbra. You have to increase the distance with the help of a second person, or by positioning the ball high on a steady stand, and move the screen until the umbra gets lost in the penumbra. Measure that distance and find the ratio of distance to ball diameter.

Mostly Umbra, some fuzzy Penumbra. All Penumbra!

At the Earth's distance from the Sun, it SHOULD be around 108 (it varies slightly over the year), that is, the length of the umbral shadow cone should be 108 times the diameter of the ball. ANY ball. Tennis ball. Marble. Beach ball. Soccer ball. Moon. Earth. Why? Because for each sphere the Sun is exactly the same angular size, generating the same geometrical kind of cone shape. Same proportions, different dimensions.

Given that information, knowing that the Moon's shadow JUST touches the Earth during a total solar eclipse, you can find the Moon's size, if somehow you know that distance in miles or kilometers. Or vice versa. Knowing that the Moon is 400 times smaller than the Sun, you can find the Sun's size that way (or the opposite), and ditto about its distance.

Note 1: It is best to do this near Sunrise or Sunset. You need a *long* horizontal distance to get that umbral shadow to disappear into the penumbra on your screen. A high Sun and a ball just a few feet of human height above ground won't cut it.

Note 2: You CAN do this by 'eclipsing' the Sun — blocking the Sun with the ball and using a solar filter in front of your eye and finding out the distance the ball JUST covers your eye; I've done it — but I wouldn't recommend it to any student.

From the Classroom Astronomer Newsletter, #39, Nov. 21, 2022

Galileoscopes for the Upcoming Eclipses

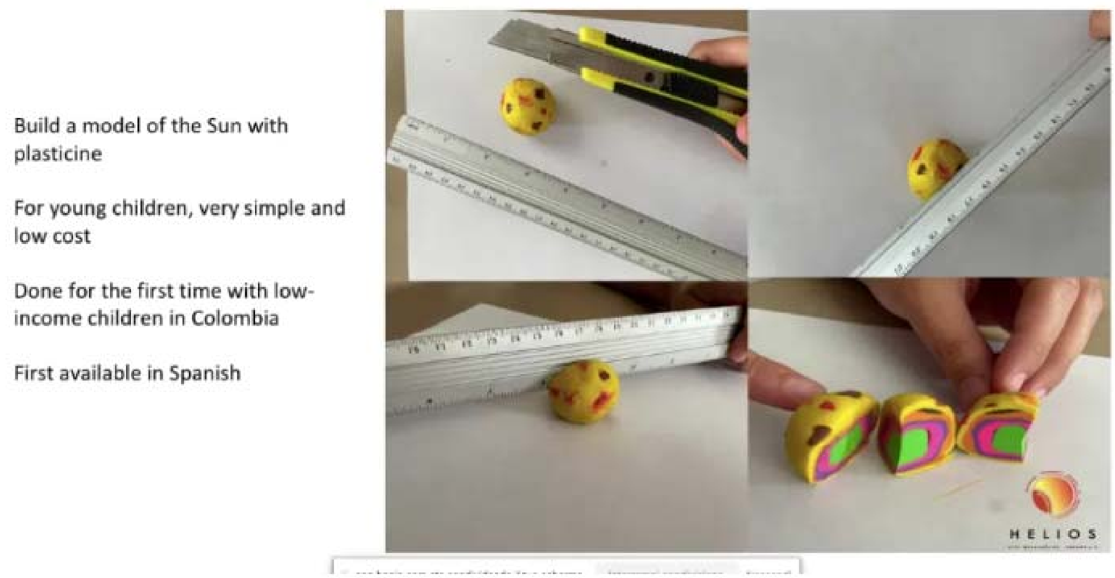
From Galileoscope co-creator Douglas Arion via the AstroIrner listserv: Explore Scientific, which took over the manufacturing and distribution of the International Year of Astronomy sensation Galileoscopes, has created a kit package “that will i*nclude safe solar filters* - primarily in support of the 2023 and 2024 eclipses, but also expanding the utility of the kits. Of course, with production lead times, we need to be getting pre-orders now in order to get them made in time for distribution this spring/summer. We're therefore reaching out to all the education institutions which could benefit from offering the new Galileoscope kits to their students. It is still the most economical, quality telescope kit out there, and dovetails with Astro 101 and higher course structures.”

Please go to http://galileoscope.org/eclipse to enter pre-orders, and thus guarantee availability from the production run that will take place.

From the Classroom Astronomer Newsletter, #41, Dec. 8, 2022

Make Your Own Sun

Carolina Escobar Garcia and Leon Jaime Restropo Quiros, Colombia

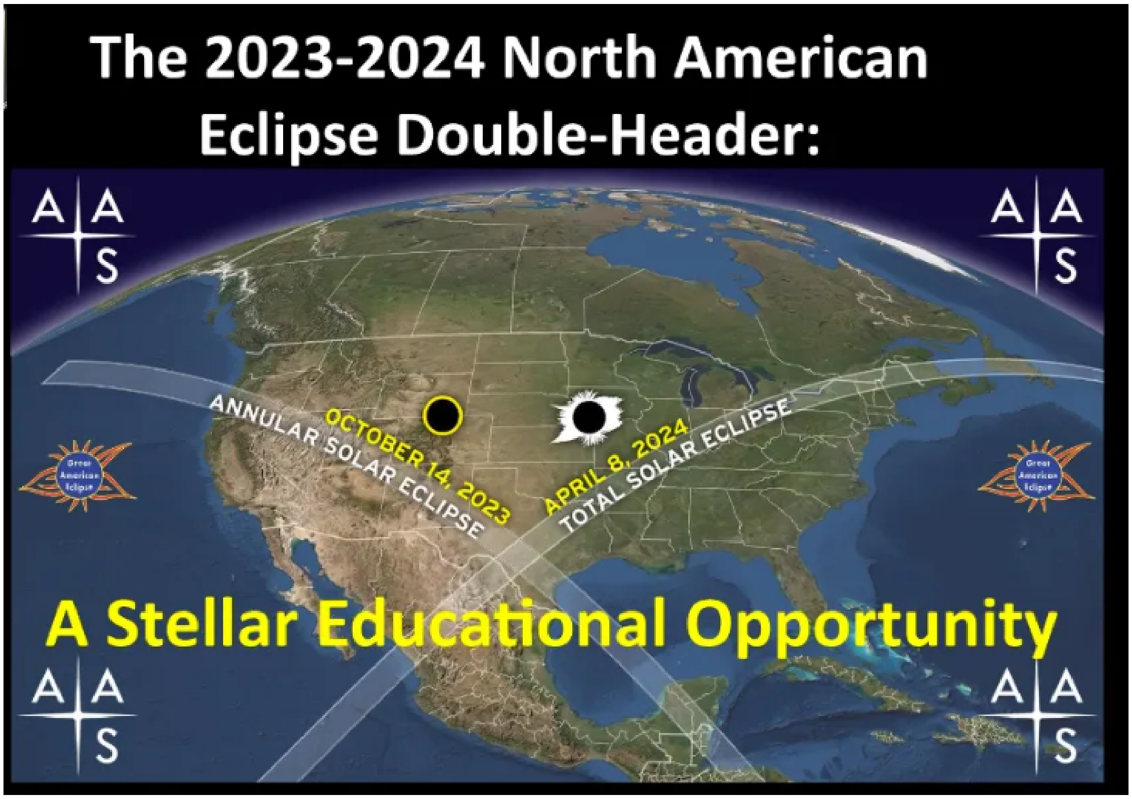


Available in Spanish and English (astroedu.iau.org/en/activities/2202/make-your-own-sun), the activity uses plasticine to make small models of the Sun's surface and interior. The answers to the five questions are:

- Who—Primary (ages 4-12 mostly),
- Where—In the unit of Sun, Solar System and Stars,
- Why?—Goals: Experience astronomy as a hands-on and fun experience; Learning Objectives: Learn about the Sun's structure and how the Sun works,
- Explain it—Go over the fusion process in the Sun's interior utilizing the Background section information,
- What do you do?—Utilize the instructions on how to make the layers, and then slice the ball open to see them.

From the Classroom Astronomer Newsletter, #45, Feb. 15, 2023

A Funding Opportunity from NASA



NASA is announcing early that it is seeking Subject Matter Experts (SMEs) for the upcoming eclipses to coordinate with it in the Heliophysics Big Year. These persons will work with both heliophysics activities AND the two eclipses' activities. NASA will provide communications training in workshops, invitation letters to faculty, connections to events, and certifications. There is funding for presentations you do both in-person and virtual.

Typical activities would be observation facilitation, scientific presentations, demonstrations, discussion panel participation, doing interviews, handing out solar glasses and giving safety talks, and showing how to build viewers. Activities would take place often before the eclipses, at libraries, schools, community gatherings, as well as somewhere on eclipse days.

Start here for more info and applications: https://scope.asu.edu/big-helio-year/ .

Astronomical Teachniques

What Can You Learn With a Ring of Fire?

Back in 2012 another annular eclipse with a path somewhat similar to this coming October's eclipse also passed through Nevada, closer to Las Vegas. Back then yours truly led a small expedition of teachers to near the southern annularity limit to make scientific observations. Our goal, as reported in *The Classroom Astronomer Magazine* were two-fold:

Total Eclipse Phenomena: Can Baily's Beads and shadow bands be detected, and for a longer time, from the southern edge of annularity? Can the flash spectrum of the chromosphere be detected from the slit-like edges of the Sun during annularity?

Environmental Phenomena: We know the sky will darken but are color changes perceived in eclipses measurable and real? What kind of changes in light intensity and temperature can be seen when the Sun is never completely covered by the Moon? [That eclipse left 11% of the Sun still exposed, about the maximum possible because the Moon was near its farthest possible apogee while the Sun was nearly at its greatest distance from Earth.]

These are still valid experiments that students and others, including the general public, can do this coming October.

To view the eclipse we had eclipse glasses for all, telescopes to project magnified images, filters to place over cameras, and various pinhole projectors and reflectors. To measure temperature, sky brightness and color, and to try to detect shadow bands besides by eyeball, we used a variety of Vernier sensors attached to a laptop, and three LabQuest units. The sensors were mounted on a flat stick taped to a camera tripod. Three of the sensors were aimed to the one point in the sky that would always be equally distant from the Sun, the North Celestial Pole. The fourth was aimed downwards towards a white sheet on the ground, for detecting shadow bands.

The first three sensors were on continuously, taking measurements every one to ten minutes. The laptop and LabQuest sensor interface-recorders were on a table nearby, shaded with an umbrella. Though capable of running on batteries, an extension cord provided power for them from a convenient outlet. Only the sky spectrum sensor, SpectroVis, had to be manually operated in recording its measures as a data file, every ten minutes.

All electronic observations began at the moment the Moon touched the Sun. Looking at "Figure 3a", there's no apparent influence of the eclipse on temperature until about .80 hours into the eclipse. The temperature declines steadily simply as the Sun lowers in the West, until two thirds of the way into the opening partial phases (annularity is for 1.72 minutes at the 1.2 hours, M, mark on the chart). It drops rapidly but then stays fairly steady until the line rejoins the normal diurnal temperature line at .55 hours before the eclipse ends. Any increase in temperature due to less coverage of the Sun by the Moon must be balanced out by cooling due to lowering solar altitude. Unlike the author's previous measures at total solar eclipses, this minimum temperature occurs before maximum coverage.

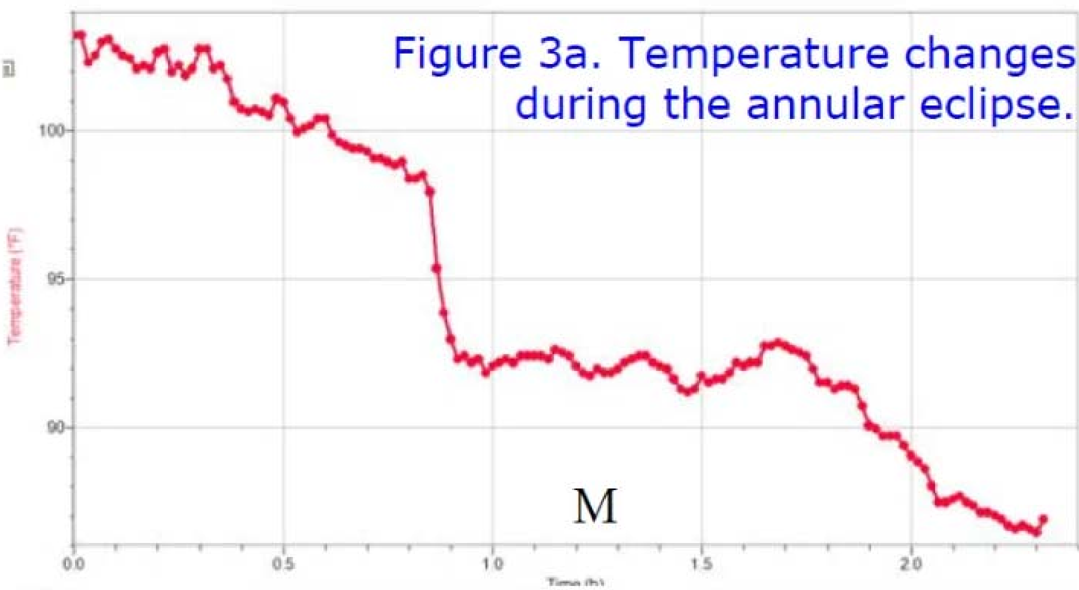


Figure 3a. Temperature changes during the annular eclipse.

The light variation, "Figure 3b", on the other hand, is quite a smooth curve with the deepest drop about 6 minutes before maximum eclipse. This and the temperature graph could indicate a systematic error in our sensors' start times. Recovery to normal light times out at the same time that the temperature sensor returns to normal as well. **Clearly an annular eclipse, and therefore a partial eclipse, will not have any effect on local lighting or temperature until it reaches a certain depth, somewhere between 45 and 66% coverage** of the Sun's visible surface.

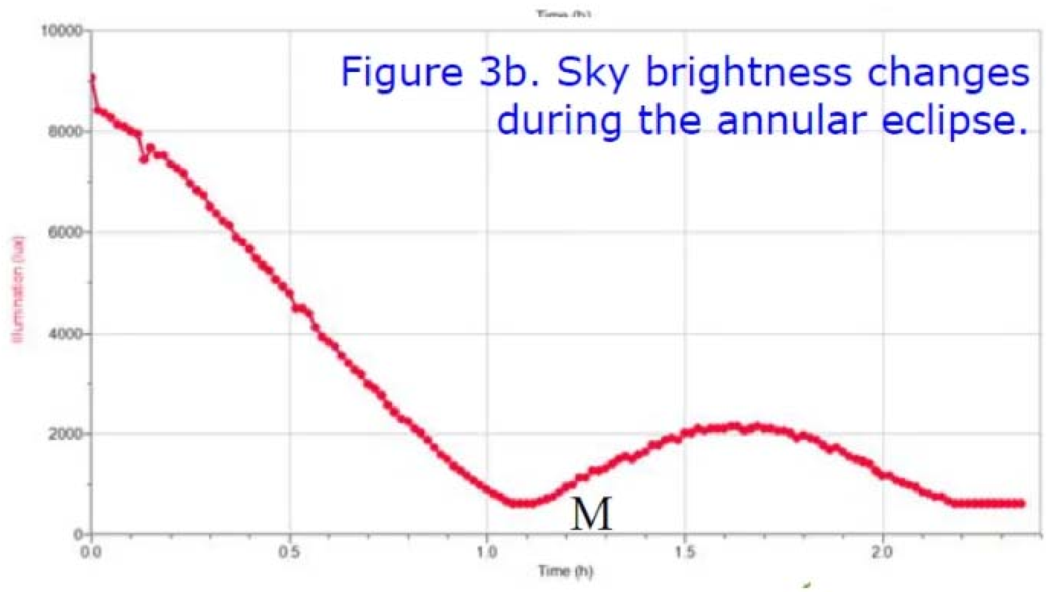
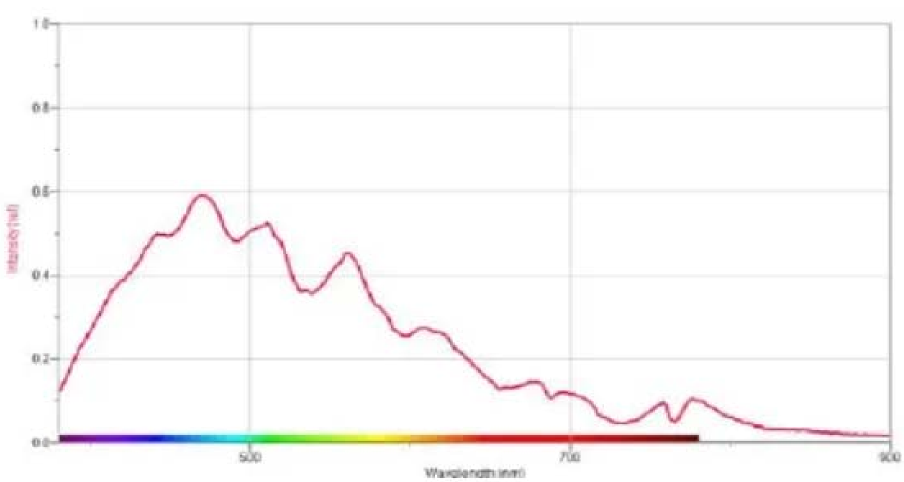


Figure 3b. Sky brightness changes during the annular eclipse.

On the other hand, the distribution of colors of the sky, **its spectrum** ("Figure 3c"), despite a common qualitative assertion that it gets perhaps bluer, **showed no changes whatsoever** beyond the uncertainties of measurement. The relative intensities of the different peaks of the sky spectrum did not waver at all. Logically, that should be true, as the sky may darken but it's still the Sun's light illuminating us and that and the scattering effects of the atmosphere should not change the relative amounts of color we see. Any bluishness must be attributable to human eye color response due to the darkening conditions but not to any real effects of the eclipse.



At the limit of annularity the Moon will cause a slit-like presentation of light on one side of the Sun, which then rotates as the Moon skirted the northern edge of the Sun until the Moon moved off, as seen in the three photos over this article's title. Thus we should have had nearly two minutes of "slits" which, during total solar eclipses, are the times when shadow bands, flash spectra and Baily's Beads can be seen. The research question we had was simple: can these phenomena be seen at all during the annularity time and, if so, can they be seen for longer periods than during a total eclipse's slit-like phase?

The answers for us for the three phenomena were, No, No and Sort Of.

No one visually saw any light variation on the surrounding landscape from shadow bands, which are believed to be distorted images of the slit-like solar light just outside the umbra due to lensing effects of bubbles of moving air high in the atmosphere. Regrettably, our Vernier sensor aimed at the white sheet was inconclusive. Observations were begun five minutes before annularity, with measurements every .002 seconds. These showed a step-like lowering of light consistent with the drop in overall light and with rising and falling values during each step, but inexplicably the sensor shut down after just two minutes. The variation in the light curve's steps could be shadow bands but we have no way to support that idea.

Using our *Classroom Astronomer Spectrum Viewers* the Sun's spectrum was vainly sought in both the first and second order diffraction spectra. Typically the flash spectrum is photographed or seen visually as ring- or crescent-shaped emission lines mimicking the moment's solar image, over a continuous spectrum. Either the wider part of the uncovered solar surface was so bright as to wash out any spectral "crescents" or the chromosphere was not visible long enough. No evidence for the flash spectrum was seen.

Some of the participants observed what appeared to be momentary Baily's Beads at the beginning of annularity but any Beads seen were difficult. Photographically, our 35mm film exposures of about 1/1000th of a second, when contrast adjusted, do actually seem to show gaps in the thinnest part of the visible solar surface. So it may be possible to claim that Baily's Beads can be seen even in this least covering of a solar disk during an annular eclipse; Beads have been previously photographed on annular eclipses when the Moon was essentially the same size of the Sun.

From the Classroom Astronomer Newsletter, #46, Feb. 15, 2023

Astronomical Teachniques & Connections to the Sky (AAS Solar Eclipse Sessions)

Prices on Solar Galileoscopes Revealed

In a past issue we reported that the Galileoscopes that had been introduced for the 2009 International Year of Astronomy were being reintroduced with solar filters and tripods for the upcoming eclipses. The prices were revealed at the January AAS meeting. The scopes will be available in lots of 10 and pre-orders were asked for in order to ascertain an initial manufacturing run by Explore Scientific. Pre-orders can be made at http://galileoscope.org/preorder and must include a 50% deposit. The first batch will be delivered this summer and more thereafter during the 2023-24 academic year.

Product Packages	Pricing (ea) (10-90 units)	Pricing (ea) (100-490 units)	Pricing (ea) (500+ units)
Galileoscope+Solar Filter+Shade	$39 ($390/case)	$35 ($350/case)	$31 ($310/case)
Tripod	$22.95 ($229.50/case)	$18.95 ($189.50/case)	$16.95 ($169.50/case)
Safe Solar Filter + Sun Shade	$3.85 ($38.50/case)	$3.75 ($37.50/case)	$3.50 ($35/case)

Solar Eclipse Things to Talk About

Looking for things to do concerning eclipses?

NASA's Chris White, an eclipse coordinator, had some ideas. I took some notes and list them here with my own comments added - LK

1. Of course you have to talk about the types of eclipses—solar and lunar, and then total, annular and partial for the solar types. For the latter, you must talk about safety issues, how to protect your eyes, and how to find or make safe devices to see the eclipse phases. Further, how during totality—AND ONLY DURING TOTALITY—is it safe to look at the Sun without solar glasses or other proper viewing devices.
2. Talk about the Sun itself. The parts of it. What we see and how we see the parts (or don't). How it is a star closeup and how other stars we see at night are the same, and different.
3. Talk about magnetic fields, of both Sun and Earth. What causes them and what effects they cause. How the Sun's affects the Earth's and how THAT affects us down below.

4. How does life on Earth react to eclipses? How animals, birds, etc., respond to the darkening during the day?
5. Cultural ties to eclipses. How people have reacted in history, and today? How education has changed our views of eclipses.
6. Most planets have moons and they cause eclipses on those other worlds. Do those other worlds have eclipses as dramatic as ours? Nope. How come?
7. Solar missions. How have we gone from studying the Sun with telescopes, and real and artificial eclipses, to space probes that observe the Sun all the time and even touch the Sun to learn more about our star?
8. Historical studies about or using the Sun, such as the discovery of helium there before finding it on Earth. Photographing the Sun to find its gravity shifted the position of stars, per Einstein. Proving the planet Vulcan (not Spock's world!) did not exist.
9. Other things you can observe during eclipses, such as shadow bands, pinhole crescents, pre-totality corona streamers, and more.

How Many Will See the Eclipse?

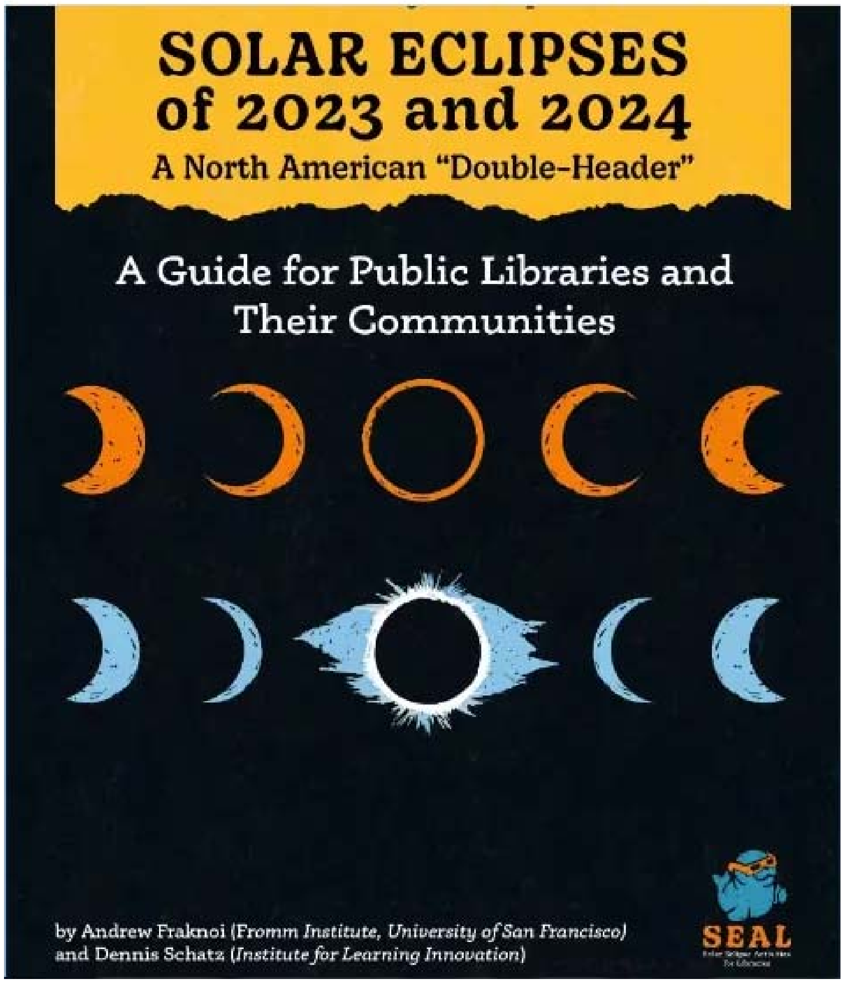
These two eclipses are a massive show for many people but only a few will be lucky enough to be in one or the other pathway of the totality or annularity of the event(s). [And a lucky few in west central Texas are in both!] But MILLIONS will be in view for a partial eclipse! How many?

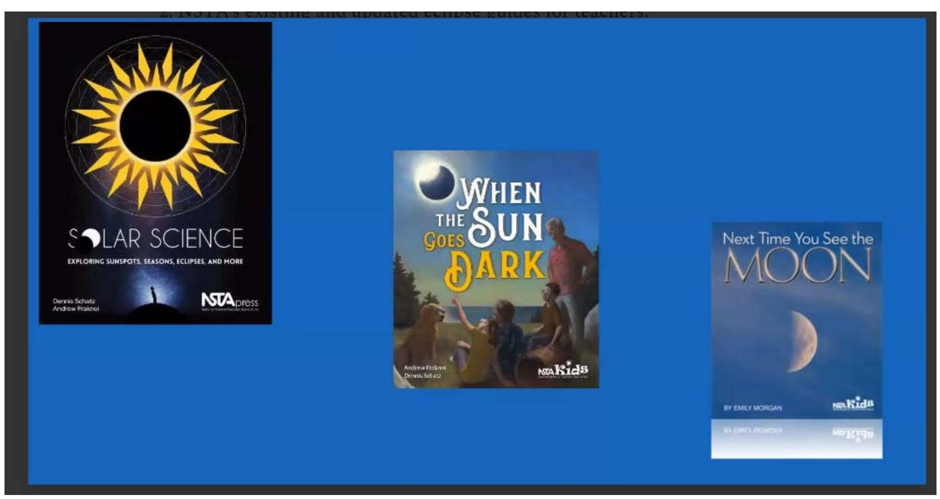
The USA? 332 million.
Canada? 37 million.
Mexico? 129 million.
TOTAL = 498 MILLION. That's a lot of potential people to educate, inspire, and get interested in astronomy and science.

Guides Available

Some resources noted in various talks—-

1. An eclipse book for free by Dennis Schatz and Andrew Fraknoi, available via STARnet (see below):



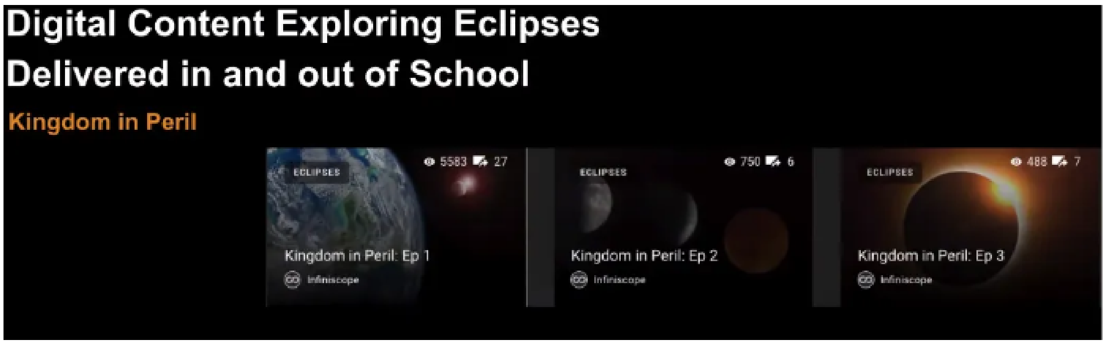


2. NSTA's existing and updated eclipse guides for teachers:

Go to www.nsta.org .

2. On YouTube [but they didn't give specifics :( ] are these three eclipse videos from Arizona State University and Infiniscope, written as medieval kingdom stories:

The films talk about the Earth-Sun-Moon arrangements, the size of shadows, and why we don't see eclipses every month.



The Eclipse at Your Library

The Space Science Institute is making a big push to use libraries as focal points for eclipse outreach. Their reasoning is interesting.

1. 70% of US citizens visit their local library at least once a year and often more frequently.
2. Library patron demographics are a 1:1 match for local demographics, often not the same pattern as other outreach programs.
3. Staff are educated and trained and eager to try new things to reach patrons.
4. Libraries are considered safe and important places in communities and provide support for government services, translation services, safety resources, and other community outreach programs.

Furthermore, libraries are found distributed wherever the citizens are.

SSI's educational service, STARnet, is providing a library-dedicated operation called SEAL, Solar Eclipse Activities for Libraries.

One of the things SEAL will do is distribute **5 million safe solar viewing glasses** to libraries, just for signing up with them. SEAL has already started doing workshops and training sessions in all

50 states (Subject Matter Experts are needed and welcome!). And they are capable of providing two sets of kits to libraries for eclipse education.

For more information or to sign up OR to join and take part, email Anne Holland at ahollland@spacescience.org, go to www.starnetlibraries.org, or use the QR code here:

Live Streaming the Eclipse

The Exploratorium Science Museum in San Francisco will be offering four different Live Streams on its YouTube channel of each eclipse, see http://www.exploratorium.edu/eclipse starting in April 2023. For each eclipse, there will be two telescope-only (no commentary) live streams and two live with commentary, one in English and one in Spanish.

The Exploratorium also offers hands-on tutorials on eclipses, making eclipse viewers, and other ‘science snacks’ on its website.

From the Classroom Astronomer Newsletter, #48, Mar. 23, 2023

Connections with the Sky: The Upcoming Eclipses

This is a low-resolution image; the full res image is too big for this newsletter or to email, but you can view it at the URL above in your browser.

* New Maps of the 2023-24 Eclipse Paths

NASA has produced some finer detailed maps of the shadow paths of the October 2023 and April 2024 eclipses across the USA. In the online article at https://www.nasa.gov/feature/goddard/2023/sun/new-nasa-map-details-2023-and-2024-solar-eclipses-in-the-us there are several charts. The first one is the full nation-wide, very high-resolution chart showing both eclipses: The site also includes a global map showing the full pathways from oceanic ends in the Pacific to those in the Atlantic. Other closer-in maps there include very detailed ones along the max center in Utah, along Lakes Erie and Ontario, and along southern Canada/northern New York and New England. There is also a close-up map where the two eclipse paths cross, in Texas (see below).

* Twice the Eclipses (and When Are the NEXT Ones?)!

These two eclipses are the second and third ones crossing the continent in recent years, the first being the total eclipse of 2017 that went from coast to coast. All three give the inhabitants of the whole North American continent three sets of partial eclipses to view! And all three tracks cross to make a triangle. A triangle has three corner points so an interesting idea to look up is….where are the three regions where two eclipses can be seen by the people living there?

The 2017 total eclipse crosses each of the future eclipse tracks—once. The first crossing is a 'just barely' patch on the extreme West Coast. The major overlap is actually over the Pacific Ocean, but there is a small triangle of Oregon where both eclipses could (have been) be seen. It is southwest of Salem, Oregon, and is roughly delineated by the cities of Lincoln City, Newport and Corvallis. Got any Oregonian friends?

The other 2017 overlap point crosses the 2024 eclipse path JUST north of the tri-state border point of Missouri, Illinois and Kentucky. Cape Girardeau and Carbondale are the largest cities in the diamond-shaped overlap zone. I'd be surprised if the hotels and campsites aren't already booked, though the eclipse is still a year away.

That leaves the last triangle overlap zone, which concerns the 2023 and 2024 eclipse tracks. It is deep in the heart of Texas, southwest of Austin, west and northwest of San Antonio. In fact, the *overlap* zone (though not necessarily the *eclipse*(*s*)) misses all the big cities along I-10 or I-35. The most biggest and famous place in the overlap diamond is Kerrville, home of the Kerrville Folk Festival.

I used to live in Austin. I wonder if I have any of my old friends' phone numbers somewhere…..?

By the way, after 2024, when are the next US eclipses? Do they cross these paths sometime? Soon? Nope. The next eclipses are in Alaska in 2039 and a total eclipse similar to the 2017 one, going from the west coast to Florida….in 2045.