SkyWAAtch

The Newsletter of Westchester Amateur Astronomers

February 2019

The Great Orion Nebula by Gary Miller

The Orion Nebula, Messier 42, is the northern hemisphere's finest deep sky showcase. Gary Miller captured this image in December. The four hot young stars of the Trapezium, discovered by Galileo on February 4, 1617, are surrounded by lovely nebulosity (which Galileo missed). The comma-shaped nebula across from the Trapezium is De Mairan's Nebula, or Messier 43. The Running Man Nebula (Sh2-279) is visible on the left edge of the image. For more on the Orion Nebula, see the article in the February 2017 SkyWAAtch. Better yet, take your scope or binoculars out on a clear night in February or March and catch its photons yourself!

WAA February Lecture

Friday, February 1st, 7:30 pm
Lienhard Hall, 3rd floor
Pace University, Pleasantville, NY

The Source of Methane on Mars: Geology or Biology?

Brother Robert Novak
Department of Physics, Iona College

Observations from Earth-based telescopes showed that methane is present in the Martian atmosphere. Mars Curiosity and Europe's Trace Gas Orbiter have supported these observations.

Is atmospheric methane coming from decaying life underneath the surface of Mars or is it from geological processes? On Earth, both these sources occur. The ratio between carbon-12 methane and carbon-13 methane differs between biologically produced and geologically produced methane. Also, the ratio between ethane and methane differs for each source. Identifying these ratios in Mars's atmosphere will give us insights as to the origins of the methane.

Br. Novak will discuss the telescopic search for methane and the method for determining these ratios. Data obtained with the ISHELL spectrometer on the NASA IRTF telescope on Mauna Kea in January, 2017 (Mars Northern Winter) and January 2018, (Mars Northern Summer) were taken to determine ethane/methane ratios. Preliminary results will be shown and discussed.

Br. Robert Novak, CFC, is a Professor Emeritus of Physics at Iona College in New Rochelle NY. He finished his teaching career in May, 2018 and is currently working at raising funds for the sciences at Iona and is continuing his collaboration with the Astrobiology Program at NASA's Goddard Space Flight Center. He holds degrees in Physics from Iona College (B.S., 1972), Stevens Institute of Technology (M.S., 1977), and Columbia University (M.Phil., Ph.D., 1980).

Free and open to the public. Find directions and map to Lienhard Hall at the WAA web site, www.westchesterastronomers.org.

Pre-lecture socializing with fellow WAA members and guests begins at 7:00 pm!

WAA Lecture March 2019

Friday, March 1, 7:30 pm
Lienhard Hall, Pace University

Catching Comets (and the Instruments that Catch Them)

Steve Bellavia, Brookhaven National Labs

Call: 1-877-456-5778 (toll free) for announcements, weather cancellations, or questions. Also, don't forget to visit the WAA website.

Starway to Heaven

Ward Pound Ridge Reservation
Cross River, NY

There are no scheduled observing events in February. Star parties will resume at on Saturday. March 2, 2019 (weather permitting, rain/cloud date March 9, 2019).

New Members

Jun Mitsumoto	Briarcliff Manor

Renewing Members

Rob & Melissa Baker	West Harrison
Catherine Beveridge	Scarsdale
Frank Clemens	Larchmont
Tom & Lisa Cohn	Bedford Corners
Alex Edwards	Mahwah
Al Forman	Croton-on-Hudson
Carlton Gebauer	Granite Springs
Jinny Gerstle	West Harrison
Jonathan Gold	Ossining
Sharon and Steve Gould	White Plains
Mark Hefter	Dobbs Ferry
Bob Quigley	Eastchester
Robert Rehrey	Yonkers
Michael H Tarlowe	New Rochelle
Mike & Angie Virsinger	Seaford

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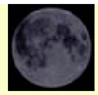
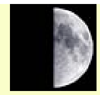
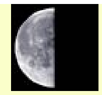
ALMANAC For [month]

Bob Kelly, WAA VP for Field Events


Feb 4


Feb 12


Feb 19


Feb 26

The ecliptic, the path of the sun and planets, makes a shallow angle with the morning horizon in early 2019. This keeps the bright morning planets low in the southeastern sky for us. The view gets better if you vacation further southward. But, at the other end of night, Mercury has the smallest of its evening greatest elongations for the year but it soars almost straight up over the Sun into the evening sky. It's Mercury's best evening sighting for the year for the northern hemisphere. Greatest elongation is on the 26th at 18 degrees east of (following) the Sun. Then, Mercury appears to tail off the right as it swings back toward the solar glare. Get a preview of Mercury in the SOHO spacecraft's C3 view now through the 9th.

Jupiter made a wonderful pairing with Venus in January, but since has left her behind, buzzing the southern horizon ahead of Venus. From the 17th though the 20th, Saturn tries to recreate the super sight of Jupiter with Venus. Saturn is 2½ magnitudes dimmer than Jupiter, so the Saturn/Venus conjunction will be great, but not quite as spectacular as Jupiter/Venus was. Our Moon, Venus and Saturn form a line up in the morning sky on the 1st, with Saturn very low in the sky. They get together higher above the horizon in early March. In the meantime, see if you can get a selfie with the Jupiter/Venus/Saturn planetary arc, especially later in the month.

Due to the way the IAU set the boundaries of the constellations, Jupiter is not in a zodiac constellation this year – it'll be in Ophiuchus (I pronounce it 'that harder-to-see constellation above Scorpius').

Mars still stands out in the evening sky, like the party guest that has nothing much to offer but refuses to leave. Its small size makes it hard to see any details in most of our telescopes. The Moon comes by on the 10th to remind Mars of better days. See how early after sunset you can find Mars with our Moon as a pointer. Mars makes itself useful by passing a degree from Uranus on the 13th. Uranus appears about half the width of Mars in a telescope and the color contrast reddish/blueish could be very nice to see.

Bob King reports, at the Sky and Telescope web site, about a possible binocular comet in February, as Iwamoto (C/2018 Y1) may get to 7th magnitude as it passes about 28 million miles from Earth. Look for it in Leo after the lion rises before midnight. It's wonderful that in the age of automated observing programs sweeping up so many comets and asteroids, human observers like Mr. Iwamoto still find some first. For folks with larger telescopes, 46P/Wirtanen and 38P/Stephan-Oterma are fading but traveling across the same part of the circumpolar sky in Ursa Major and Lynx, respectively.

Make sure you get a look at the superest supermoon Moon of 2019! The closest full moon of the year occurs on the 19th just four hours after the closest lunar perigee of the year about 5am. This should make for some great photos of the setting Moon that morning.

The International Space Station will be visible to the unaided eye during evenings through 9th and mornings starting on the 22nd.

A footnote to seeing Saturn in the sky this year: Saturn spends 2019 scooting under the teaspoon asterism in Sagittarius, just to the upper left of the 'teapot'. I've been a bit obsessed with the fact that Pluto, and by extension, the New Horizon spacecraft and, now, Ultima Thule, were in the teaspoon in the last few years, and now Saturn is taking up residence there. The Kuiper Belt residents are still hanging together, from our point of view, near the teaspoon. It's a good way to get a feeling for the range of distance in the Solar System and the vastness that extends beyond it into the stars of Sagittarius and then on to the center of the Milky Way behind it. One way to see all this for yourself is to type in "Ultima Thule" in the search box at theskylive.com. (You can type in 'New Horizons', but its label may overlap and obscure Ultima Thule's tag.)

WAA Members: Contribute to the Newsletter!
Send articles, photos, or observations to
waa-newsletter@westchesterastronomers.org

SkyWAAtch

Editor: Larry Faltz
Assistant Editor: Scott Levine
Editor Emeritus: Tom Boustead

Member Profile: WAA President Paul Alimena

Home town: *Rye, NY*

Family: *Wife, Judy; Sons Ben (28) and Chris (26)*

How did you get interested in astronomy? I had a passing interest in astronomy as a kid, growing up in the era of the space program and Star Trek, but as a college student I had a roommate, Jim Beletic, who was constantly spending nights on the roof of the science building as part of his "physics research." We all thought something more recreational was going on, but after graduation he went on to obtain his Ph.D. in Applied Physics from Harvard. His research team was featured in an article in *National Geographic*, so I decided I needed to learn a little more about his field. Jim gave a talk to WAA back in 2013 and hopefully will return in the near future. His career has included serving as director of the Optical Detector Team for the European Southern Observatory (ESO) project in Chile, deputy director of Keck Telescope, and is currently president of Teledyne Imaging Sensors, responsible for most of the sensor chip arrays on the James Webb Space Telescope instruments. At the time, he recommended *Coming of Age in the Milky Way* by Timothy Ferris which I read and was hooked!

Paul lecturing at Harrison Library, 2017

Do you recall the first time you looked through a telescope? What did you see? The very first object probably was a street light through a dreaded 60 mm department store refractor, but I clearly remember viewing the Pleiades through the 10" reflector on the roof of Rye High School as a student there.

What's your favorite object(s) to view? Easy - the Sun during total eclipse. Also M13, the Hercules cluster, in the club's 20" Obsession scope.

What kind of equipment do you have? I have adhered to the keep it simple rule and have a 4 ⅛" Astroscan and an 8" Orion Dob, in addition to my 10x50 Celestron binoculars.

What kind of equipment would you like to get that you don't have? I would have to clear that with Judy first!

Have you taken any trips or vacations dedicated to astronomy? Judy and I have made three wonderfully successful expeditions to view the totally eclipsed sun. We were in Germany in August 1999 with our kids, the Greek Islands in March 2006 for our 25th anniversary, and Central Oregon in August 2017 for the Great American Eclipse. Each vacation included visits to a number of tourist destinations so that a pleasant vacation would not be totally dependent upon a successful view of the eclipse, but each time we were not disappointed. That being said, the 1999 conditions were not great and we were very fortunate to have a break in the clouds at the most opportune time.

Do you have any favorite personal astronomical experiences you'd like to relate? We all enjoy sharing our passion for viewing the night sky, and I think my most memorable episode was a mid-winter camping trip with my son's cub scout pack when I took the club's 20" Obsession scope and showed the kids and their parents Saturn on a frigid January night. In spite of temperature in the low single digits, there was a long line of cubs waiting to exclaim "Wow!" over and over again as they saw Saturn and her impressive rings through the magnificent scope.

What do you do (or did you do, if retired) in "real life"? I am a general dentist. I've completed several marathons. I love to run early in the morning before work. Hence, I am not very good at staying up late for astronomy adventures!

Have you read any books about astronomy that you'd like to recommend? In additional to the aforementioned book by Ferris, I have enjoyed the currently very topical *Chasing New Horizons* by Alan Stern, *Chasing Venus: The Race to Measure the Heavens* by Andrea Wulf about the history of the pursuit of the science to be gained from observations of the rare Transit of Venus, any of Dava Sobel's books especially *Longitude* about the "amateur" Harrison, *A Brief History of Time* by Stephen Hawking, and *Black Holes and Time Warps: Einstein's Outrageous Legacy* by Kip Thorne.

If you have a position in WAA, what is it, what are your responsibilities and what do you want the club to accomplish? I have been a long time member of WAA since the mid 90’s when we used to meet at the Andrus Planetarium at the Hudson River Museum. I have previously served as Treasurer, most recently as Vice President for Membership, and now have been honored to become President. Under the leadership of Larry Faltz, the club has grown in number and mission from a small dedicated group of observers to a terrific community organization providing outstanding education and exciting outreach opportunities for us all to share thanks to the many contributions of our talented club members. I want to see continued growth and expansion of our presence and strongly encourage everyone in WAA to participate not only in our events but in administering our group. We always need and welcome new people to enjoy taking part in our continuing pursuit of this goal of sharing our avocation.

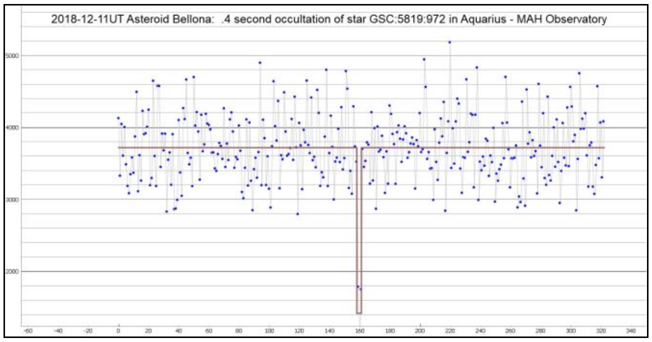
Is there any other information you think would be interesting to your fellow club members, and don’t be bashful! I am especially grateful to WAA members for their enthusiasm, guidance and camaraderie. In particular, Rick Bria’s generous contribution of time to, among other things, the updating of the club’s Obsession telescope has been indispensable.

Paul and Rick Bria at the WAA booth, NEAF 2015.

Paul and Judy in Madras, Oregon at the August 21, 2017 eclipse

Determining the Shape of Asteroid 28 Bellona by Occultation

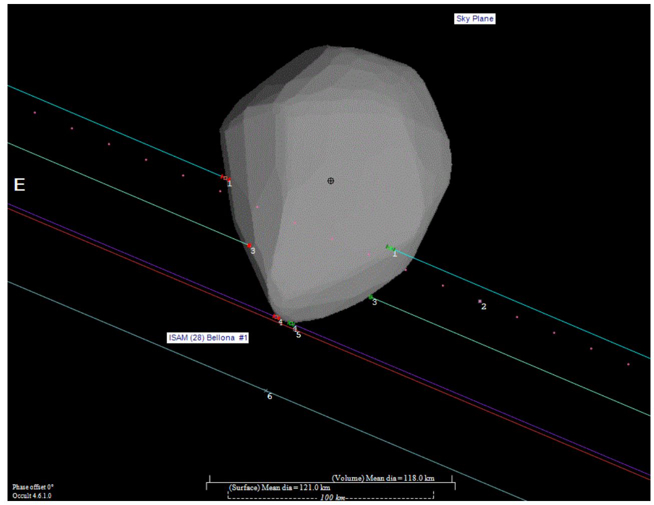
Rick Bria



On December 11, 2018 a team of amateur astronomers and students at the the Mary Aloysia Hardey Observatory in Greenwich, CT successfully timed asteroid 28 Bellona as it briefly blocked the light of a star in Aquarius. We used the observatory's new 14" PlaneWave Corrected Dall-Kirkham Astrograph telescope to image the 12.7 magnitude body.

We were part of a five member team observing the Bellona occultation. The graph shows a 0.4-second drop in brightness as asteroid Bellona blocked the light from the star from our location. When occultation times from different locations are added together, they produce a statistical silhouette of the asteroid. The result will refine Bellona's size, shape and position. We submitted our data to the International Occultation Timing Association and it was correlated with data from other observers.

My observation cord (purple line #4) marked the very edge of the asteroid. That explains why I had a 0.4-second event when the predicted event duration was 6 seconds. The Westport Astronomical Society (red line #5) just missed the edge from their location.The red dotted line (#2) shows the predicted path was off by about 20 km. In all, we had three positive cords and two misses. Other members of the team were clouded out for this event. Had they not been, we would have had more cords and a better shape prediction. In asteroid occultations, the more the merrier. The image below was created by IOTA member Steve Messner, who used Occult and DAMIT software.



Asteroids smaller than 320 km (200 miles) in diameter do not have enough mass to collapse into a sphere. Bellona is pear-shaped and is 121 km in diameter. It is thought to be almost twice as long as it is wide.

Our observation from December 11, 2018 is the first team observation of asteroid Bellona in 16 years. Our recent data with updated equipment will certainly be a welcome addition to those researching asteroid Bellona.

28 Bellona was discovered in 1854. It was named after a Roman war goddess, apparently in recognition of the start of the Crimean War.

SIMPLICIO: How do you deduce that it is not the Earth, but the Sun, which is at the center of the revolutions of the planets?

SALVIATI: This is deduced from most obvious and therefore most powerfully convincing observations. The most palpable of these, which excludes the Earth from the center and places the Sun there, is that we find all the planets closer to the Earth at one time and farther from it at another. The differences are so great that Venus, for example, is six times as distant from us at its farthest as at its closest, and Mars soars nearly eight times as high in the one state as in the other. You may thus see whether Aristotle was not some trifle deceived in believing that they were always equally distant from us.

Galileo Galilei, *Dialogue Concerning the Two Chief World Systems* (1632)

Stars, Calendars and February

Hans Minnich

February has always been a strange and unique month. It is the shortest, the only variable month and full of holidays and special days. How did it get this way and how are these special days related to the sky?

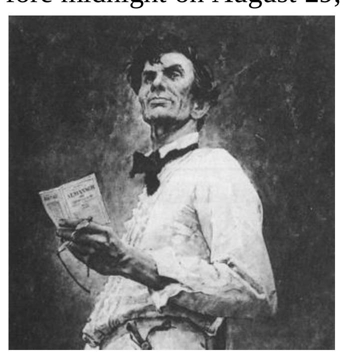
The original legendary Roman calendar, supposedly instituted by Romulus in the 700's B.C., consisted of 10 months in a year. Six months were of 30 days and 4 months were of 31 days for a total of 304 days. The Romans seem to have ignored the remaining 61 days, which fell in the middle of winter. The calendar simply ended after the last day of December and did not start until the Pontifex Maximus (head priest) announced the beginning of the New Year. Thus the length of the year could vary widely depending on whether the Pontifex wanted the political powers to stay in office for a longer or shorter time. The 10 months were named Martius, Aprilis, Maius, Junius, Quintilis, Sextilis, September, October, November, and December. The last six names were taken from the words for five, six, seven, eight, nine, and ten. According to tradition, the Roman ruler Numa Pompilius added January and February to the calendar in order to bring the calendar in sync with the lunar year of 354 days. This is 12 lunar synodic cycles of 29.5 days each. He took one day away from the 30 day months to make them 29 days long. The original 10 months added up to 298 days. This left January and February with 56 days between them to give a total of 354 days. However the Romans had a superstitious dread of even numbers so one day was added to January so that the total number of days in the year added up to 355. February was left with 28 days. To make the calendar correspond approximately to the solar year, a 22-day leap month, called Mercuris, was added every 2nd year.

February 2 One of the traditional cross-quarter days. This is the approximate half-way point between the Winter Solstice and the Vernal Equinox. The other cross quarter days are May Day (May 1), Lamas (August 1) and All Saint's Day (November 1). February 2 is also Candlemas, the day commemorating the presentation of Jesus to the Temple. It is 40 days after Christmas and marks the end of the Christmas season in the Church calendar.

In America it is celebrated as Groundhog Day. If the Groundhog comes out of his winter burrow and can see his shadow this portends six more weeks of winter.

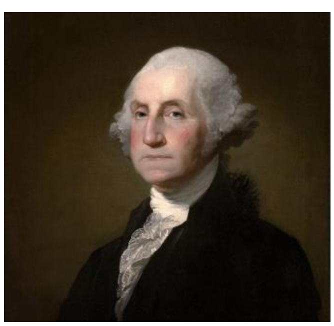
February 5 新年快樂 Lunar New Year. This is determined by the 2nd New Moon after the Winter Solstice and is considered a spring festival in China. It is the year 4717 in the Chinese calendar and the year of the Pig in the Chinese astrological system. Pigs are a symbol of wealth and good fortune so this should be a good year. The Chinese calendar is dated from a time when there was a propitious configurations of planets and the Moon. All the visible planets and the Moon could be found in the same region of the sky and this was considered the year 1 of the calendar. Celebrations continue until the Lantern Festival 15 days after the start of the New Year.

February 12 Abraham Lincoln's Birthday (1809). Although this does not have any direct astronomical significance, in 1858 Lincoln famously defended an Illinois man named William Armstrong accused of murdering James Reston Metzker a few minutes before midnight on August 29, 1857. The principal prosecution witness against Armstrong was a man named Charles Allen, who testified he had seen the murder from about 150 feet away. When Lincoln asked how he could tell it was Armstrong given that it was the middle of the night and a considerable distance away Allen replied, "By the light of the Moon". Lincoln then produced the 1857 copy of the Farmer's Almanac which showed that the Moon was in its first quarter and about to set at that time and there would not have been enough light for him to see Armstrong or anyone else. The jury agreed with Lincoln and William Armstrong was acquitted.



February 14 Beware the Ides of February! Valentine’s Day. The Ides – as in beware the Ides of March – were basically the time of the full moon in the Roman calendar system. This occurs on the 15^{th} of the month for March, May, July and October and on the 13^{th} for all other months. The Roman festival of Lupercalia ran from February 13-15. It was basically a two day drunken revel. The Roman emperor Claudius II executed two Christians both named Valentine on February 14 in different years in the 3^{rd} century. Their martyrdom was honored by the Catholic Church with the celebration of Valentine’s Day. Pope Galasius I combined St Valentine’s Day with Lupercalia in the 5^{th} Century to drive out the pagan rituals. This however didn’t stop it from being a day of fertility and love.

February 18 Purim Katan. A moveable feast (celebrating another miraculous escape for the Jews) that occurs on 14^{th} of Adar I, this year on the 18^{th}. This occurs during leap years in the Jewish caledar. The Jewish calendar is a lunar-solar calendar that must follow the Metonic cycle of 235 lunar cycles for every 19 solar cycles. Thus there must be 7 extra leap months added every 19 years.



February 22 George Washington’s Birthday. When you look up the birthday of the father of our country it reads February 22, 1732. However when Mary Ball Washington – George’s mother – looked at the wall calendar when George was born it read February 11, 1731. England and colonial American were still on the Julian calendar when Washington was born. By this time 1732 the discrepancy between the Julian and Gregorian calendar had increased to 11 days. Also at this time the New Year in Colonial America was on March 1. When the calendar reform took place in 1752, 11 days were cut from the calendar making February 11 to February 22. New Year’s Day was changed from March 1 to January 1. Hence Washington was born February 22, 1732 in the Gregorian calendar and February 11, 1731 in the Julian calendar.

February 29 Leap day. In the Gregorian calendar there is a leap year every 4 years except if it is a century year not divisible by 400. The years 1700, 1800 & 1900 were leap years in the Julian calendar, but not leap years in the Gregorian calendar. The discrepancy between the two calendars has increased from 10 days in 1582, when the Gregorian calendar was implemented, to 13 days today. This discrepancy will grow to 14 days in 2100.

Every day of the year is a special day. Here are some officially named festive days in February that don’t seem to have an astronomical association, but you may be interested in celebrating them anyway. I leave how to do that to your imagination.

February 1	Go to Work Naked Day
February 4	Create a Vacuum Day
February 9	Toothache Day
February 13	Get a Different Name Day
February 13	Do a Grouch a Favor Day
February 28	Public Sleeping Day ■

Leadership Transition Celebrated at WAA Meeting on January 11th

Prior to Joe Rao’s wonderful talk on upcoming astronomical events that kicked off our 2019 lecture series, the club toasted outgoing President Larry Faltz, who served from 2013-2018. WAA Vice President for Membership and Chief Confectioner Eva Andersen presented Larry and his wife Elyse with a 12-inch wide astronomy cookie (with WAA logo!).

(L) Larry Faltz & Paul Alimena (R, top) The cosmic cookie (R, bottom) part of the crowd

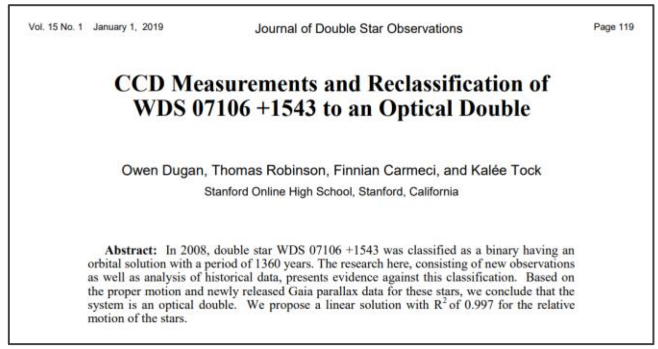
Original Research by a Young WAA Member

Some amateur astronomers, especially if they have very fine refractors, like to observe double stars. Doubles can be colorful showpieces, like Albireo. Close doubles can be exacting tests of optical quality and eyesight. There are many reasonably bright pairings that can be observed in light-polluted skies, making them tempting objects for those of us who can't get out of suburbia that often. There are two types of double stars: true binary stars that are in orbit around each other, and optical doubles, two stars that appear close in the sky but aren't gravitationally bound. There are also exotic multiple star systems such as the famous "double-double" in Lyra. Observations of double stars over years allow their orbits to be plotted, and their relative masses to be determined. With some additional data like radial velocity, actual masses can be ascertained.

WAA's youngest active member is Owen Dugan of Sleepy Hollow. Still in high school, Owen often observes at Ward Pound with his father, Brian, using a Celestron CPC1100 or a Celestron Nexstar 6SE. Owen's mastery of astronomy is impressive. At the September 2018 WAA Members' Night, Owen presented original research he and three of his school colleagues did on the star WDS 07106 +1543 (WDS is the Washington Double Star Catalog of over 100,000 systems).

WDS 07106 +1543 is listed as a binary system with an orbital period of 1360 years. Owen's team observed the star using a robotic Australian telescope, examined historical records and observations and obtained data from the recent Gaia survey. A variety of sophisticated models were proposed for the stars' potential interaction. The only viable explanation of the data was that other than their proximity on the sky, the stars had nothing to do with each other, and previous claims by professional astronomers that they were interacting were wrong. The two stars are at dramatically different distances from Earth and they are heading in different celestial directions.

In addition to his presentation at the Members' Night, Owen discussed his research at the Medomak Astronomy Retreat and Symposium in Washington, Maine in August 2018. A detailed paper was published in the January 2019 issue of the Journal of Double Star Observations (Owen Dugan, Thomas Robinson, Finnian Carmeci, and Kalée Tock, CCD Measurements and Reclassification of WDS 07106 +1543 to an Optical Double, *J Double Star Observations* 15:199-127, 2019. You can read the whole paper on line at http://www.jdso.org/volume15/number1/Dugan_119_129.pdf. It's pretty amazing work.



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CCD Measurements and Reclassification of WDS 07106 +1543 to an Optical Double

Owen Dugan, Thomas Robinson, Finnian Carmeci, and Kalée Tock

Stanford Online High School, Stanford, California

Abstract: In 2008, double star WDS 07106 +1543 was classified as a binary having an orbital solution with a period of 1360 years. The research here, consisting of new observations as well as analysis of historical data, presents evidence against this classification. Based on the proper motion and newly released Gaia parallax data for these stars, we conclude that the system is an optical double. We propose a linear solution with R^2 of 0.997 for the relative motion of the stars.

Owen Dugan (R) and his father Brian at the 2017 Medomak Astronomy Retreat & Symposium in Maine, with a makeshift dew shield for their Celestron Nexstar 6. Owen was substantially taller at the 2018 retreat!

Longitude by Lunar Occultation

Robin Stuart

Amateur astronomers and those with a background in the physical sciences often exhibit a predisposition to become interested in celestial navigation. I'm one of those individuals. So it was that when the *Sky & Telescope* website posted an announcement of a conference on traditional navigation to be held at Mystic Seaport in 2008, I was able to summon little resistance. Don't be surprised: there's an actual, if archaic, psychiatric condition called "thalassophilia," a predilection for men to leave their families and take to the sea. Three sextants and many sights later my condition could be described as being well-managed.

Over the last several months I have been collaborating with a small group of similarly afflicted individuals who are deciphering and replicating the navigational calculations that appear in the original log books of the famous Imperial Trans-Antarctic Expedition of 1914-16 led by Sir Ernest Shackleton. We had come together through the navigation forum, NAVLIST, which focuses on traditional navigation. This is a valuable resource as many of the navigation methods used on the expedition are no longer taught or practiced today. The expedition's logs are housed in the Canterbury Museum in Christchurch, New Zealand. Our results have now been published in the Records of the Canterbury Museum.

In this article, I'll give some of the history behind celestial navigation, explain how it works, and outline the state of the art in 1915, when the expedition found itself trapped aboard its vessel Endurance in the pack ice of the Weddell Sea. The vexing problem of how to find longitude will be the primary focus. I'll describe a simple observation that anyone equipped with a small telescope or binoculars can make to find their longitude by essentially the same methods the Frank Worsley, captain of Endurance, used in the depths of the Antarctic night of 1915.

Celestial Navigation

Celestial navigation is the practice of using celestial bodies—the Sun, Moon, planets or stars—to determine position, generally at sea. With hand-held instruments, accuracies of under a minute of arc (1') can be achieved, which corresponds to a fix in position of better than 1 nautical mile on the Earth's surface. Only altitude and separation between objects can be measured to the required level of accuracy. Quantities such as azimuth and vertex angles must be inferred using formulas derived from spherical trigonometry, which can entail some weighty calculations if carried out manually.

The Marine Sextant

This photograph shows a modern nautical sextant. Its function is measure the angular separation between objects being viewed. The model shown has a Vernier drum with divisions at 0.2' intervals. Typically the sextant is used to measure the altitude of the Sun, Moon, a planet or star above the horizon. It is equipped with hinged shades for observing the Sun. Looking through the sextant's telescope, the navigator adjusts the moveable index mirror so that the body being observed (or limb in the case of the Sun and the Moon) is seen superimposed on the horizon. The altitude is then read off the scale seen on the sextant's arc. The name "sextant" refers to the fact that the arc subtends roughly a sixth of a circle or 60°. The presence of a mirror in the light path then means that it can measure angles up to double that, 120° (a bit more than that in the case of the one shown). Since it is primarily used to measure the altitude of objects above horizon, which cannot be greater than 90°, why would one need a 120° arc? Why not just build an octant (with a scale subtending 45° and thus able to measure 90°)? After all, both Sextans and Octans feature in the cadre of modern constellations. This question will be answered shortly.

Combining a measurement of the altitude of a body with its known celestial coordinates, right ascension (R.A.) and declination (Dec.) at the time the sight was made allows the observer's position to be determined. The simplest sight is the so-called Noon Sight. For that the navigator observes the Sun just prior to culmination at local noon. The Sun will be seen to rise slowly and then hang in the sky briefly, marking local noon, before it begins to descend once more. By recording the maximum altitude and performing some quick and easy calculations the ship's latitude can be determined. If the altitude of the Sun is measured when it is well off the meridian, it is possible to infer its local hour angle. This is called taking a time sight and yields the local apparent time. It is the time that is shown on a sundial but the sextant allows it to be read to an accuracy of a few seconds. If you somehow knew what the local apparent time was at Greenwich then its difference from your local time would immediately give your longitude.

Noon sights are still widely used but time sights have been phased out of modern navigation. They were still standard practice in the early part of the 20th century.

The Problem of Longitude

In the early 18th century the seafaring nations of the world lacked a way to reliably determine longitude at sea. This resulted in some tragic losses and meant ships could not reach their destinations by the most direct routes. Solving the longitude problem would offer huge commercial and strategic advantages.

As noted above, if you have a way of knowing the time at Greenwich you can find your longitude, but for that you need a clock than can maintain uniform time on a moving and rocking ship subject to changes in temperature and humidity. In the 1700's mechanical clocks were not stable or reliable enough to fulfil this role. However, the motion of the Moon against the background stars is sufficiently rapid that it can serve as a clock. Think of the hour angles of right ascension as the markings on a clock face and the Moon as the hand. The R.A. of the Moon at an instant in time can be inferred by measuring its distance from the Sun, planets or stars. To do that requires accurate knowledge of its position. Calculations of the motion of the Moon are complex and in the 18th century lunar ephemerides were not initially up to the task.

So it was that the British Parliament passed the Longitude Act of 1741, under which Commissioners of Longitude were appointed to oversee a competition to develop an accurate method to determine longitude at sea. An award of £20,000 (an enormous sum in the 18th century) would be made for any method that could determine longitude to thirty "Geographical [Nautical] Miles" and lesser amounts for lower precision.

None other than Sir Isaac Newton, then president of the Royal Society, wrote a list of four promising methods and their limitations:

1. A Watch to keep Time exactly.
2. Eclipses of Jupiter's Satellites.
3. The Place of the Moon.
4. Mr. Ditton's project.

The last of these involved anchoring ships at known locations across the globe and having them launch shells at specified times that could be seen by other ships.

If you read the popular book *Longitude* by Dava Sobel (1995) you might come away with the impression the lone genius of John Harrison overcame all unreasonable encumbrances thrown in his path by the Commissioners of Longitude and the Astronomer Royal, Neville Maskelyne, who was promoting his own impractical lunar distance method and had a vested interest in seeing Harrison fail. Eventually Harrison triumphed, the lunar distance method was discredited and the Royal Navy could easily find longitude from then on by carrying Harrison's clock aboard ship. This makes for a good drama but is not really the truth. Moreover it does a huge disservice to Maskelyne. A more balanced account of the great man's contributions can be found in Dunn and Higgitt (2014) and Higgitt (2014).

The longitude prize also spurred advances in the theory of the motion of the Moon. German astronomer Tobias Mayer, encouraged by the mathematician Leonhard Euler, made great strides in this area and the Commissioners acknowledge this by awarding a grant of £3,000, unfortunately only to his widow.

Harrison did produce a viable chronometer, but these mechanical devices were expensive and rather finicky. They needed to be kept in a controlled environment, carefully wound at the same time of day and their errors and rates constantly monitored. Even by the early 20th century they could still be expected to experience a random drift of anywhere between ½ and 2 seconds per day. Tomes were written on their "care and feeding" (Shadwell 1861). It is because of the random drift that they needed to be frequently regulated or rated by comparing them to reliable sources. This might be done taking a time sight from a position of known longitude or taking a lunar distance sight. In a few places, before leaving harbor the navigator could set the hour by watching through a telescope the abrupt drop of a time ball conspicuously mounted atop the local observatory. This practice is recreated symbolically each year on New Year's Eve in Times Square and elsewhere.

The Shackleton Expedition set out with 24 chronometers on board but by its end only one was considered to be in good working order.

Sight Reduction

In reality, the true altitude of the celestial body is not what the sextant shows. To obtain sub-arc minute accuracy the raw reading has to be corrected for a number of factors to obtain the true altitude. Some of these corrections should be fairly obvious but others are more subtle.

- Dip: Due to the height of the observer's eye the horizon dips below the horizontal. For typical observer standing on the shore the dip is around 2 minutes of arc.
- Refraction: All objects have their apparent positions raised due to atmospheric refraction by an amount that depends on their altitude.
- Semi-diameter: If the sight was taken to the lower limb of the Sun, then an allowance needs to be made for its apparent semi-diameter. This varies by a little over 0.5 minutes of arc through the year depending on the Earth's distance from it. For the Moon it is much greater, around 2.4 minutes. Moreover the since Moon gets closer to the observer as it rises in the sky, its apparent diameter also increases. This is called augmentation and also needs to be taken into account.
- Parallax: The Moon is close enough that parallax is very significant. At the horizon, the position of the Moon is displaced by about 1° due to its horizontal parallax. At certain times and altitudes, parallax corrections for Mars and Venus need to be taken into account to reach the required level of accuracy.
- Annual Aberration: This is the variation of the apparent direction of a celestial object to the motion of the Earth in its orbit. This means that the right ascension and declination of stars are different at different times of year. If you have ever done precise polar alignment using a polar axis scope you may know that, in addition to precession, the offset of Polaris from the pole has a seasonal component that varies over a range of about 0.7 minutes of arc due to the aberration of light.

That the parallax of planets needs to be accounted for when reducing observations made with a hand held device is quite an eye-opener.

Fortunately for the navigator all these effects have been packaged up into a form that makes celestial navigation tractable. The positions of the Sun, Moon, planets and stars are listed in the indispensable *Nautical Almanac* (NA).

The Nautical Almanac

Thumbing (virtually) through copies of the *American Nautical Almanac 1915* and the *British Nautical Almanac 1915* can provide some interesting insights into the history and development of navigation and astronomy. The British published the *Nautical Almanac* and *Astronomical Ephemeris* in a single volume, showing that the two fields were very much intertwined. It contains the usual tables of the positions of the Sun, Moon and planets, eclipses, configurations Jupiter's moons, etc., but there is a large volume of material that is included to allow the reader to accurately determine Greenwich Mean Time and hence longitude. There is a table of occultations of stars down to about 7th magnitude and tables of Moon Culminating Stars. The explanation section still describes how to observe and calculate lunar distances, although the tables to streamline this process had been dropped in 1906.

The names of stars used are also noteworthy. Many are familiar but others such as α Argûs that appears in both the British and American NA's may not be. This is Canopus, the second brightest star in the sky. It was originally part of the constellation Argo Navis which represented the ship of Jason and the Argonauts. The IAU officially broke this large constellation apart into Carina, Puppis and Vela in 1930 but NA's continued to use α Argûs rather than α Carinæ until 1939. When the split was made, Bayer's Greek letter designations for the stars were not reassigned. Hence there is an α and β in Carina but none in Puppis or Vela. For fainter stars not denoted by Greek letters, the almanacs appear to have been early adopters. One finds for example q Velorum in both already in 1915. The British NA refers to stars in the constellation of Malus, the mast, whereas in the American NA list the same stars as being in the constellation of Pyxis, the ship's compass. Recognizing that a magnetic compass on the ship of the Argonauts is a serious anachronism, John Hershel proposed its replacement in 1844 but it has not survived to the present day.

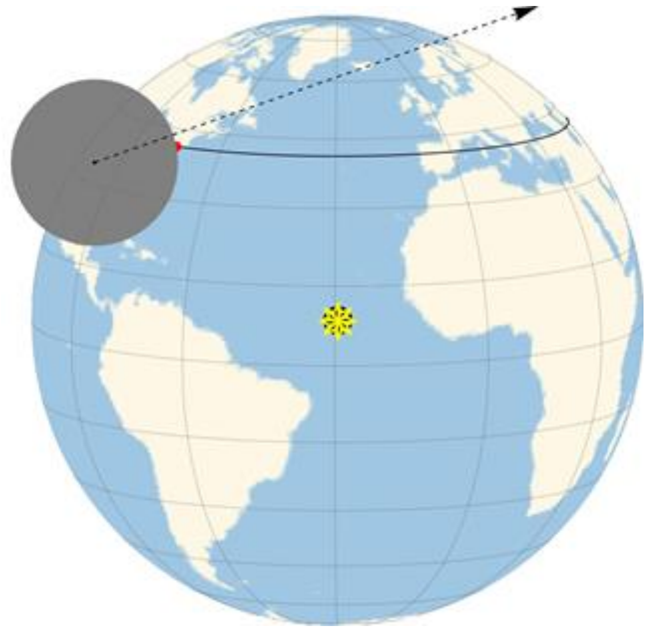
The Imperial Trans-Antarctic Expedition

By June 1915 the expedition had been trapped for six months in the ice pack of the Weddell Sea, out of sight of land. Their chronometers had last been rated in October, 1914 during a stop in Buenos Aires and by this time their longitude was wildly uncertain. Captain Frank Worsley and physicist Reginald James carried out a series of lunar occultation timings to determine GMT and hence their longitude. These observations were far from routine, especially aboard ship, but the ice provided a stable platform from which to observe. From purely practical considerations it is easiest to time the disappearance or immersion of a star on the dark limb of the Moon, which means it should be waxing. In reality, timing an occultation of a star is an accurate version of the lunar distance method. The disappearance or reappearance of the star occurs when the lunar distance is precisely one lunar semi-diameter.

Observing a Lunar Occultation

I had never personally found longitude by timing a lunar occultation but decided to remedy that situation. Although there are programs out there that can do the job, I chose to start from scratch and found a very nice program called Skyfield. It is written in Python, which is freely available and is fairly straightforward to install. Skyfield can not only compute high precision positions for the Moon based on JPL Ephemerides but can also link the entire Hipparcos star catalog. This makes it relatively straightforward search for possible occultations and compute their Besselian Elements. These are computed by making an orthographic projection of the Moon's position onto the so-called fundamental plane. This effectively produces the view that an observer located on the star would have with a really, really big telescope. These elements are also used for computing local circumstances of eclipses as can be found in Meeus (1989) or at Fred Espenak's NASA Eclipse page[1] but for occultations things are quite a bit simpler. As the star is effectively a point source there is no partial phase in an occultation.

As my code was beginning to spit out believable numbers I noticed that there seemed to be a favorable upcoming event. Around 5:37 pm EST on 18 December 2018 the 12 day old Moon would occult 4.3 magnitude ξ^2 Ceti nearly 40° above the horizon…and it was going to be clear! The figure below shows the view of the disappearance as seen by an observer on the star with the gray disk representing the Moon. My parallel of latitude is the black line and my location can be seen as the red dot peeking out at the limb of the Moon. The symbol at the center of the image marks the geographic position of the star or the point on the Earth where it is directly overhead.



An hour before the predicted event I set my Televue Pronto up on the front lawn and could see the star standing well to the east. When I returned at 5:30 it was much closer and at 5:37:13, quite unceremoniously, it wasn't there anymore. When the calculations were done, my longitude came out to under 1/5 of a mile of the correct value, which is very good indeed. To do better I'd have to read the time to within less than a second which I can't do without specialized equipment.[2] To be realistic this very accurate result is likely something of a fluke. There are some effects that I have not and do not intend to take into account in my calculations. The geometric center of the Moon is known to be offset by about 0.6 arc seconds from its center of mass and I used linear Besselian elements which approximates path of the Moon across the fundamental plane as a straight line. Also the result you get depends somewhat on the value adopted for *k*, the ratio of Moon's radius to that of the Earth. I use the

[1] https://eclipse.gsfc.nasa.gov/eclipse.html

[2] Sophisticated occultation timers like WAA's Rick Bria use specialized radio receivers to provide the exact timing of frames from astro-cameras.

value *k* = 0.2726 as recommended by the 1915 Nautical Almanac.

The calculation has been bundled into a user-friendly Excel application and I will make it available to anyone interested in giving this a try (robinstuart@earthlink.net). The table below shows some of the predicted occultations from the Meadow Parking Area in Ward Pound Ridge Reservation. The table below lists observable events for February and March 2019.

Epilogue

In the end, the problem of finding longitude was solved by a means that was not on Newton's 1714 list and indeed that he could probably not have imagined. By about 1925 radio time signals allowed ships equipped with a suitable receiver to rate its chronometers anywhere in the world.

And why do modern sextants have an arc can measure up 120° when reality is limited to altitudes 90°? It's a legacy of the lunar distance method. Some of early trials of the lunar distance method and Tobias Mayer's tables were made using a full "repeating circle" but it was found to be cumbersome and reduced to a range of up to 120°. The first true sextant was built by London instrument maker John Bird in the 1750's and was specifically designed with lunars in mind.

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Lunar Occultations for Ward Pound Ridge Reservation, February and March 2019

				Immersion			Emersion		
HIP	Bayer/Flamsteed	Magnitude	Moon Age	Date	UT	Altitude	Date	UT	Altitude
12828	μ Ceti	4.27	7.16	02/12/2019	01:40:20.8	35.0	02/12/2019	02:23:44.3	27.1
47189	8 Leonis	5.73	14.18	02/18/2019	23:59:39.8	26.0	02/19/2019	00:04:46.1	26.9
52911	l Leonis	5.32	15.37	02/20/2019	06:00:43.4	59.0	02/20/2019	06:36:38.1	57.2
34608		6.43	9.43	03/16/2019	02:30:09.5	58.0	03/16/2019	03:41:34.6	45.5
46232		6.31	11.63	03/18/2019	08:05:40.7	16.9			
50333	37 Leonis	5.42	12.49	03/19/2019	03:25:50.1	62.4	03/19/2019	03:49:58.4	61.9
77853	θ Libræ	4.13	18.59				03/25/2019	05:38:26.6	18.4

Images by WAA Members

Supernova in M77 by Rick Bria

47 million years ago, in a galaxy far far away... a giant star exploded. The light from that supernova explosion reached Earth this year.

Supernovas are extremely bright, sometimes outshining an entire galaxy. This one occurred in the galaxy Messier 77 (NGC 1068), so it is very faint as seen from Earth.

Using a video camera meant for timing asteroids, Rick decided to try to take a picture of this new supernova. He combined 30 seconds of video to create the attached picture of galaxy M77. The Supernova is marked with right angle lines to make it easy to find.

Rick writes: “Though crude, the resulting success surprised me. At the time I acquired the data, the supernova was only at magnitude 15. I took it with a video camera not designed for this type of object. It was really a ‘what if?’ test of the new 14” telescope at Sacred Heart. Imagine what can be done with our new, as yet untested, dedicated astronomical camera.

M77 was the first galaxy found to have broad emission lines characteristic of an active galactic nucleus.

Research Highlight of the Month

The Atacama Large Millimeter/Submillimeter Array is a 66-dish radio interferometer sensitive to infrared and microwave radiation. It's located on a plateau in Chile at over 16,000 feet of elevation (see the November 2017 SkyWAAtch). The Disk Substructures at High Angular Resolution Project (DSHARP) project used the antennas at their maximum spread for 65 hours of observing time to capture images of dust around stars as young as 300,000 years. The data suggest that planets may form sooner after star formation than previously thought. The studies were reported in a series of 10 papers that will be published in the *Astrophysical Journal Letters*. More information is at https://www.almaobservatory.org/en/home/.

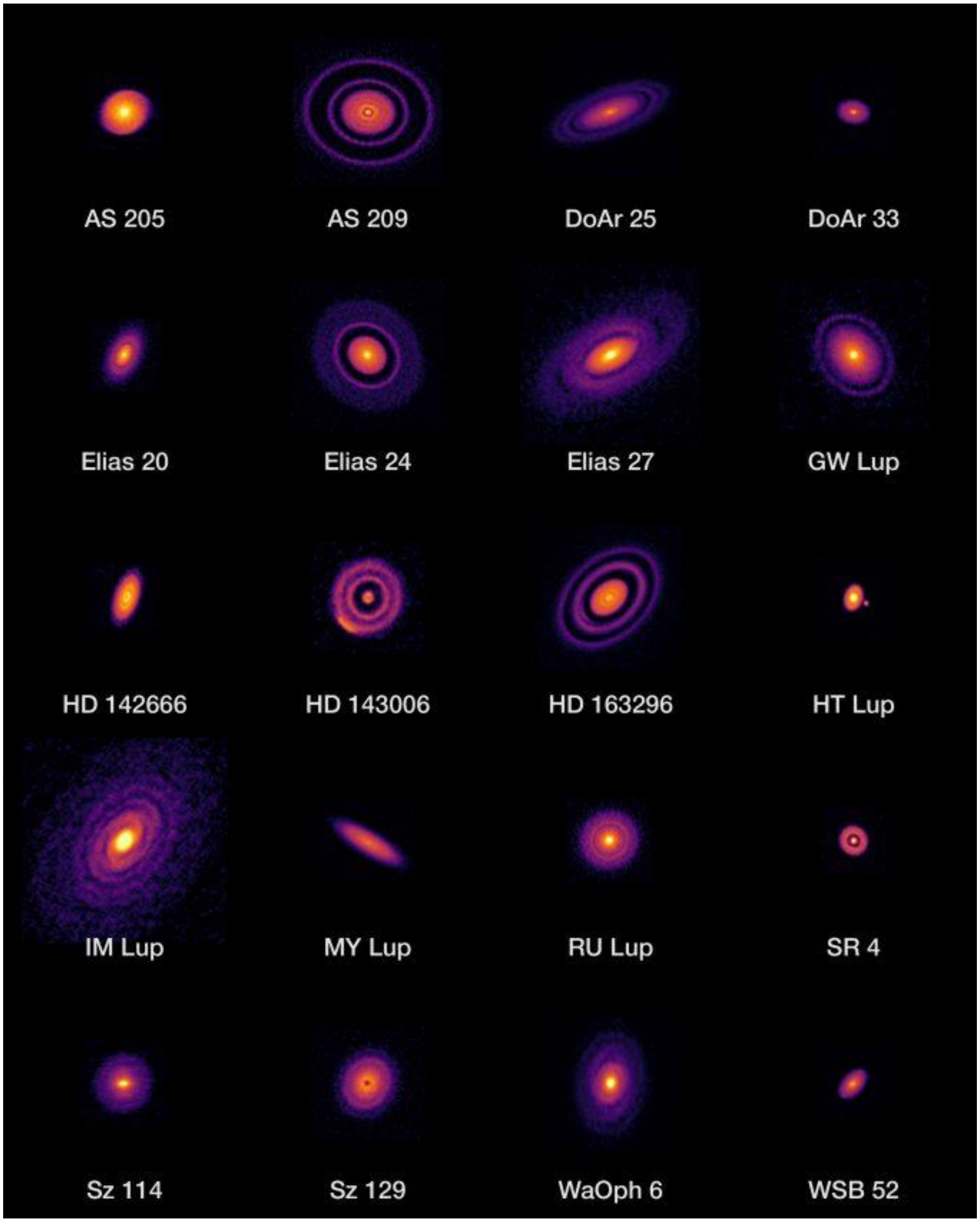

Image: ALMA (ESO/NAOJ/NRAO), S. Andrews et al.; N. Lira

Member & Club Equipment for Sale

Item	Description	Asking price	Name/Email
Celestron 8" SCT on Advanced VX mount	Purchased in 2016. Equatorial mount, portable power supply, polar scope, AC adaptor, manual, new condition.	$1450	Santian Vataj spvataj@hotmail.com
Celestron CPC800 8" SCT (alt-az mount)	Like new condition, perfect optics. Starizona Hyperstar-ready secondary (allows interchangeable conversion to 8" f/2 astrograph if you get a Hyperstar and wedge). Additional accessories: see August newsletter for details. Donated to WAA.	$1100	WAA ads@westchesterastronomers.org
Meade Research Grade 12½" f/6 Newtonian telescope.	Ex Bowman Observatory, Greenwich. New in 1985, normal wear but it is complete and everything works. 8" Beyers drive, 80mm f/15 guide scope. 50mm finder. Moonlite focuser. Drive control. Updated mirror mount. Mirrors refinished 2013 Metal pier.	Free!	Rick Bria rickbria22@gmail.com
Celestron StarSense autoalign	New condition. Accurate auto-alignment. Works with all recent Celestron telescopes (fork mount or GEM). See info on Celestron web site. Complete with hand control, cable, 2 mounts, original packaging, documentation. List $359. Donated to WAA.	$225	WAA ads@westchesterastronomers.org
Meade 395 90 mm achromatic refractor	Long-tube refractor, f/11 (focal length 1000 mm). Straight-through finder. Rings but no dovetail. 1.25" rack-and-pinion focuser. No eyepiece. Excellent condition. A "planet killer." Donated to WAA.	$100	WAA ads@westchesterastronomers.org
Televue Plossl 55mm 2-inch	Very lightly used. Excellent condition. Original box.	$175	Eugene Lewis genelew1@gmail.com
Orion 150 Mak-Cass	Excellent condition. Will include heated dew-shield.	$300	Tom Boustead bousteadtom@gmail.com
Celestron 114mm f/8 reflector	Equivalent to Powerseeker 114, this older model has a beefier EQ2 GEM mount and a strong wooden tripod, unlike current aluminum tripods. Slow motions on both axes. Setting circles. No motor drive, not go-to. One 10mm wide-field eyepiece. Finder. Optics in good shape. Very good condition. Donated to WAA.	$50	WAA ads@westchesterastronomers.org

Want to list something for sale in the next issue of the WAA newsletter? Send the description and asking price to ads@westchesterastronomers.org. Member submissions only. Please only submit serous and useful astronomy equipment. WAA reserves the right not to list items we think are not of value to members.

Buying and selling items is at your own risk. WAA is not responsible for the satisfaction of the buyer or seller. Commercial listings are not accepted. Items must be the property of the member or WAA. WAA takes no responsibility for the condition or value of the item or accuracy of any description. We expect, but cannot guarantee, that descriptions are accurate. Items are subject to prior sale. WAA is not a party to any sale unless the equipment belongs to WAA (and will be so identified). Sales of WAA equipment are final. *Caveat emptor*!