Highlights of the April Sky. . .

- - - 2nd - - -

DAWN: Mars is 1° below Saturn in the south-southeast, while Jupiter and the Moon are in the southwestern sky.

- - - 3rd - - -

AM: Jupiter is 6° below the Moon when they rise in the southeastern sky.

- - - 7th - - -

DAWN: A waning gibbous Moon is 1½° above Saturn and about 4° to the upper right of Mars.

- - - 8th - - -

Last Quarter Moon
3:18 am EDT

- - - 16th - - -

New Moon
9:57 pm EDT

- - - 17th - - -

AM: Saturn is at aphelion and hasn't been further from the Sun since 1959.

- - - 18th - - -

PM: A slender waxing crescent Moon is near the Hyades cluster and 2° from Aldebaran.

- - - 22nd - - -

AM: The Lyrid meteor shower peaks. Expect 15 - 20 meteors per hour.

First Quarter Moon
5:46 pm EDT

PM: The Moon is near the famous Beehive Cluster (M44) in Cancer. Both will be visible in 7×50 or 10×50 binoculars.

- - - 24th - - -

PM: The Moon is 3° to the left (west) of Regulus in Leo.

- - - 29th - - -

Full Moon
8:58 pm EDT

- - - 30th - - -

PM: The Moon is 6° to the lower left of Jupiter.

Prime Focus

A Publication of the Kalamazoo Astronomical Society

★ ★ ★ April 2018 ★ ★ ★

This Months KAS Events

General Meeting: Friday, April 6 @ 7:00 pm

Kalamazoo Area Math & Science Center - See Page 12 for Details

Observing Session: Saturday, April 7 @ 8:00 pm

Galaxies of the Virgo Cluster - Kalamazoo Nature Center

Board Meeting: Sunday, April 8 @ 5:00 pm

Sunnyside Church - 2800 Gull Road - All Members Welcome

Observing Session: Saturday, April 21 @ 8:00 pm

Moon, Venus & Jupiter - Kalamazoo Nature Center

Inside the Newsletter. . .

March Meeting Minutes

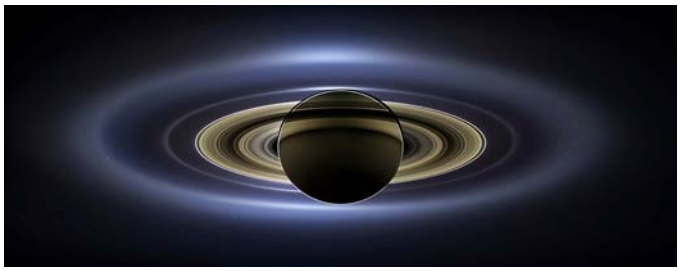
The general meeting of the Kalamazoo Astronomical Society was brought to order by President Richard Bell on Friday, March 2, 2018 at 7:07 pm EDT. Approximately 48 members and guests were in attendance at the Kalamazoo Area Math & Science Center (KAMSC).

Richard started his President's Report by asking members in attendance to help distribute newly printed 2018 Public Observing Session brochures. He then asked for volunteers for Science Night at Vicksburg Middle School on March 7th. Several members stepped forward (see Richard's column on page 5 for more). Richard then gave another update on the Robotic Telescope Project (see the board minutes on page 4 for the latest details). Richard thanked Becky & Kalman Csia for their generous donation of a Celestar 8-inch SCT, 25×100 binoculars, and multiple accessories. For the time being, the C8 will be kept in Owl Observatory and made available to members during public sessions. Don Stilwell again volunteered to clean up another recent donation - an 8-inch Coulter Odyssey Dobsonian. Finally, Richard reminded all members that we already have several telescopes available for loan. Details can be found on the KAS website.

The evening's guest speaker was Dr. Shannon Schmoll, the Director of Abrams Planetarium at Michigan State University. Dr. Schmoll was feeling a little under the weather, so her presentation was given via Skype. (Thanks again to Mike Sinclair for making all the arrangements.) The title of Dr. Schmoll's second talk for the KAS was *Goodbye Cassini: What the Probe Taught Over the Past 20 Years*.

Saturn, being one of the five naked eye planets, has been known since antiquity. Saturn currently resides in the constellation Sagittarius, above the famous Teapot asterism. One future observing highlight will be the Great Conjunction of Jupiter and Saturn on December 21, 2020. The two giant planets will appear to be about 6 arcminutes (1/10°) apart. That's close enough to be visible together in the field-of-view of any amateur telescope!

Using his small telescope in 1610, Galileo was the first to see Saturn as a world instead of a "wandering star" in the sky. Galileo thought Saturn was a triple body system at first, a planet with two large moons. Overtime, the view changed and he joked that Saturn had ears! Due to the limits of his telescope, he did not recognize the rings as a disk. In 1655, Christiaan Huygens realized that the rings were a disk surrounding but not touching the planet. Huygens also discovered Titan, Saturn's largest moon, that same year. Several more moons, and a large gap in Saturn's rings (later named the Cassini division), were found by Giovanni Domenico Cassini between 1671 and 1674.



Saturn, its rings and seven of its moons appear backlit by the Sun in this image from Cassini. View a higher resolution version of this image HERE.

The Space Age brought about the next period of great discoveries at Saturn. *Pioneer 11* performed the first flyby of Saturn in 1979 and discovered the narrow F-ring. *Pioneer 11* also discovered Saturn's magnetosphere. This flyby was soon followed by *Voyager 1* in 1980 and *Voyager 2* in 1981. Highlights of these encounters include the discovery of the G -ring, Saturn's North Polar Hexagon, and two small "shepherd moons" that maintain the F-ring. *Voyager 1* made a close flyby of Titan, which is the only moon in the solar system covered by a dense atmosphere. Enceladus was revealed to have a geologically young surface in some areas.

Scientists soon began making plans to return to Saturn with an orbiting mission and a Titan lander. Funding for the Cassini-Huygens mission was secured in 1988. Dr. Schmoll then gave a brief overview of the Cassini spacecraft (see this web page for further details).

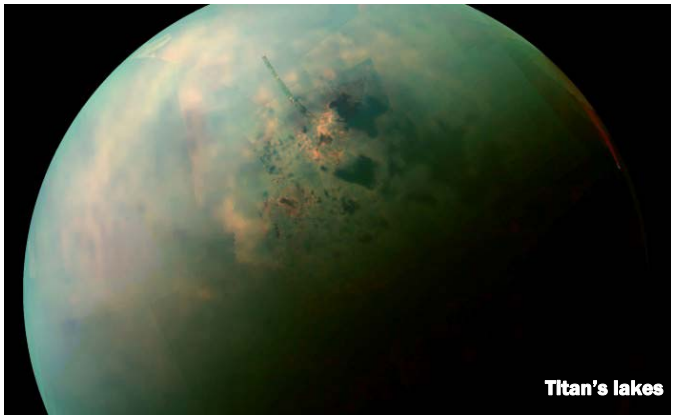
Cassini was launched on October 15, 1997. It performed two flybys of Venus on April 25, 1998 and June 24, 1999 and one flyby of Earth & Moon on August 17, 1999. Cassini then encountered Jupiter on December 29, 2000 and was able to showcase its abilities. Cassini became the first spacecraft to orbit Saturn on June 30, 2004. The original mission ended on May 31, 2008, but was extended until February 2, 2010. The mission was extended for another seven years and ended on September 15, 2017 when Cassini (purposely) burned up in Saturn's upper atmosphere. Cassini completed 294 orbits around Saturn during its lifetime.

Dr. Schmoll said Cassini discovered "eight-ish" moons during its mission. Some of the objects were "moonlets" within Saturn's rings that barely stood out amongst the billions of individual ring particles. Cassini's first encounter at the Saturnian system was the moon Phoebe. Phoebe was thought to be a captured asteroid, but images revealed it to be quite icy. It's now thought to be a captured Centaur, comet-like objects orbiting the Sun between Jupiter and Neptune. Iapetus is Saturn's "yin yang" moon. One hemisphere is quite dark, while the other is very bright. Scientists think the dark material is residue from the sublimation of water ice on the surface of Iapetus, and possibly darkened further upon exposure to sunlight Iapetus also has an extensive ridge that runs along the equator, but only on the darker hemisphere. The nature of this ridge remains a mystery.

Cassini discovered a tenuous atmosphere around the moons Rhea and Dione. Hyperion is an irregularly shaped moon that looks like a sponge. The "star" of Saturn's satellite system is Titan, the second largest moon in the solar system (larger in diameter than the planet Mercury). The Huygens probe landed on Titan's surface on January 14, 2005. During its two-and-a-half hour decent to the surface, it revealed

riverbeds, gullies, and the shoreline of a dried up lake or sea. Once on the surface it saw fist-sized chunks of rounded ice covered in organic residue. The Huygens mission lasted about 72 minutes due to the harsh conditions on Titan's frigid surface (-290° F).

Over 98% of Titan's atmosphere is composed of nitrogen and 1.8% methane. The methane should break up over time, so some process must replenish it in the atmosphere. The most likely source is Titan's system of ethane and methane lakes and seas. Instead of a hydrological cycle (like on Earth), Titan has a hydrocarbon cycle. Kraken Mare is the largest body of liquid, located in Titan's northern hemisphere. It's larger than the Caspian Sea on Earth. Cassini also revealed dunes on Titan's surface, although they're composed of ice and not silicate material like on Earth. Using a form of Doppler radar, Cassini revealed that Titan likely contains a subsurface ocean.


Titan's lakes

Saturn's small moon Enceladus was one of the Cassini mission's greatest highlights. Like Rhea and Dione, Enceladus also has a tenuous atmosphere. Scientists suspected that Enceladus was geologically active via the venting of water vapor, but Cassini was the first to clearly see the plumes. Cassini actually flew through the plumes and discovered that they're composed of water ice. All the plumes erupt from tectonic features dubbed "Tiger Stripes" in the southern hemisphere. The plumes of Enceladus are the source of Saturn's broad E-ring. Tidal heating (gravitational flexure) caused by Saturn have created hydrothermal vents on the floor of an global subsurface ocean beneath the icy crust of Enceladus.

Dr. Schmoll then moved on to Saturn's most noteworthy feature: it's rings. Saturn's rings are very broad and very thin. The width of main rings is 43,500 miles, yet they are only 12.5 miles thick. The moon Daphnis, discovered by Cassini in 2005, orbits within the Keeler gap in Saturn's A-ring. As it orbits, it creates gravitational ripples on the edges of the gap as ring particles are attracted toward the moon and then fall back down toward the ring. Cassini also observed vertical structures, dubbed towers by Dr. Schmoll, in some places along the outer edge of the B-ring. The towers are up to 1.6-miles high and were probably created by unseen embedded moonlets. Cassini also saw the spokes suspended above the B-ring. These were last seen by the Voyager spacecraft in the 1980's. The exact cause of the spokes is still unknown. They may be microscopic dust particles suspended away from the main ring by electrostatic repulsion.

Cassini made several observations of Saturn's North Polar Hexagon. This peculiar shape may form in an area of turbulent flow between the two different rotating fluid bodies with dissimilar speeds. Oddly enough, there is no such feature around Saturn's south pole. Cassini was also able to observe a massive storm, referred to as Ouroboros, develop in Saturn's northern hemisphere. This is a unique, but short-lived phenomenon that occurs once every Saturnian year, roughly every 30 Earth years, around the time of the northern hemisphere's summer solstice.


The Ouroboros Storm

Cassini was in good health toward the end of its mission, but it was running low on maneuvering fuel. The probe may have contained some stowaways in the form of microbes from Earth, so the decision was made to crash Cassini into Saturn's upper atmosphere. The chances were remote, but scientists didn't want to risk the probe crashing into Enceladus and contaminating lifeforms that may exist in its subsurface ocean.

Richard gave a preview of the International Space Station's solar transit on March 4th after the snack break. The transit was predicted to occur along a narrow path through the Kalamazoo region at about 11:04 am EST. Amazingly enough, skies were predicted to be clear. (Editor's Note: several members successfully reported observing and capturing video of the transit. Perhaps we'll share some reports at the April meeting.) Some members then shared brief observing reports. Matt & Dan DePriest observed Jupiter through their 8-inch Newtonian from their home in Vicksburg. Josh Taylor-Lehman snapped some images of the Moon with his 6-inch Meade SCT. Roger Williams observed a flyby of a near-Earth asteroid online. Jean DeMott proposed several field trips. One was of two lectures at Michigan State University on March 15th. (Editor's Note: one of the lectures, on the recent Michigan meteor, is available for viewing online.) She also hopes to get a group together to attend the Apollo Rendezvous in June (see her column on page 4). The meeting was adjourned at 9:03 pm.

BOARD Meeting Minutes

The KAS Board met on March 11, 2018 at Sunnyside Church. President Richard Bell called the meeting to order at 5:10 pm. Members present were Joe Comiskey, Rich Mather, Jean De Mott, Jack Price, Don Stilwell, and Roger Williams.

Rich, having returned to Kalamazoo after the winter season, delivered the Treasurer's Report in person. Cash inflow was primarily from membership dues and donations. Significant outflow items were rental for our storage facility and a counterweight for the robotic telescope.

Richard's summary of coming events included the general meeting of April 6th (with Richard as speaker), Public Observing Sessions on April 7th and 21st, and the highly-anticipated general meeting of May 4th, featuring University of Michigan professor and LIGO scientist Keith Riles speaking on gravitational wave astronomy.

Follow-up items began with an update on the Robotic Telescope Project. Even with all of the cables moved to the outside of the mount and a new counterweight added, the drive still stalled occasionally. Limiting the slew speed to 75% of maximum has so far seemed to avoid stalls. There still has been no demonstration of automated guide star acquisition. It was also noted that we still have no contract with Observatory Solutions about the cost of their work and the performance guaranteed when it is completed. Richard asked for an estimate of the cost if Observatory Solutions needed to visit the site, and it was too high to be considered. The work group continues to pursue a solution to the problem.

Other Follow-up business concerned 2018 outreach activities. Jack again mentioned the Portage Green-A-Thon at Celery Flats on April 14th. Jack had been the contact person for this event in the past, but he would be unable to do so this time. Don agreed to be the coordinator. Jean and Rich could also help. Other events needing volunteer help are the Science Festival at Pierce Cedar Creek on April 28th and the Rock & Mineral Show on May 5th & 6th. The other item in this category was a membership survey, for which Richard had brought a sample from another club, searched from the internet. Richard asked the Board to continue thinking of questions that should be on the survey.

Under New Business, Joe reported that the publicity office was consuming a lot of time for data entry. He asked some questions about the details of the job, and suggestions were made for making it more manageable. Field trips were discussed again, and it was reported that Apollo Rendezvous reservation forms were now available for June 9th. Longer range, planning is also underway for a trip to Abrams Planetarium on November 3rd. With no other business, the meeting was adjourned at 6:30 pm. The next meeting date was set for 5pm on Sunday, April 8th at Sunnyside.

Let's Go to Apollo Rendezvous

by Jean De Mott

It has been awhile since KAS members have gone out of state as a group for an astronomy event. In the past we have traveled to NIAG Fest in Indiana, the Winter Star Party in the Florida Keys, and the Texas Star Party. It definitely has been too long since we made a trip as a group and it is time to get on the road again.

Over the years members Jack Price and Mike Sinclair have attended the Apollo Rendezvous put on by the Miami Valley Astronomical Society in Dayton, Ohio and have had a great time. Because it is not too far away and is a single day event it will be a good way to get the "On the Road" tradition going again. The Rendezvous is about a 5-hour drive from Kalamazoo and is a very user-friendly event. It is different in that the programming is primarily indoors and there is not the usual camping out on a field, however the event does conclude with an evening star party held outside Dayton.

Traveling to astronomy events is a lot of fun and a great way to get to know fellow members, gain knowledge and skills in astronomy and take in the sights and experiences of traveling. If you are new to the club it is a highly recommended way to become involved with activities and get started learning if you are new to the hobby. This event, like most larger astronomy gatherings, will also feature a vendor area where you can check out and often get good deals on equipment. Plus, Apollo Rendezvous has one of the best parts of any star party type event: the door prize giveaway!

Dayton is also home to the National Museum of the Air Force where the B-17 Memphis Belle has been restored and will go on display starting May 17th of this year. The museum is one of those not to be missed attractions. In addition, the Armstrong Air and Space Museum is located in Neil Armstrong's home town of Wapakoneta, Ohio. It is conveniently located on the route to Dayton and would make a nice additional stop on the trip.

Apollo Rendezvous will be held on Saturday, June 9, 2018 with main programming from 9am to 5pm at the Boonshoft Museum of Discovery in Dayton. In the evening, activities will shift to the John Bryant State Park Observatory.

In the past we organized a group for the trip and then worked to form carpool travel arrangements based on length of time folks want to spend on the road. There could be options for leaving early to take in other attractions and stopping in Wapakoneta for the Armstrong museum on the way back. Luckily there are a variety of hotel/motel accommodations in close proximity to the event. Check out the Miami Valley Astronomical Society website for all the Apollo Rendezvous details. You will need to register before the event and early registration closes on May 10th.

Contact Jean De Mott at jeamott@hotmail.com if you are interested in hitting the road with the KAS.

Observations by Richard S. Bell

Do your old pal Richard a solid and attend the general meeting on Friday, April 6th at 7pm. Why, you ask? Because yours truly will give the feature presentation and I do despise small crowds. This will be the fourth and final installment of my "Seasonal Stargazing" series and I'm calling it *The King of Spring*. There will be something in this talk for everyone. Naturally, it'll cover basic night sky navigation of the spring stars and constellations, but also present some interesting facts of the best deep sky objects of the season and how to find them for yourself (star charts will be provided). I'll also cover mind-blowing topics like supermassive black holes and the large-scale structure of the universe. There will even be something for the astronomical history buffs in the audience! Not to mention, I'll take full advantage of KAMSC's high definition projection system by displaying beautiful astronomical images.

You can review past installments of my Seasonal Stargazing series in past issues of *Prime Focus*. It began with the winter sky in February 2010 with *Orion Always Comes Up Sideways* (March 2010, page 2). Next up was *Star-Hopping the Summer Milky Way* in June 2013 (July 2013, page 2). The third talk was titled *Clash in the Autumn Sky* and was presented at the September 2015 meeting (October 2015, page 2). Now that the series is complete, I hope to present them at various libraries at the start of each season for years to come. It'll be a great way to encourage people to venture out under the stars and another way to promote the KAS.

Our Messier Marathon enjoyed clear skies for the first time in three years on March 17th. Unfortunately, member participation was very light - no doubt due to the low temperatures. In all, I think only eight people came out to Richland Township Park. Those that did attend didn't stay too long, since they weren't properly prepared for the weather conditions. Obviously, they didn't attend my winter stargazing talk where I covered dressing properly for winter observing! Dave Woolf and I were there well after 11pm

McKenzie & Aaron Roman prepare to bag some M-objects with their trusty Dobsonian telescope at the KAS Messier Marathon on March 17th.

John Miller explains the workings of a sundial at our hands-on table during Science Night at Vicksburg Middle School on March 7th.

and we both agreed that it wasn't *that* cold (at least for an experienced amateur astronomer). Instead of tracking down M-objects, I spent some time imaging the Orion Nebula. Sorry, I haven't processed those images yet!

Another season of Public Observing Sessions at the Kalamazoo Nature Center begins this month. The first session is scheduled for April 7th. I can't recall how many times the first session of the year turned out to be one of the best; at least in terms of sky conditions. So let's hope skies are clear on April 7th. The other session will be held on April 21st, which is International Astronomy Day. Again, here's hoping for clear skies, because observing will be our only contribution for Astronomy Day this year. We're taking a much-needed hiatus from our large-scale event. Please remember that Public Observing Sessions depend on member participation. We need volunteers to share views of the night sky through their telescopes. We also need members to help other members and the public learn to setup and use their telescopes. Don't have a telescope? Perhaps you can learn to operate the 12-inch SCT in Owl Observatory. We'll also have the 8-inch SCT donated by Becky & Kalman Csia available for use. That's an old-school telescope (no Go-To), so anyone can use it.

We had a great time at Vicksburg Middle School's 14th annual Science Night on March 7th. Several members generously volunteered their time this year. Jack Price passed out KAS literature at our greeting table. Dan DePriest and Dave Woolf passed out NASA goodies at the freebie table. John Miller helped students make sundials at our hands-on table. Matt DePriest, Don Stilwell, and Josh Taylor-Lehman all brought telescopes to display. Matt setup his 18-inch Dobsonian, Don brought his 92-mm refractor, and Josh shared his 6-inch SCT. We certainly needed some special attractions, because Science Night grows bigger and better every year. Thanks again to all our volunteers. See you all (I wish) at the meeting on April 6th!

Desert Astronomy for Me

by Bill Nigg

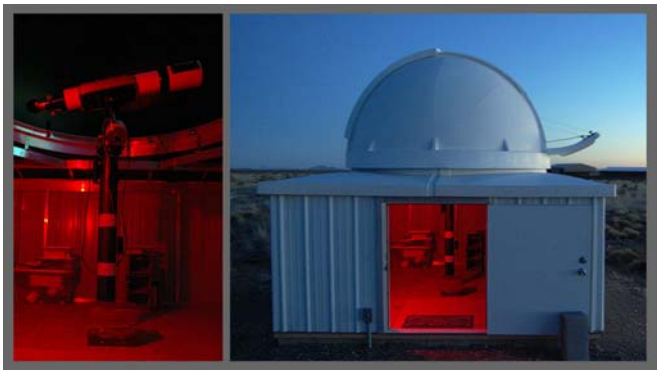
I moved out into the desert a year ago and have lots of observational astronomy to report. There are many social and economic items to consider too, but this report is mainly about better/great astronomy observations for me. I am in the New Mexico Astronomy Village (NMAV) with 11 other astronomers.

1 - Horizon

I have 360-degrees with no trees or hills in the way. I see Mercury often and have 10 more degrees of southern latitude than Michigan for more stars and deep sky objects, such as Canopus and Omega Centauri. Plus, the ecliptic and planets are 10-degrees higher into more stable air. I observe the sunrise and sunset horizon position and make small daily changes like the ancient observers. (See my "Blockhenge" picture below.) All my village neighbors have 5-acres or more, so buildings aren't in the way either.

2 – Weather

I had 25 clear days and nights last January. How was your January? My "clear" is at least 6 hours of astronomy imaging and observing session quality. Temperatures go down to 20° – 30° in the winter and usually up into the 60s during the day. We get about 9-inches of rain each year – mostly in the monsoon season of July and August. I rarely use the AC because I have ceiling fans and don't do anything strenuous – no grass to mow. There are no mosquitoes or ants to contend with either. Low humidity means very rare dew or frost. We have more daytime wind and dust than Michigan, but my dome shields that quite well.



3 - Magnitude 6 Dark Sky Without the Moon Up

The Milky Way and Zodiacal Light are routinely visible. I can easily see all the stars in Ursa Minor every clear night. I can see the Milky Way from my bedroom pillow and often add in another hour of observing around 3am. The observatory is all set up and viewing starts 1 minute after I open the door. Checking seeing on planets and viewing comets are my main targets. I have 6 small telescopes and each can be dovetail interchanged on the AP400 mount. Plus, I use an Orion Sky View Pro as my portable rig at the local state park public observing.

I easily photographed the recent lunar eclipse and am experimenting with CCD imaging. I have been "clouded out" only 3 times this year. I don't need to travel for dark skies – just for solar eclipses. Heaven on Earth! I'm at 32.49° N, 107.98° W. You can contact me at bill@ziptang.com. I have RV hookups and B&B also.

Spotting a Gravitational Lens

by Frank Severance

When Albert Einstein proposed the general theory of relativity, physicists began to look for ways in which it could be tested. Early on, observational astronomers pointed out that as rays of light passing close to a galaxy with a large gravitational field, they would experience distortion effects of gravity. This is because the space-time continuum would be deformed, which would in turn bend the light much as a lens focuses images in our telescopes. From this, the idea of actually looking for such an occurrence, which is credited to the irascible Fritz Zwicky in 1937, was followed up in 1979 when the Twin Quasar (also known as the Twin QSO or Double quasar) was observed and identified as a gravitationally lensed object. The images of the twins are in actuality a single quasar, with the galaxy YGKOW G1 located on the line-of-sight between Earth and the quasar, acting as the gravitational lens.

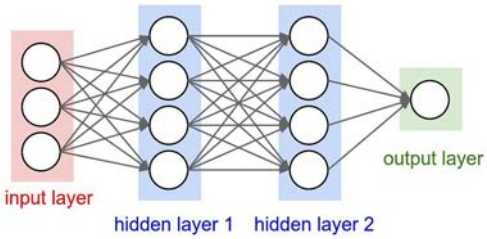
The observation of the Twin Quasar is an example of what is now called weak lensing in which multiple (in this case two) images are seen when there is really only a single source object. In this case astronomers thought there were two quasars with remarkably similar physical characteristics. It was only after extensive analysis that Dennis Walsh, Bob Carswell and Ray Weymann using the 2.1-meter telescope at Kitt Peak National Observatory deduced they were seeing the same thing twice!

Walsh and company reasoned that this is just what Einstein and Zwicky claimed was possible. At the same time, if there is weak lensing, there must also be strong lensing! This is where there are easily visible distortions such as the formation of Einstein rings, arcs, and multiple images. These are the classic objects that we see in all the "cool" pictures that nobody seems to understand! Even-so, they are straight-forward. Unlike an optical lens, a gravitational lens deflects the most light passing closest to the intermediate galaxy. It produces the least deflection further away, yielding a magnification about a focal line rather than a focal point such as our telescopes have. The result is a series of rings around the "magnifying" galaxy as the object's image gets stretched out along the circle centers at the magnification galaxy.

At this time, gravitational lensing is rather well understood. Still, we continue to look for more and more examples. Unfortunately, this is rather time-consuming work. Traditionally, astronomers first scour the night sky for

Einstein's rings. Once a candidate is found, modeling and analysis takes an expert considerable time. Even-so, exemplars keep coming and the problem becomes one of time to make the identification followed by authentication. A more automated means to discover these was needed.

Today this is done by using a mathematical device called an artificial neural network (ANN). An ANN is a nonlinear function which is based on a physiologically real neural network composed of an interrelated network of simple neurons. The knowledge and intelligence of such a device lies in the network rather than the neurons themselves. It learns from using known exemplars to make its judgement. Incremental changes to its modeling parameters are performed dynamically. Astronomers train the ANN by giving it a series of exemplars which are either true gravitational lenses or not. In each case, the network is effectively either rewarded for a correct answer (no change to its parameters) or punished (an incremental change is called for). Eventually, the network "learns" to identify the real thing! Of course, the network doesn't know why it got the answer and we must trust its results despite the lack of deduction, but such a device actually works! Indeed, current algorithms can also compute estimates of some of the physical constants associated with both the source object and the magnifying galaxy.



The amazing thing about ANN's is that they actually do learn and are able to make identifications. Once trained, they can be made into a simple "app" for a smart phone and work almost instantaneously. They also have the feature that they learn much as children do. For instance, when we teach children to know a dog when they see one, we don't give them a set of rules. Instead, we give them a set of examples along with feedback. Eventually, they not only know a dog when they see one, but they also know its color, breed and name. It is no different with gravitational lenses!

Measuring the Movement of Water on Earth

by Teagan Wall

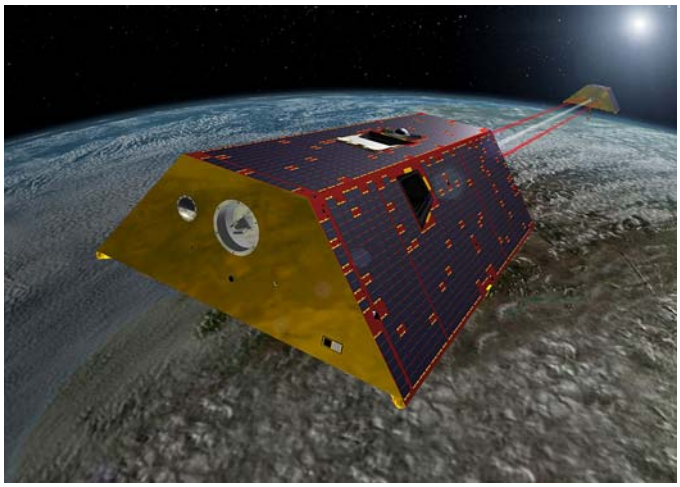
As far as we know, water is essential for every form of life. It's a simple molecule, and we know a lot about it. Water has two hydrogen atoms and one oxygen atom. It boils at 212° Fahrenheit (100° Celsius) and freezes at 32° Fahrenheit (0° Celsius). The Earth's surface is more than 70% covered in water.

On our planet, we find water at every stage: liquid, solid (ice), and gas (steam and vapor). Our bodies are mostly water. We use it to drink, bathe, clean, grow crops, make energy, and more. With everything it does, measuring where the water on Earth is, and how it moves, is no easy task.

The world's oceans, lakes, rivers and streams are water. However, there's also water frozen in the ice caps, glaciers, and icebergs. There's water held in the tiny spaces between rocks and soils deep underground. With so much water all over the planet — including some of it hidden where we can't see — NASA scientists have to get creative to study it all. One way that NASA will measure where all that water is and how it moves, is by launching a set of spacecraft this spring called GRACE-FO.

GRACE-FO stands for the "Gravity Recovery and Climate Experiment Follow-on." "Follow-on" means it's the second satellite mission like this — a follow-up to the original GRACE mission. GRACE-FO will use two satellites. One satellite will be about 137 miles (220 km) behind the other as they orbit the Earth. As the satellites move, the gravity of the Earth will pull on them.

Gravity isn't the same everywhere on Earth. Areas with more mass — like big mountains — have a stronger gravitational pull than areas with less mass. When the GRACE-FO satellites fly towards an area with stronger gravitational pull, the first satellite will be pulled a little faster. When the second GRACE-FO satellite reaches the stronger gravity area, it will be pulled faster, and catch up.



An artist's rendering of the twin GRACE-FO spacecraft in orbit around Earth. Credit: NASA

Scientists combine this distance between the two satellites with lots of other information to create a map of Earth's gravity field each month. The changes in that map will tell them how land and water move on our planet. For example, a melting glacier will have less water, and so less mass, as it melts. Less mass means less gravitational pull, so the GRACE-FO satellites will have less distance between them. That data can be used to help scientists figure out if the glacier is melting.

GRACE-FO will also be able to look at how Earth's overall weather changes from year to year. For example, the satellite can monitor certain regions to help us figure out how severe a drought is. These satellites will help us keep track of one of the most important things to all life on this planet: water.

You can learn more about our planet's most important molecule here: https://spaceplace.nasa.gov/water

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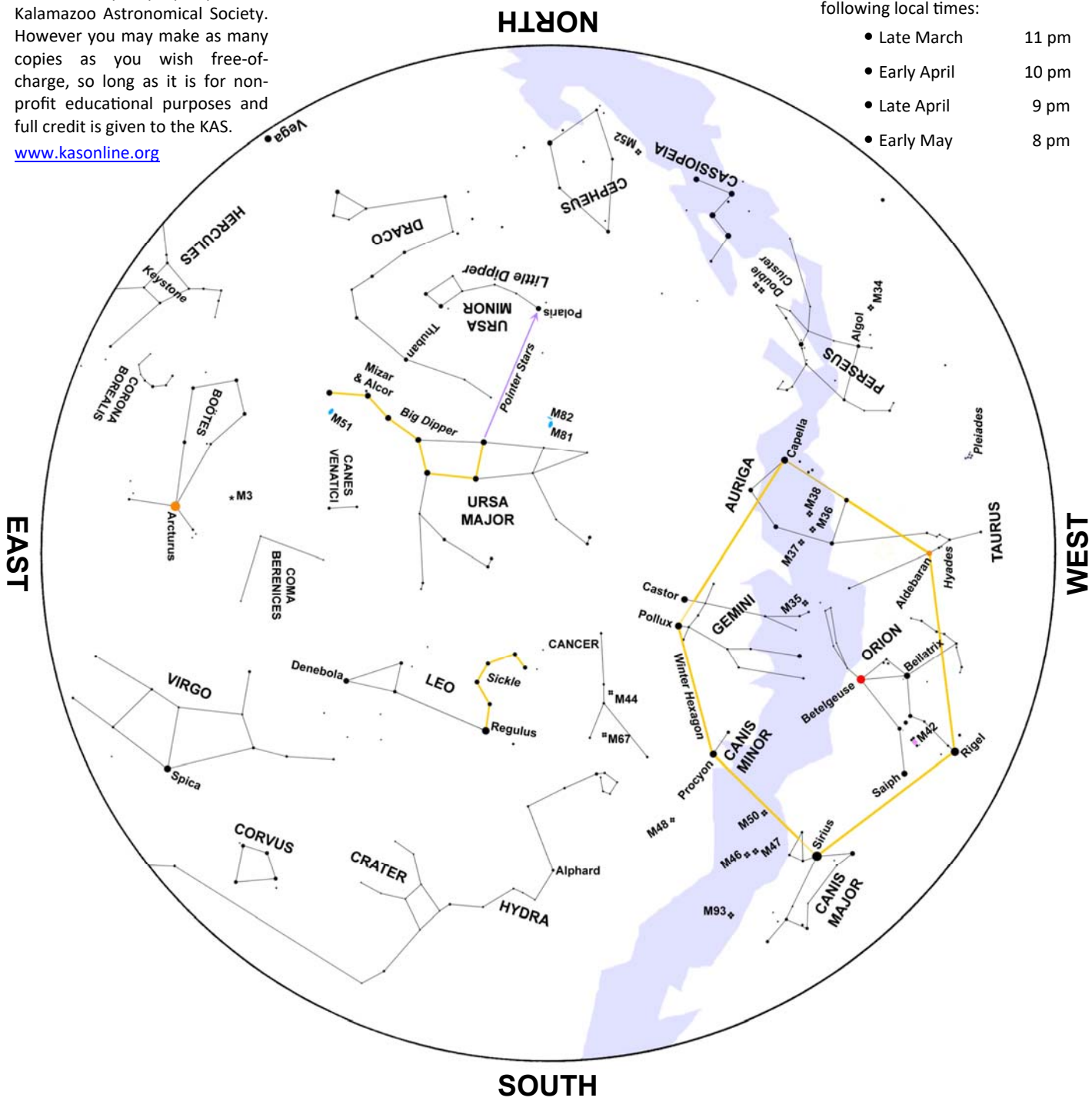
Membership of the Kalamazoo Astronomical Society. . .

1.	Griffin Abbott	Family	2018
2.	Thomas Abraham	Senior	2018
3.	Christina Allen	Regular	2018
4.	Paul Asmus	Senior	2019
5.	Harold Ballen	Senior	2019
6.	Susan Baskerville	Regular	2018
7.	Richard Bell	Lifetime	n/a
8.	Jonathan Berndt	Senior	2019
9.	Karen & Peter Berzins	Senior Family	2019
10.	Charles Bibart	Senior	2018
11.	Betty Bledsoe	Senior	2019
12.	Jack & Lorrie Bley	Family	2019
13.	Joseph & Patti Borrello	Family	2019
14.	Matthew Borton	Regular	2019
15.	Tommy Brown	Regular	2018
16.	Eddie Bryant	Regular	2018
17.	Otto Buder	Senior	2018
18.	Jason Burke	Regular	2019
19.	Phyllis Buskirk	Lifetime	n/a
20.	Michael Bussey	Regular	2018
21.	Beverly Byle	Senior	2018
22.	Joseph Cain	Family	2019
23.	Dale A. Campbell	Regular	2018
24.	David Carpenter	Family	2018
25.	Mike Chaffee	Family	2018
26.	Tonya Chase	Regular	2019
27.	Sarve Cherukuri	Senior	2018
28.	Jason Combs	Regular	2018
29.	Joe & Ellen Comiskey	Family	2019
30.	Roark Consolatti	Senior	2019
31.	Michael Cook	Family	**2017**
32.	Harry Cotterill	Senior	2018
33.	Greg Cowles	Regular	2018
34.	Robert Cox	Regular	2018
35.	Brian Crittendon	Regular	2019
36.	Scott & Lisa Crummel	Family	2019
37.	Kalman & Becky Csia	Family	2018
38.	Matt Dean	Regular	2018
39.	Jean DeMott	Regular	2018
40.	Sue DeNise	Regular	2019
41.	Matthew DePriest	Family	2018
42.	Srinivas Dhara	Family	2018
43.	Joshua Dickey	Family	2018
44.	Richard Dirrenberger	Senior Family	2018
45.	David Doan	Senior Family	2018
46.	Kristi & Steve Durbin	Family	2018
47.	Fred E. Dutton	Senior	2019
48.	James Dyer	Senior Family	2018
49.	Clifton E. Ealy Jr.	Senior	2018
50.	Fred Espenak	Honorary	n/a
51.	Joseph Evankovich	Regular	2018
52.	Bill Finger	Family	2018
53.	Bradley Franks	Student	2019
54.	Martha & Ron Gammill	Family	**2017**
55.	Dave Garten	Family	2018
56.	Brendan & Dee Gauthier	Senior Family	2019
57.	Tom George	Regular	2019
58.	Dick & Jackie Gillespie	Senior Family	2018
59.	Manisha Golas	Regular	2018
60.	Tony Gurczynski	Senior	2019
61.	Alexander Hanchar	Senior	2019
62.	Brady Harnishfeger	Family	2018
63.	Robert & Barbara Havira	Senior Family	2018
64.	Alec Hays	Student	2018
65.	David Heinrich	Senior Family	2018
66.	Geoffrey Hickok	Senior	2018
67.	Christopher & Lydia Hodshire	Family	**2017**
68.	Lydia Hoff	Regular	2018
69.	John Hooper	Family	2018
70.	Nicholas Hotra	Senior	2018
71.	Will Howard	Family	2018
72.	Arya Jayatilaka	Family	2019
73.	Eric Jeska	Regular	2019
74.	Dean Johnson	Regular	2018
75.	Kevin Jung	Regular	2018
76.	Daniel Keto	Regular	2019
77.	Rodney & Marlene Kinne	Senior Family	2019
78.	Jessica Kingsley	Family	2018
79.	Mark Kinsey	Family	2018
80.	Melissa Kohler	Family	2018
81.	Kirk & Angela Korista	Family	2018
82.	Zosha Kuiper	Student	2018
83.	Jim Kurtz	Regular	2018
84.	Tim Kurtz	Regular	2018
85.	Cal & Jean Lamoreaux	Family	2018
86.	John Lee	Senior Family	2018
87.	Dale Reed Lighthizer	Family	2018
88.	Keith Longjohn	Senior	2018
89.	Andrew Loveless	Family	2018
90.	Gary & Phyllis Lubbert	Family	2019
91.	Chuck Lund	Senior	2018
92.	Scott Macfarlane	Family	2019
93.	Phillip & Linda Marshall	Senior Family	2018
94.	Jon Towne & Bobbi Martindale	Family	2019
95.	Richard Mather	Senior	2018
96.	Randy & Michelle Matson	Family	2018
97.	Raul & Carrie Maysonet	Family	2018
98.	Joe McJilton	Regular	2019
99.	Paul McKinley	Senior	2019
100.	Michael J. Melwiki	Regular	2018
101.	Chris Miller	Regular	2018
102.	John Miller	Regular	2019
103.	Mark & Ninah Miller	Family	2018
104.	Dave & Carol Mitchell	Senior Family	2019
105.	Katie Morgan	Regular	2019
106.	David Murphy	Family	2018
107.	Ryan Nehring	Family	2018
108.	Bill Nigg	Lifetime	n/a
109.	Richard Olsen	Regular	2019
110.	Jim & Christene Oorbeck	Family	2018
111.	Amy Ohrstrom	Regular	2018
112.	Charles Overberger	Regular	2018
113.	Mike Patton	Regular	2018
114.	Thomas M. Peters	Senior Family	2018
115.	Mike Potter	Regular	2018
116.	Jack & Ruth Price	Family	2018
117.	David Puzycki	Regular	2018
118.	Sam Qualls	Regular	2018
119.	Jonathan Reck	Regular	2018
120.	Phillip Relich	Regular	2018
121.	Christopher Roberts	Regular	2018
122.	Andrew C. Robins	Regular	2019
123.	David & Keira Rockwell	Family	2018
124.	Florence Roe	Senior	2018
125.	Aaron Roman	Family	2018
126.	Eric Schreur	Regular	2018
127.	Frank & Susan Severance	Family	2018
128.	Diane Schear	Regular	2019
129.	Rick Shields	Senior	2018
130.	Lloyd Simons	Family	2019
131.	Michael & Karen Sinclair	Family	2018
132.	Greg Sirna	Regular	2019
133.	Merri Moore & David Smullen	Family	2018
134.	Don Stilwell	Family	2019
135.	Stephanie Stratton	Regular	2019
136.	Eric R. Sullivan	Regular	2018
137.	Brian & Terri Swisher	Family	2018
138.	Renée Szostek	Regular	2018
139.	David Taylor	Regular	2018
140.	Josh Taylor-Lehman	Family	2019
141.	Gary & Karen Theisen	Family	2018
142.	Henry L. Upjohn II	Family	**2017**
143.	Michael Vandeveer	Senior	2019
144.	Patricia Villalobos	Family	2019
145.	John Vollmer	Regular	**2017**
146.	Jim Vukelich	Senior	2018
147.	Robert Wade	Supporting	2018
148.	Brian Walesh	Family	2019
149.	Philip B. Wareham	Regular	2018
150.	Katelyn Waters	Student	2018
151.	Jay Wehrly	Family	2018
152.	Bob White	Senior	2019
153.	Roger & Molly Williams	Family	2018
154.	Sheryl Willis	Regular	2018
155.	Klay & Karen Woodworth	Family	2018
156.	David Woolf	Family	2018

— April Night Sky —

This map represents the sky at the following local times:

- Late March 11 pm
- Early April 10 pm
- Late April 9 pm
- Early May 8 pm



Mars will be 1° below Saturn before dawn on April 2nd. Look for them in the south-southwestern sky above the Teapot asterism in Sagittarius. The waning gibbous Moon will join Mars and Saturn, now 4° apart, on April 7th. The Moon will be 1½° above Saturn.

Saturn reaches aphelion, its farthest point from the Sun, on April 17th. This is typically unnoteworthy, but Saturn will not have been more distant from the Sun since 1959.

A thin waxing crescent Moon visits the Hyades cluster in Taurus on the evening of April 18th. It will be about 2° from the bright star Aldebaran.

A first quarter Moon lies in Caner, the Crab, on April 22nd. It'll be about 3° below M44, the Beehive Cluster. Both Moon and cluster will easily fit in the field-of-view of 7× or 10×50 binoculars.

The Moon, just one day past full, and Jupiter rise together shortly after sunset in Libra, the Scales, on April 30th.

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Share the Sky! Volunteers Needed For...

Green-A-Thon
Saturday, April 14th @ 11:00 am - 3:00 pm
Portage Celery Flats

Science Festival
Saturday, April 28th @ 10:00 am - 3:00 pm
Pierce Cedar Creek Institute

Rock & Mineral Show
Saturday, May 5th & Sunday, May 6th
10:00 am - 6:00 pm (Sat.) / 10:00 am - 5:00 pm (Sun.)
Kalamazoo County Expo Center

Please contact us for more information and/or to volunteer. We need you!

8" SCT Available for Loan

Our Celestron 8" Schmidt-Cassegrain telescope is mounted on a very stable Super Polaris Equatorial mount. It's quick and easy to setup. A dew cap, 4 eyepieces, and a Tel-Rad finder are included.

This is a serious amateur telescope that will provide dazzling views of the Moon and planets, and is capable of showing you thousands of deep sky objects.

Visit the Telescopes for Loan webpage for more information and contact KAS Equipment Manager Arya Jayatilaka today if you'd like borrow it.

Public Observing Sessions

Saturday, April 7th
Features: Galaxies of the Virgo Cluster

Saturday, April 21st
Features: The Moon, Venus & Jupiter

Gates Open: 8:00 pm • Observing Begins: 8:30 pm

Kalamazoo Nature Center
— 7000 N. Westnedge Ave. —

General Meeting Preview

The King of Spring

***presented by* Richard S. Bell**

Spring ushers in a new season of stargazing for many skywatchers. Those long, cold nights of winter are at last behind us. Skies become clearer, temperatures become more bearable, and nights are still long enough to explore the splendors of the spring sky. Among the spring stars we find ancient heroes and mighty beasts that rule over the night. Looking closer with binoculars or a telescope will reveal magnificent star clusters and distant galaxies. Please join us as Richard takes us on a colorfully illustrated tour of the spring sky. Along the way we'll explore supermassive black holes and the large-scale structure of the universe, and find out who (or what) is the true King of Spring. Star charts will be provided.

Friday, April 6 @ 7:00 pm

Kalamazoo Area Math & Science Center

600 West Vine, Suite 400 • Use Dutton St. Entrance

– ***Dutton Entrance Locked by 7:10 pm*** –

Kalamazoo Astronomical Society
c/o KAMSC
600 West Vine, Suite 400
Kalamazoo, MI 49008

STAMP