SkyWAAtch

The Newsletter of Westchester Amateur Astronomers

December 2019

M8-The Lagoon Nebula by Gary Miller

A familiar object at summer star parties, M8 in Sagittarius was first glimpsed by John Flamsteed in 1680 and called "The Lagoon Nebula" by the Irish astronomer Agnes Clerke in *The System of the Stars* (1890). It is an emission nebula which re-radiates the energy of several hot young stars embedded within it, including 9 Sagittari (dead center). It also surrounds the open cluster NGC 6530, a system of 113 young stars. Although it's low in the summer sky from Westchester, it's a wonderful visual object in nearly any telescope.

WAA December Meeting

Friday, December 6th at 7:30 pm

Lienhard Hall, 3rd floor
Pace University, Pleasantville, NY

The History of Glass: The Power Behind Discovery

Alan Witzgall
Senior Optician, ESCO Optics

Alan is an active member and officer of several amateur astronomy societies in New Jersey. In his professional life, he is a Senior Optician for ESCO Optics of Oak Ridge, NJ. His career in optics started with building telescopes in his basement during his high school and college years. In 1977, one of them, a 10-inch reflector, took first award at Stellafane, the birthplace of the amateur telescope-making hobby in America.

Mr. Witzgall has been "pushing glass" for a living for over 40 years, and will speak on how his favorite material has built the modern world and opened up all sciences and technologies.

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

This is the official 2019 Annual Meeting of WAA with election of officers for 2020.

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

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

New Members

No new members this month. Tell your friends to join WAA!

Renewing Members

Edgar S Edelmann	Tarrytown
Al Forman	Croton-on-Hudson
Kevin Mathisson	Millwood
William Meurer	Greenwich
Scott Nammacher	White Plains
Kevin Shea	Carmel
Oliver E. Wayne & Elizabeth Scott	Cliffside Park

WAA January Meeting

Friday, January 10th at 7:30 pm

Lienhard Hall, 3rd floor
Pace University, Pleasantville, NY

Why Go Back to the Moon?

Andy Poniros
NASA Solar System Ambassador

Andy has been a NASA volunteer since 1997 and a NASA/JPL Solar System Ambassador since 2004 . He has a degree in Electrical Engineering and has worked as a Medical Imaging Engineer for 45 years. He is certified by NASA to handle Lunar samples, is a science correspondent for radio station WPKN in Connecticut where he produces astronomy and space mission radio shows and podcasts. He's also an amateur astronomer and telescope maker.

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

The next star party will take place in March. We will ring in the equinox with a star party on March 21st, with a rain/cloud date of March 28th.

Westchester
Amateur Astronomers

Also In This Issue

ALMANAC for December 2019

Bob Kelly, WAA VP for Field Events


1Q
Dec 4


Full
Dec 12


3Q
Dec 18


New
Dec 26

Jupiter appears to be pushed into the solar glare by mid-month, upstaged by Venus. Saturn is next to be voted off the evening view. Look for them low in the southwest early in the month. Jupiter and Saturn don't quite meet up this year, but their reappearance in the morning sky early in 2020 starts an inexorable drive to a spectacular conjunction low in the southwest on December 21st, 2020 when they will be just 6 minutes of arc apart. Mars makes its own presence known in the evening sky next summer when it brightens into negative magnitude territory.

Venus arcs higher into the evening sky. The magnitude -4.0 goddess planet gets ten degrees above the horizon at the end of bright ("civil") twilight after mid-month. Venus slips under Saturn on the 11th. Sources say she claims to have nothing to do with the disappearance of Saturn and Jupiter. The Moon arrives on the 27th to investigate. Venus tries to point to Saturn, but by then Jupiter and Saturn will be well down in the Sun-glow and hard to see. The Moon pairs nicely with Venus on the 28th, perhaps wondering, "Where did everyone go?" Pluto is visited by Venus on the 12th but it's too faint to observe in the increasing solar glare, no matter how powerful your telescope. Venus moves to number one on the list of planets closest to Earth later in the month, supplanting Mercury, the planet most often closest to Earth and in fact the planet that on the average is closest to every other planet in the solar system. Confused? Click this link.

Mercury is well worth looking for in the morning during the first half of December. It floats a good ten degrees high above the horizon in the southeastern sky about 6:30 am Standard Time, at half the height of Mars above the horizon. Mercury has the advantage in brightness, at magnitude -1.6 vs. Mars at +1.7. In a telescope, Mercury appears a bit less round and twice as large as Mars. By the time the Moon passes Mars on the 23rd, Mercury is very low and hard to find. The Moon sinks to Mercury's level on Christmas morning.

There is an annular Solar Eclipse on the other side of the world on the 26th. I'm looking forward to the April 2024 total eclipse in western New York State.

The Solar and Heliospheric Observatory (SOHO) spacecraft catches two planets transiting its C3 camera's view this month. Jupiter edges into the view of C3 starting on the 17th. Mercury drops in from the opposite side starting on the 28th.

Uranus and Neptune are still hanging in the evening sky. Uranus appears about as large as Mercury and Mars, so it's worth a glance in a telescope.

The reliable Geminid meteor shower peaks during the USA's daytime on the 14th. The almost-full Moon sits next to Gemini during the nights of the 14th and 15th, drowning out the fainter fragments of asteroid 3200 Phaethon. A patient observer facing away from the Moon may see a bunch of the brighter meteors. The Geminids are among the slower meteors of the major showers, giving a better chance of finding them in the glare.

The Ursid shower peaks on the night of the 23rd/24th. There aren't too many of them, but they tend to be bright and slow. The thin morning Moon will be picturesque and not bright enough to interfere with the shower.

On the night of the 12th/13th, the almost-full Moon runs over two third-magnitude stars in Gemini. Propus (*Eta Geminorum*) is covered about 11:35 pm on the 12th and uncovered at 1:25 am EST on the 13th. Another third-magnitude star, Tejat (*Mu Geminorum*), is covered at 4:58 am and uncovered at 5:56 am. We'll need binoculars or telescopes to see these events. The uncoverings on the dark limb of the Moon will be easier to see.

Don't forget to wave to the International Space Station from time to time. The crew is performing a series of four spacewalks to repair the Alpha Magnetic Spectrometer, designed to detect cosmic rays and help us learn about dark matter in our universe. It's so important to physicists it had its own Space Shuttle flight added as the program was winding down. Now, the AMS is being repaired even though it was not designed to be fixed while in space. Good times to see the ISS are in the evening until the 14th, and the morning after the 19th.

The solstice occurs on the 21st at 11:19 pm EST (04:19 on the 22nd in Coordinated Universal Time). Of course, it's the winter solstice from our point of view. I hear Aussies go to the beach to surf at Christmastime. Californians do, too, but it's much colder. The earliest sunset is on the 8th, the shortest daylight day on the 21st and the latest sunrise is in early January. Nearer to the equator, the earliest sunset is in late November. The dates of earliest sunset are closer to the solstice at more northerly latitudes. ■

Astronomy 101: Constellation or Asterism? Scott Levine

Astronomy 101 is a new newsletter feature that we'll run from time to time. We'll talk about astronomy ideas and concepts aimed at beginners, but we also hope more advanced observers will learn something, too.

Let's step into Mr. Peabody's "way-back" machine. What were the first things your grade school teachers taught you about astronomy, after the names of the planets and that the Moon goes through phases? Pretty early on, you probably learned that the groups of stars we see each night are called constellations.

That's on the right track, but not entirely true.

People have seen patterns among of the stars for as long as there have been people to see them. If you've ever had the chance to be under a deep and disorientingly dark sky, it's not hard to imagine what our ancestors saw and spent their nights talking about. Cultures across the world had their own stories for what they saw. The characters and their meanings were different from one people to another.

In the Western tradition, the Greek poet Aratus and the astronomer Ptolemy described 48 constellations more-or-less for the first time in the second century A.D. These patterns (visible from the Mediterranean) sometimes changed and were added to as the world was explored. In 1922, the International Astronomical Union (IAU) standardized the list to 88 official regions that cover the entire sky, each with defined borders, just like countries cover Africa or states cover Australia.

This means, for example, when you talk about Gemini, Cygnus, or Ursa Major, you're referring to an entire section of the sky, and the stars you see almost seem like the constellations' big cities, shining in the distance. This definition wraps the constellations around its stars and is particularly useful for identifying far-off galaxies and finding our way back to them.

Asterisms, on the other hand, are informal but recognizable star patterns that can be part of one or more than one constellation. The stars you think of when you think of Orion are that constellation's asterism – the recognizable pattern of stars that portrays the great hunter from his shoulder to his knees. But there are many more stars within the constellation's boundaries that you might never have noticed before. Meissa, maybe?

The Summer Triangle, meanwhile, is an asterism of three stars; one in each of three constellations: Vega (in Lyra); Altair (Aquila); and Deneb (Cygnus). The Big Dipper is a famous asterism within the constellation Ursa Major. You can even make up your own. The Fall Coffee Mug? Check. The Great Office Chair of Corvus? Right on. The Perfectly Straight Line of Four Dim Stars Near Cygnus? If you say so.

Orion is actually a great group of stars to illustrate all of this. In the middle of December, the hunter rises into the southeast by mid-evening. You can easily find its main asterism, with Betelgeuse at the right shoulder and Rigel at the left knee, without much trouble. That group is within a much bigger asterism, the Winter Hexagon. It's an asterism of six first-magnitude stars in six different constellations: Capella (Auriga), Pollux (Gemini), Procyon (Canis Minor), Sirius (Canis Major), Rigel (Orion), and Aldebaran (Taurus).

Lots of people think of the three stars in Orion's belt (Alnitak, Alnilam, and Mintaka) as another asterism. I do. His sword is one, too, and if you look closely at its middle star, you'll see it's not a star at all, but the Orion Nebula. Glowing within all that dust is the Trapezium cluster. In even a small pair of binoculars, you can see it as an asterism of three or four stars.

There you have it: a cascade of asterisms. A small asterism (Trapezium) within a bigger one (Orion's sword) within Orion's main asterism, and all of it is tied within the enormous Winter Hexagon. Wow.

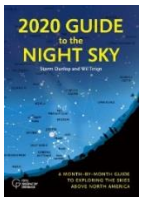
In our modern astronomical system, constellations are the regions of the sky, but no longer just the star patterns within them. Asterisms are the patterns themselves. I hope you'll head out and make up some of your own tonight. ■

You can read more of Scott's take on astronomy at scottastronomy.wordpress.com and email him at astroscott@yahoo.com.

Annual Review of Annual Astronomy Reviews — Bob Kelly

The sources I use the most, day to day, are the Canadian Almanac, Guy Ottewell's list of events, the monthly issues of Sky & Telescope and The Mobile Astronomy planetarium app on my android device.

Observer's Handbook 2020 – Royal Astronomical Society of Canada. Make sure you request the USA Edition with United States' language and location information. Lots of facts and data in a one-pound book. Each month has a two-page list of events and summary of planetary locations and visibility. Well-written sections on astronomical events and observing them. One bug: the Moon-phase diagrams on the month-by-month pages are all wrong. A cut-and-place replacement is available on their web site. So far, the book is not available at Amazon.com or Barnes & Noble. Try directly at the RASC shop at $40 including shipping or try My Science Shop.com . Takes two weeks to arrive.



2020 Guide to the Night Sky by Storm Dunlop and Wil Tirion. Get the North American edition. Light and wonderfully handy. I haven't seen this year's copy. Last year, the information on the location of January's total lunar eclipse was wrong and there was no entry for the transit of Mercury in November 2019. I had no problems with the 2018 edition. The layout is a fantastic use of small space. Includes sky charts, descriptions of objects and how to find them, and diagrams of significant sights for each month.

SkyWatch 2020 from Sky and Telescope - not available for 2020. S&T says they will skip this year as they take some time to work with their new owner, the American Astronomical Society.

Skygazer's Almanac 2020 from Sky and Telescope. A graphical almanac on one sheet of paper, this two-page graph of rise and set times is a great way to see how our universe moves on a giant timeline of the night sky. It's worth getting January's issue of S&T just to get the chart.

Astronomy Magazine - January 2020 issue. In 2019, they had a sixteen-page guide to events in the upcoming year. Their sales department was unsure about 2020 but said the January issue would be on newsstands around December 6th. The guide has a summary for each month and a focus on a particular event for that month. Worth a visit to your local Barnes & Noble periodical rack to see if you like it, especially since the Sky and Telescope version is not available for 2020.

Astronomical Almanac for the Year 2020 and **Astronomical Phenomena for the Year 2020** from the US Department of the Navy and UK Nautical Almanac Office. The latter was a free download from the U.S. Naval Observatory site, but that site is down until April 2020. Too bad, since Astronomical Phenomena has most of what we will use, as it is a slimmer version with selected information from the Astronomical Almanac. The Almanac contains detailed, precise ephemerides of the Sun, Moon, planets, and satellites, data for eclipses and other astronomical phenomena for a given year. It's $49 if you really need it. The U.S. Government Printing Office sells Astronomical Phenomena for $14, but it is out of stock right now. This year, just download a list of conjunctions and other events from **Guy Ottewell's site** at https://www.universalworkshop.com/astronomical-calendar-any-year/

The Evening Sky Map at www.skymaps.com is published online each month, free to download and use or copy for friends and co-workers. It's my go-to public handout sheet for star parties.

The Abrams Planetarium Sky Calendar $12 for 12 months, starting anytime. Charts of bright-object sky events in calendar format for each month.

The Astronomical Almanac (2020 – 2024) by Richard J. Bartlett $20. Divided into sets of 10 days, with daily information about lunar and planetary location, brightness, phase, size and visibility. List of significant events. Illustrations show the apparent size of the planets each 10 days. Glossary not only explains all the entries, it often has helpful descriptions of how to use the data. At almost three pounds, not super-portable, but have this on your bookshelf if you like to plan way ahead. Bartlett also publishes **2020: An Astronomical Year (North American Edition): A Reference Guide to 365 Nights of Astronomy** for $15, but I haven't seen that yet.

What's out Tonight? by Ken Graun ($30) has events through 2050. Charts give an indication of the position of the planets for each month on an annual chart, four to a page. It includes sunrise and set times, Moon phases, elongations and selected conjunctions and lots of basics about viewing the sky. Ken also has a downloadable monthly sky chart that looks pretty good, free at whatsouttonight.com. ■

Member Profile: Woody Umanoff

Home town: Mount Kisco

Family: Married, 3 children (ages 35, 32, 18)

How did you get interested in astronomy? When I was a teenager I had an uncle who built his own 6-inch reflector and would take us out to a meadow on Long Island to observe. Those sessions instilled a fascination with astronomy that lingered for years. I only got involved more seriously as an adult, about 9 years ago, when I had more time to spend on the hobby.

Do you recall the first time you looked through a telescope? It was with my uncle's telescope looking at the Moon. What did you see? Of course, I was awestruck looking at the surface details.

What's your favorite object(s) to view? Galaxies and nebulae. It's still mind boggling to make the connection between a dim, distant, diffuse smudge of light and the number of stars, planets, and, of course, the possibility for life that it represents.

What kind of equipment do you have? I have an Orion XX12 Dob, a push-to system with setting circles and Wixey digital readouts, various eyepieces (mostly Explore Scientific), Steiner 7 x 50 binoculars and other accessories.

What kind of equipment would you like to get that you don't have? An observing chair.

Have you taken any trips or vacations dedicated to astronomy?. I would love to visit the Atacama Desert in Chile, New Mexico and Maine or Stellafane for observing.

Are there areas of current astronomical research that particularly interest you? I'm fascinated with cosmology and some of its major questions: what is dark matter? What's the basis for the discrepancy between measurements of the Hubble Constant using Cepheid variable stars versus the cosmic microwave background?

Do you have any favorite personal astronomical experiences you'd like to relate? I'm a visual observer (no astrophotography) and enjoy hunting for targets. After a number of unsuccessful attempts to find galaxies from my light polluted backyard, I was thrilled to find several under the belly of Leo (including the Leo Triplet) one winter evening several years ago. That's when I felt like I was beginning to get some basic competency in my observing skills.

What do you do in "real life"? I am a biochemist/molecular biologist by training. I am working as a scientific analyst at a New York City law firm. I keep abreast of current biochemical and biological scientific research and present and explain that information as required by, and relevant to, ongoing projects.

Have you read any books about astronomy that you'd like to recommend? An older but very practical book is *How to Use an Astronomical Telescope* by the British astronomer James Muirden. Of course, *Turn Left at Orion* is a great observing guide. A number of good books on cosmology: *The Trouble with Physics* by Lee Smolin, *The Accidental Universe* by Alan Lightman and *A Universe from Nothing* by Lawrence Krauss.

How did you get involved in WAA? I started going to some of the star parties. I was already learning my way around the sky with binoculars and planisphere and thinking about purchasing a telescope.

What WAA activities do you participate in? I try to get to star parties, outreach events and lectures as often as I can. It's been hard over the past few years due to time constraints and family commitments. But now that our last child is off to college, I'm hoping to have more time for these activities.

If you have a position in WAA, what is it, what are your responsibilities and what do you want the club to accomplish? I've staffed the club booth at NEAF for several years.

Provide any other information you think would be interesting to your fellow club members, and don't be bashful! I think the WAA is a great and talented group of fellows/amateur astronomers. I am thankful for all that the officers do and their commitment to furthering amateur astronomy. I really appreciate my interactions with the members and am grateful for all that the WAA has to offer amateur astronomers here in Westchester. ■

Transit of Mercury Outreach at Rye Playland — Larry Faltz

7:05 am: L-R: Fulco, Webber, Alimena, Kelly (photo by LF)

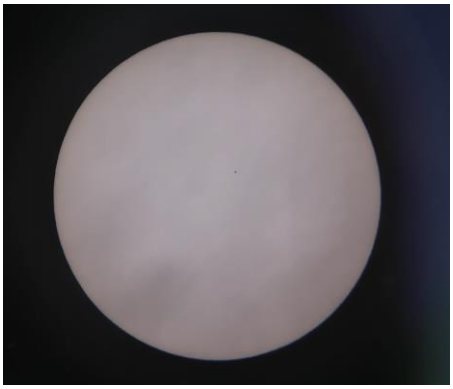
A bunch of hardy WAAers assembled on the boardwalk at Playland early on the morning of November 11th to view the transit of Mercury, which ran from 7:31 am to 1:04 pm. The event was organized by Charles Fulco, a former Port Chester science teacher and good friend of WAA who is involved with astronomy outreach all over the country. Although it was temptingly clear pre-transit, clouds increased during the first hour, making the view of the tiny Mercurian silhouette somewhat difficult. The sky improved for the rest of the transit, with very thin haze for the mid-portion of the event giving way to thicker haze for the last hour and a half, although the planet was easily visible until it finally left the edge of the Sun, not to blemish its face again until 2032.

In the off-season, the beach at Rye Playland is a popular dog run. There were plenty of frisky canines and their owners, and quite a few kids, passing by throughout the transit. Most of them, except for the dogs, took a look through one or more of the (properly filtered) scopes. Josh Knight and Charles Fulco both had 8" Celestron SCTs; Jordan Webber had an Orion 70-mm refractor, Bob Kelly set up a 60-mm refractor but quickly switched to an 8" Orion Dobsonian, Alex Mold had a 127-mm Orion Maksutov, and WAA President Paul Alimena tried to record the transit with a small video camera and telephoto lens. I had an 80-mm Stellarvue refractor (observing at 26x to get a full-disk view) and a 60-mm Lunt hydrogen alpha scope also at 26x. The H-alpha view wasn't as impressive as I had hoped. The solar surface was boring, without a single sunspot or filament and there were just two tiny, faint prominences. The hazy sky made surface granulations hard to see, so I put the scope away about 10:30 and concentrated on white light viewing. Rick Bria, a bit inland at the Mary Aloysia Hardey Observatory at Sacred Heart University in Greenwich had better skies and viewed with an 80-mm double-stacked Lunt. His fine image is on page 16.

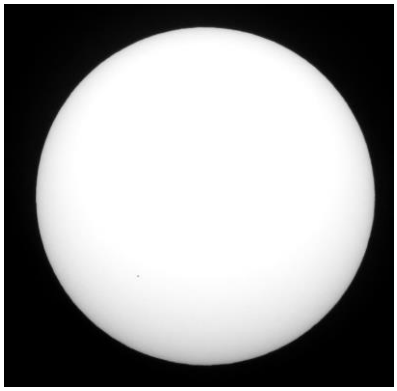
The astronomers enjoyed themselves and we all had wonderful interactions with the public, who were eager to look and learn. Towards the end of the event, a cameraman from WABC-TV came by and interviewed a bunch of us. Apparently Paul and I were briefly on the news that evening. I didn't see it. Thankfully no one called to say I sounded like an idiot.

Photos of the transit were pretty bland. Without any sunspots to accompany the planet, it's just a big disk with a tiny dot somewhere on it. It's the astronomical equivalent of one of those super-minimalist Barnett Newman abstract paintings from the 1950's, large white canvases with one thin black line, not at all like the Italian futurist Giacomo Balla's wild 1914 painting *The Transit of Mercury* (see the July 2014 SkyWAAtch, page 6). I sent one of my photos to another WAA'er, who wrote back "I first thought I that was seeing a floater." But here are three images anyway. You'll have to enlarge the page to pick out the tiny planet on the two full-disk photos. The Sun-Mercury ratio 196:1.

Alex Mold, phone camera



Bob Kelly, phone camera



Larry Faltz, DSLR at prime focus

WAA VP for Field Events Bob Kelly wrote

I was saluted as a great "astrologer" several times today. It seemed like some people use the terms interchangeably. It's frustrating, something we are always having to correct.

I was just overjoyed (jumping up and down overjoyed, I must have looked like a nut) to have a clear view of the transit, after my failure to see through the thin clouds at the last transit of Mercury.

The rolls of thick clouds that formed after 8 am dissipated, despite an ominous forecast, leaving thin high clouds that slowly thickened, but never to the point of total obscuration, as the morning went on. My Dob was great, with my strongest two-inch-wide eyepiece making 40x. I thought we'd need 70x or more to pick out Mercury, but it wasn't necessary.

Mercury was a tiny but intensely black dot. With one hour to go, between the thickening high clouds, Mercury approaching the solar limb and a fogging eyepiece (only one kid tried to use it as a touchscreen) Mercury got harder to pick out. Focus was critical and varied from person to person. I think the two inch eyepiece gave people the chance to get their eye in a good spot to see the whole picture. The "aaah" when they found Mercury was proof we were all seeing the same planet.

This was one of the days of greatest joy I've had as a public astronomer, although when we got to 12 noon my body started to tell me I had not really eaten much in my excitement, and I realized we were running a marathon. How many times have we done an event that ran over five hours, and at full tilt? And here we were in the fifth hour! I was relieved when 1:04 pm came, but I lingered to savor the win.

There are always some things I could have done, such as stopping for a bit and doing prime focus photography. But the iPhone photo actually looked better than it really was. Mercury was darker. I have a tiny bit of dismay I didn't contribute to the press coverage. I just don't multitask well and I felt I needed to stay focused on our visitors. And, hey, I like being the center of that attention! I appreciate the help from Paul, who stepped in when I got tongue-tied! It was great to have the team of people with various scopes. I should have looked through the others a bit more. If we had a clear day (I knew we wouldn't), I would have tried for Venus. [I tried with my go-to iOptron mount, but the haze was thick enough to obscure the planet, and nothing was seen.—LF]

All in all a great day for observational astronomy and for WAA.

Not every WAA'er observed at Playland, of course. Eric Baumgartner thought about observing at Ward Pound, but scoping out the site on Saturday and measuring the angles, he found that first contact would be just below the tree-line to the southeast. So he observed from New Pond Farm Education Center, about three miles from his house in Connecticut. The facility has an "Astronomy Hill" with a roll-off observatory, and the site had a full view of the Sun throughout the transit. Eric reported "I saw the entire transit. Mostly clear, save for the last hour, when it was through high clouds. New Pond Farm advertised the event, and I would say that we had about 40 people over the first three hours." He used an Astro-Physics Stowaway refractor on a DiscMount DM-6 and a Baader Planetarium Herschel wedge.

Eric Baumgartner showing the transit

SkyWAAtch Assistant Editor Scott Levine wrote:

I was hoping to race down to Playland and then come to work late. Then my kids told me they wanted to see it but there'd be no way for me to get them back home. I got out my big binoculars and hoped to show it to them by projection, but they wound up sleeping in. So it goes.

But... I went to a foot bridge that crosses 9/9A in Croton and looked a bit there. I was able to project an image, though not a very good one, on the wall. I convinced myself I saw a black dot just inside the disc right around 8:00. Two early joggers saw me, stopped, and asked questions. Then a woman came by and started talking about Mercury retrograde and the conversation became about astrology. Sigh. Why is it people with the least useful things to say, say the most, too? As the joggers fled, I yelled "join the WAA!" and somehow extracted myself from the astrologer.

Continuing to do outreach events is probably the best way to engage, educate and ultimately dispel ignorance among those not committed to the irrational. ■

The Brief Life of the Planet Vulcan

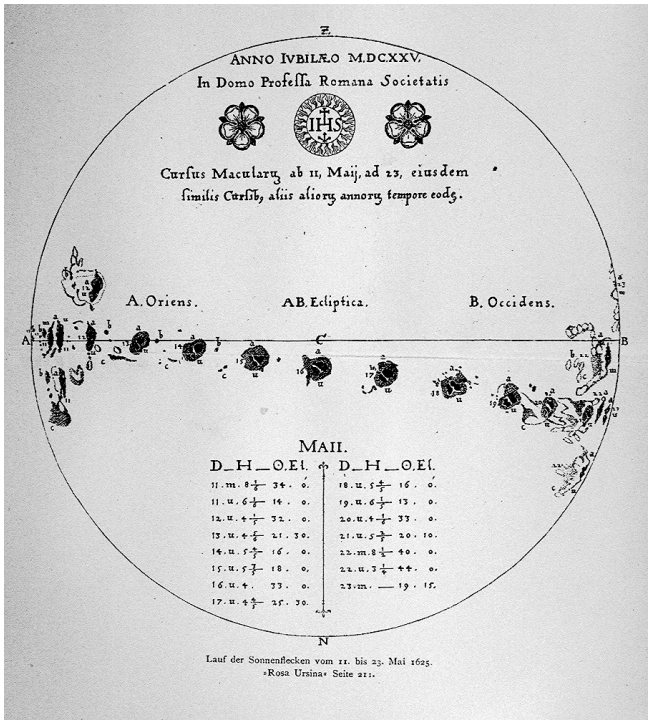
Larry Faltz

In the November 2019 SkyWAAtch I reviewed the historical importance of transits of Mercury, leading up to the announcement by Urbain Le Verrier in 1859 that the perihelion of the orbit of Mercury precessed 38 seconds of arc per century more than could be accounted for by computing the gravitational influence of all the other planets. Le Verrier was completely convinced that all planetary motion was due to Newton's law of gravity and exact orbital solutions could be found as long as the masses and positions of all of the planets relative to the Sun and each other could be accurately determined. The proof, seemingly, was his successful prediction of the position of the as-yet unknown planet Neptune in 1846, as well as the accurate calculation of cometary orbits by him and others. In the 19th century, telescopes, measuring devices and clocks kept pace with the needs of the astronomical community. In particular, ever-larger refractors on finely-machined mounts proliferated in the 19th century. Their precision made celestial positions more accurate. Mercury's anomalous precession, a displacement of less than the diameter of Jupiter per century, bothered the compulsive Le Verrier. He naturally proposed that there had to be missing mass in the form of one or more intra-Mercurial planets that would account for the discrepancy, an interior analogue of the impact of the exterior Neptune on the orbit of Uranus.

He was not the first to suggest that there were solar system bodies interior to Mercury, although he was certainly the first to base it on a thorough mathematical analysis using the parameters established by a law of physics.

The possibility of astronomical bodies close to the Sun has a long history. Sunspots were known to the ancients. Chinese and Greek astronomers mentioned dark blemishes on the surface of the Sun, and official sunspot counts were kept in China. Perhaps some type of pinhole projection was used to image the solar surface. The English monk John of Worcester mentions them in 1128. There seemed to be little excitement about the astronomical meaning of these anomalies until the invention of the telescope.

Following his remarkable discoveries in 1609 and 1610, Galileo turned his primitive instrument to the Sun, using a (undoubtedly inadequate) smoked glass filter. In the spring of 1611 he noted that the solar disc was "spotty and impure, with markings that moved along the solar surface and changed shape. (He had the benefit of not being at a solar minimum, like we are right now!) He thought they may be clouds. About the same time, the Jesuit astronomer Christoph Scheiner, professor of Hebrew and mathematics at the Jesuit college in Ingolstadt, used a 30x telescope to view the Sun. He saw what Galileo saw, but, being a Jesuit he could not countenance an interpretation at variance with Aristotle's dictum, which harmonized with Church doctrine, that heavenly bodies were unchanging (and revolved around the Earth, of course). So these dark objects must be planets in a geocentric orbit close to the orbit of the Sun. His findings were published in January 1612. Galileo published *On floating bodies* in March 1612, and in its second edition, in the fall of 1612, he stated that the sunspots were surface phenomena and that they moved because the Sun rotated.



Sunspots from Scheiner's Rosina *Ursina sive Sol,* 1625

It's not exactly clear who should get priority for the telescopic observation of sunspots. Two other astronomers, the Englishman Thomas Harriott and the Frisian scholar Johann Fabricius, also viewed the Sun in 1610-1612, and Fabricius' account was actually the first published, a pamphlet that was available at the Frankfurt Book Fair in 1611. In September 1612

Scheiner published *De Maculis Solaribus et Stellis circa Iovis Errantibus Accuratior Disquisition* (A More Accurate Disquisition Concerning Solar Spots and Stars Wandering around Jupiter). He argued that the Moons of Jupiter that Galileo had so clearly observed were due to the same "dark matter" that caused sunspots, which Scheiner continued to claim had to be planets. Clearly happy to pick a fight with Scheiner, Galileo published *Letters on Sunspots* in 1613, in Italian rather than Latin, all the more to reach the general public. He not only strengthened his arguments but specifically made his first public endorsement of the Copernican system. This, of course, threw down the gauntlet to the Church, resulting in the Inquisition's determination in 1616 that heliocentrism was heretical. But of course, Galileo was right about both sunspots and heliocentrism. He and Scheiner continued to scrap about both the priority of the discovery and the nature of the phenomenon until Galileo's death in 1642 (Scheiner died in 1650).

There seemed to be little organized interest in intra-Mercurial planets once the sunspot controversy settled down until Le Verrier's 1859 report, although the possibility of such a planet seemed to exist at the periphery of astronomical orthodoxy.[1] Le Verrier published his analysis on September 12, 1859. On December 22, he received a curious letter from a country doctor and amateur astronomer, Edmond Lescarbault. Writing from the town of Orgères-en-Beauce some 60 miles southwest of Paris, Lescarbault reported that he had been observing the Sun on and off for 6 years with a 3½-inch Cauche refractor, using measuring instruments of his own construction. He told Le Verrier that on March 26, 1859 he saw a small, round body cross the limb of the Sun. He estimated the duration of the transit as 1 hour, 17 minutes, 9 seconds. He withheld reporting because he wanted to see the object again to confirm his observation, but after reading an article in the astronomy journal *Cosmos* about Le Verrier's calculations he decided to communicate his observation. On December 30, Le Verrier showed up unannounced at the doctor's surgery to cross-examine him on his activities. He inspected the telescope and later made inquiries in the town as to the doctor's character. Satisfied that Lescarbault was a credible individual, Le Verrier went back to Paris, did some more calculations and on January 2, 1860, announced the discovery of a new planet to the Académie des Sciences. Given Le Verrier's prestige, the observation was immediately taken as proof that a planet had been found.

The finding became the rage of Paris. Lescarbault received the *Legion d'Honneur* from Emperor Napoleon III. Le Verrier's star, high after Neptune (he had been appointed Director of the Paris Observatory in 1854), rose even further. Le Verrier calculated that the new planet would have a distance from the Sun of 0.147 AU. Its nearly circular orbit, inclined 12° 10' to the ecliptic, had a period of 19 days, 17 hours. There should be 4 transits a year of this body. In the February 3, 1860 issue of *Cosmos*, Abbé François-Napoléon-Marie Moigno, founder and editor of the journal, formally dubbed the planet "Vulcan" after the Roman God of fire.

Several "pre-discovery" reports of mysterious transiting objects observed between 1762 and 1858 surfaced. Although there were few details, they contributed to what can only be called "Vulcanmania." The hunt was on. This was in spite of the fact that Le Verrier himself noted that Lescarbault's planet was far too small to account for the advance of Mercury's perihelion, by a factor of 17! Maybe there were multiple interior planets, forming some type of ring around the Sun.

Vulcan was searched for during four expected transits in the spring of 1860, but nothing was seen. Meanwhile, on March 8, 1860, another French astronomer, Emmanuel Liais, published a report in the prestigious German journal *Astronomische Nachrichten*. Liais, observing from Brazil, had been looking at the Sun at exactly the same time as Lescarbault while studying the gradient of brightness across the solar disk. He saw nothing. He made the point that a body this close to the Sun should be very bright and would have been visible, at least telescopically, to other observers just before or after a transit. He suggested that if anything was seen, it was a body much closer to the Earth. This would account, perhaps, for the object being visible in France but not in Brazil, if in fact it was seen at all. Parenthetically, Christoph Scheiner's first interpretation of what he had seen in 1611 was that there was something in his eye!

Over the next few years, many astronomers looked for Vulcan, and several claimed to have found it. On August 7, 1869, four English amateur astronomers viewing a solar eclipse claimed to see a bright spot just outside the corona, but at the same eclipse the noted American astronomer Simon Newcomb saw nothing.

[1] The Library of Congress has a map of the Solar System dated 1846 that includes the planet Vulcan, with a proposed distance of 16,000,000 miles from the Sun. See https://www.loc.gov/resource/g3180.ct003790?r=0.157,0.28,0.92,0.564,0.

Benjamin Apthorp Gould, Jr., founder of the *Astronomical Journal*, reported that the star 82 Cancri was probably the object seen by the amateurs. An extensive search by 16 astronomers in England in 1869 organized by amateur William Frederick Denning found nothing, and a repeat search the following year also failed to bear fruit. A predicted transit on March 24, 1872, was the subject of a world-wide search, also futile.

Astronomer Christian Heinrich Friedrich Peters was not a believer. In 1873 he had written that

> …during the last ten or fifteen years the Sun has been studied so assiduously by professional astronomers that they necessarily would have fallen in with a transit if a planet at a distance from the Sun less than Mercury's existed. We have to consider, therefore, the non-existence of such a planet or group of planets as a question set at rest.

Peters suggested that the observations, and the mathematical reductions that followed, were simply in error and that no real anomaly existed. But on April 4, 1876 Heinrich Weber, viewing in China, reported a small round spot moving across the Sun. He sent a report to Europe via telegraph. Although he gave few details, Le Verrier, upon hearing of the sighting, made new calculations, tilting Vulcan's orbit 10.9° from the ecliptic and lengthening the period to 33 days. He predicted transits in early October.

The situation at that time was summarized in a peculiar editorial[2] in the *New York Times* on September 26, 1876, simply entitled "Vulcan." In the flowery prose of newspaper reporting at the time, the anonymous author noted that

> …determined hostility to Vulcan finally made it a hazardous matter for an astronomer to profess a belief in its existence. Public astronomic opinion insisted that there were quite enough planets between the Earth and the Sun already, and that to have this miserable little Vulcan take the first place on the list, and crowd the Earth back to fourth place, would be little less than an outrage.

The article goes on the report that Le Verrier, "the discoverer of Neptune and confessedly a crack shot with the long-range telescope"[3] calculated that Vulcan would cross the solar disc on October 2nd or 3rd, but that "this announcement has been received in grim silence." Yet, per the *Times*, "Vulcan exists, and its existence can no longer be denied or ignored." The article goes on to posit some silliness about the working day on Vulcan and the trials of Vulcan newspapermen, who would need to prepare new editions every 4 hours because the planet's day might only be 4 hours long. The anonymous author goes on to insult professional astronomers, ascribing their interest in the transit of Venus (one which occurred in 1874, with another coming in 1882) merely to their desire to take long ocean voyages to exotic places at the public's expense. The author goes on to say that "it is evident that the first half dozen transits of an entirely new planet will be more interesting and important than the hackneyed transits of Venus,[4] and that astronomers all over the world will promptly urge this view of the matter on their respective Governments" in order to go on "astronomic picnic excursions." The coming glut of transit of Mercury expeditions "ought to awaken the gravest apprehensions among the friends of economy and retrenchment in public expenses." It was hard for me to decide whether this article was serious or not. It shows that the question of Vulcan was very much in the public's eye, even while being disdained by at least some in the professional community.

At the predicted October 2-3 transit Vulcan was assiduously searched for by many observers, but nothing was found. In its October 4, 1876 edition, the New York Times reported on the fruitless search by the US Naval Observatory, and included this note:

> UTICA, Oct. 3–Dr. Peters, astronomer of this city, who has been observing the Sun's disk for the expected transit of Vulcan, reports that as yet nothing has been discovered.

Another transit was predicted for October 9-10, and on October 7th the *Times* ran this story:

> The Missing Planet Vulcan
>
> DETROIT, Oct. 6–The following was received here this afternoon from Prof. [James Craig] Watson's observatory at Ann Arbor, Mich.:
>
> The French astronomer Leverrier (*sic*) requests me to cause observations to be made upon the disk of the sun on Oct. 9 and 10, and, if possible, as far West as San Francisco. I desire, therefore, through the Associated Press, to ask persons having telescopes to keep watch of the sun on these two days and in case any dark spot is

[2] If you are a Times subscriber, you can view every page of the Times ever published on the TimesMachine web site https://timesmachine.nytimes.com.

[3] Le Verrier was actually completely uninterested in observing, dedicating himself to calculations and basically ignoring the new science of spectroscopy.

[4] "Hackneyed" is peculiar adjective considering that only 4 Transits of Venus had been observed as of 1876, and the first of those, in 1639, was seen by just two people.

> seen in addition to those now upon its disk, to note the position and the local time of the observation, and to transmit a copy of the record to me. Recent observations indicate the possibility of the passage of a planet inferior to Mercury across the disk of the sun on one of the days named, and it is especially desired that observations be made on the Pacific coast. The position of the planet, if seen, may be noted relatively to any of the ordinary spots upon the sun's surface.

Nothing was seen in October. But hope springs eternal. Le Verrier made new calculations and put out a call for more observations for predicted transits in March 1877. Again, astronomers world-wide searched for the planet. On March 27, 1877, the *Times* reported:

> The Transit of Vulcan
>
> SAN FRANCISCO, March 26.–In accordance with the request of M. Leverrier of Paris, Prof. Davidson, of the Coast Survey, made observations at Summit Station, on the Central Pacific Railroad, on the 21st, 22nd, and 23rd inst., to determine the question of the transit of Vulcan over the sun's disk. At Summit the weather was favorable, except in the afternoon of the 21st and late in the afternoon of the 22nd, but no signs of the planet were visible, although one spot and a disturbed area were seen on the 21st and 22nd, and a second disturbed area appeared on the 23rd. Those are important as indicating what size of spot could be observed, and it is believed that had the planet appeared with a diameter of five seconds of arc it could very readily have been seen. The disk of the sun was very sharply defined during the greater part of the time of the observations. At San Francisco, Mr. Pratt, of the Coast Survey, made a similar search for the planet, and at San Bernardino, W.G. Wright, of that place, with less favorable weather, observed through the three days. The former saw a spot of the 21st and a disturbed area on the 23rd, and the latter saw a spot of the 21st. Prof. Davidson has officially reported the result of his search.

The next major opportunity for a look would be during a transit of Mercury and a solar eclipse in 1878, but Le Verrier would not live to see it. He died of liver cancer on September 23, 1877, 31 years to the day after Neptune was sighted by Galle. But Vulcan lived on.

The next and essentially climactic chapter in the search for Vulcan played out in the setting of a competition between two important and productive American astronomers previously mentioned, James Craig Watson of the University of Michigan and C. H. F. Peters of the Litchfield Observatory at Hamilton College in upstate New York. Both men were accomplished astronomical mathematicians and asteroid discoverers. By the end of his life (1890) Peters had discovered 48, the first being 72 Feronia and the last 287 Nephthys. Watson discovered 22, starting with 79 Eurynome and ending with 179 Klytaemnestra. Both were elected to the National Academy of Sciences and were viewed with respect by their colleagues. Watson's book *Theoretical Astronomy Relating to the Motions of the Heavenly Bodies*, published in 1868, had been praised by Le Verrier.

Le Verrier, Watson, Peters

Watson and Peters initially engaged in a friendly and respectful competition to discover more minor planets than their established European colleagues in order to boost the status of American astronomy, but the contest turned personal and their relationship became strained over the years. The race was highlighted in the press, each newly discovered asteroid breathlessly reported and a score being kept. By 1876, Peters was in the lead 26 to 19. In early 1878 Watson was contacted by the US Naval Observatory, who wanted him to assist with observations of the May 6, 1878 transit of Mercury. Simon Newcomb, said that the event would resolve "whether the result of Le Verrier…is really correct." He helped get government funding for the attempt.

Watson observed the event from Detroit with a 40-foot-long horizontal telescope and a coelostat at a magnification of 400x in order to time the contacts as accurately as possible. Among the other astronomers looking at the Sun that day, Maria Mitchell showed the transit to her students at Vassar College in Poughkeepsie, while Peters held a public outreach at Hamilton College. Thomas Edison observed from Menlo Park, NJ, and Dr. Henry Draper hosted several enthusiasts in his observatory in Hastings-on-Hudson (now the Hastings Historical Society in Draper Park). The seeing that day in the East was terrible, and Mercury danced around the field, but Watson had a good view in Michigan. He determined that first contact, always difficult to pinpoint accurately, was within 9 seconds of the time computer by Le Verrier, proving that the perihelion indeed advanced (although Le Verrier, who had chafed at a 16-second discrepancy in 1843, might not have been satisfied). Watson, like Le Verrier, was

convinced that an interior planet must be the cause of the anomalous precession. The *Detroit Free Press* wrote that Watson thought the results would convert "even Dr. Peters to Le Verrier's theory." Peters was, however, completely unmoved. The Naval Observatory felt the hunt for a direct sighting should continue. The next opportunity would be the total solar eclipse of July 22, 1878, just 10 weeks away. Congress was persuaded to allocate $8,000 to fund a number of expeditions to the West.[5] Perhaps the legislators forgot the peculiar warnings of the 1876 *Times* article, although conditions in the path of the eclipse were hardly going to be a picnic. There was a good bit of unrest among the Nez Perces and Utes, and it had only been two years since the Sioux under Crazy Horse had annihilated General Custer's 7th Cavalry at Little Big Horn in Montana.

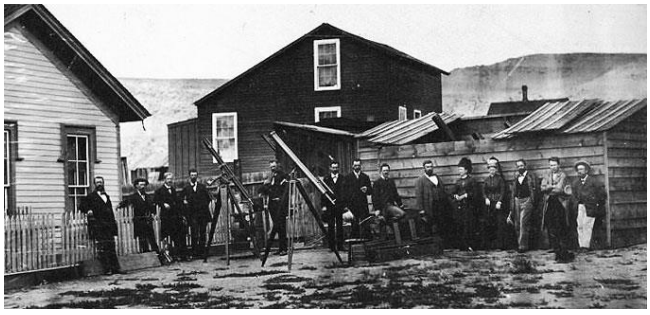

The Chicago Times.

MONDAY MORNING, JULY 22, 1878.

THE PATH OF THE ECLIPSE.

David Baron tells the story of the eclipse and the personalities involved in his superb 2017 book *American Eclipse*. The total solar eclipse of 1878 was perhaps the most momentous event in the history of American astronomy. Just two years after the nation's centenary and 13 after the close of the Civil War, it was the opportunity to show that the United States could rival or even outstrip its European forbearers in matters intellectual and scientific. Astronomy had been a focus since the administration of the scientifically-minded John Quincy Adams. Within fifty years, dozens, if not hundreds, of telescopes and astronomy programs had been established. Nearly every American astronomer of note would be observing totality (seemingly only Peters stayed home), which crossed the western United States from northern Idaho to Louisiana. It would go right through the new state of Colorado and its capital, Denver, and totality would be visible from atop Pike's Peak, at 14,115 feet the highest mountain on the Front Range of the Rockies. The weather in July is generally clear, so astronomers would have a high likelihood of successful observing.

Watson, an unabashed acolyte of Le Verrier, decided to search for Vulcan during the eclipse with a 4-inch Clark refractor. He and his wife joined a party of astronomers at Rawlins, Wyoming, a frontier town of 800 citizens along the Union Pacific railway line. Among the group, organized by Henry Draper, were J. Normal Lockyer, discoverer of helium and founder of the British journal *Nature*, and the already famous 31-year old Thomas Alva Edison, who was there to test a "tasimeter," a device he invented to measure the temperature of the solar corona. They were joined later by the redoubtable Simon Newcomb, who brought a 5" refractor also to look for Vulcan, setting up just a few miles away at a place called Separation. A bit further down the line near the tiny town of Creston, Wyoming, a team organized by Newcomb and led by William Harkness of the US Naval Observatory included another USNO astronomer A.D. Skinner, telescope maker Alvan Clark and French artist and astronomer Étienne Léopold Trouvelot (who also holds the dubious distinction of having brought the gypsy moth to the United States in an ill-fated attempt at creating a silk production industry).



Rawlins, Wyoming Territory, prior to the eclipse. Watson is the portly bearded man 6th from the right. Further to the right are Mrs. Watson, Mrs. Draper, Dr. Henry Draper, Thomas Alva Edison and J. Norman Lockyer.

Much of the scientific work during the eclipse was about spectroscopy and the nature of the corona, but a number of astronomers besides Watson and Newcomb searched for Vulcan, from locations like Central City, Denver and La Junta. Except for Watson, all the observers saw nothing. Watson, however, was sure that he had detected an object near, but distinct from, θ Cancri that wasn't on any star chart.

Watson announced his finding to a press eager for a dramatic discovery. The *Laramie Daily Sentinel* wrote that Watson was "now the most noted astronomical

[5] A substantial sum in 1878. For comparison, in 2017 Medicare spent $8,000 in 0.38 seconds.

observer and discoverer in the world." Professionals were more skeptical. Why hadn't anyone else seen it?

A few weeks later, amateur astronomer and prolific comet discoverer Lewis Swift, who had observed from Denver with a 4½-inch refractor, reported that he too had seen something near θ Cancri. In fact, he reported *two* non-stellar objects. He said he withheld an immediate report out of scientific caution. The report buoyed Watson and added to Vulcan's credibility. Watson then had to revise his data because of timing corrections, and by the time he finished he also claimed two objects.

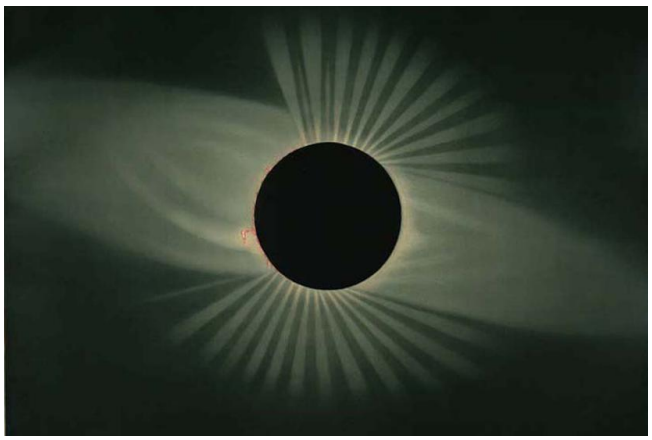
A lengthy report in the *New York Times* on August 16, 1878 summed up the initial scientific findings from the eclipse. The article was entitled "Vulcan and the Corona: Results of the Recent Eclipse." It stated

> One brilliant discovery will probably date from this occasion, and hold a conspicuous place in the annals of science. The planet Vulcan, after so long eluding the hunters, showing them from time to time only uncertain tracks and signs, appears to have at last been fairly run down and captured. At least it seems to us that the observations of Prof. Watson at Rawlings, and Swift at Denver must for the present be taken as conclusive, though perhaps not settling the question beyond the possibility of reopening or dispute…. The negative results of Profs Newcomb, Wheeler, Holden and others, who, with similar instruments, went over the same ground and found nothing, are, indeed, unsatisfactory and puzzling; but they can hardly outweigh the positive evidence on the other side, though they certainly justify a certain reserve in accepting the conclusion."

Watson claimed that that Vulcan was seen at magnitude 4.5. At this brightness it would be only 200-400 miles in diameter. An object of this diminutive size could not account for the anomalies in Mercury's orbit. The *Times* goes on "If really thus minute, it is easy to see how it has so long escaped discovery; indeed, the question at once arises whether there must not be several such Vulcans." Watson is reported as wanting to continue his transit search. He suggested

> There is, however, a bare possibility by arming a large telescope with a very long tube, projecting beyond the object glass, and thus enabling the observer to examine the sky within a degree or two of the sun without letting the sunlight fall upon the lens. If the experiment could be tried at a considerable altitude, where the atmospheric glare is at a minimum, the chance of success would be greatly improved.

Over the next few months, Watson's claims were scrutinized by Peters in a detailed article in the *Astronomische Nachrichten* in early 1879. Peters dismissed the findings outright. He found fault with Watson's method of notating the observations using a device that made marks on a paper disk while the observer looked into the eyepiece and maneuvered the telescope. Peters also calculated that in order to have the required effect on Mercury's orbit, there would have to be at least a million, and possibly 38 million, of Watson's objects, which seemed ridiculous. He concluded that Watson and Swift had merely seen the same background stars that others had seen. It was simply impossible to believe that all the other astronomers, using equipment of equal quality, had missed the intra-Mercurial planets. The British astronomer Agnes Clerke writes in *The History of Astronomy during the Nineteenth Century* (1885) that "The most feasible explanation of the puzzle seems to be that Watson and Swift merely saw the same two stars in Cancer: haste and excitement doing the rest." One has to remember that in those pre-photographic days, astronomical observations were essentially verbal or relied on sketches made at the eyepiece. And during a three-minute eclipse, haste and excitement are inevitable.



Trouvelot's pastel drawing of the Eclipse

Watson, however, wouldn't capitulate. He responded with outrage, saying that Peters had made an "attack on the integrity of my observations" and by extension the integrity of Watson himself. He resolved to continue the hunt. He was still a formidable astronomer with a fine reputation. He was coaxed away from Ann Arbor to the University of Wisconsin, which constructed an observatory for him with a 15.6-inch Clark refractor, and he began to build, with his own funds, of a peculiar subterranean solar telescope that he thought would allow him to see stars near the Sun during daylight, which it actually would not have been able to do. He was spared the disappointment by suddenly becoming ill and dying in 1880 at the age of 42.

A few astronomers, Swift foremost among them, continued to look for Vulcan, usually during solar eclipses, but most of the astronomic community moved on. The *Times* ran this story on January 6, 1889:

> They Have No Faith in Vulcan
>
> *From the Utica Herald, Jan. 2.*
>
> Dr. Peters, the astronomer of the Litchfield Observatory, stated yesterday that the eclipse of the sun which occurred [on Jan. 1, 1889] was not of special interest except to scientists observing the spectroscopic features and their physical relations. As to Prof. Swift's search for the intra-Mercurial comet, that theory was a baseless one, having been long ago exploded by the discovery that there was an error in the calculations of the astronomers who declared that an undiscovered planet must exist in the neighborhood of the Sun to account for certain movements. This hypothetical planet, to which the name Vulcan has been given, is not believed in, to any great extent, by the most prominent astronomers, Dr. Peters among them.

In 1895, Simon Newcomb published new tables for the four inner planets that he had been working on since Le Verrier's death two decades earlier. The anomalous precession of Mercury's perihelion was now calculated to be 43 arc-seconds per century. The reason was still completely baffling. Asaph Hall, the discoverer of the moons of Mars, suggested that gravity did not follow an inverse square law, $1/r^2$, but varied by a factor of $1/r^{2.00000016}$. No clear rationale for that particular deviation could be formulated, other than it might fix the Mercury problem (but then it would completely mess up the Moon's orbit). Other explanations were equally fantastic and unsupported by observation.

There were a few more futile hunts during solar eclipses after the turn of the century. W.W. Campbell of Lick Observatory pronounced the problem "closed" in 1909. The last stab at Vulcan seems to have been in 1929 when photographs taken during a total solar eclipse in Sumatra were examined, to no avail.

It wasn't so much an "error in the calculations" that destroyed Vulcan, as the *Times* story of 1889 stated, but an unswerving faith in the physics of Isaac Newton. How else could Le Verrier and his disciple Watson have thought of the problem after the triumph of Neptune? The unaccountable component of the precession of Mercury's perihelion was real. "When you eliminate the impossible, whatever remains, however improbable, must be the truth" said Sherlock Holmes. Newtonian gravity was not the solution. Albert Einstein put the matter to rest with the theory of General Relativity, proving that the mass of the Sun curves the fabric of space and changes the trajectory of anything moving in that part of space.

In 1949, Walter Baade, using the 48-inch Schmidt at Mt. Palomar found an asteroid, appropriately named Icarus (numbered 1566 in the asteroid catalog). Its perihelion is interior to Mercury at 0.1867 AU and its aphelion is beyond the orbit of Mars, with an orbital eccentricity 0.8268 and an inclincation of 22.85 degrees. A tiny body 1.4 km in diameter, it spins madly, rotating every 2.2 hours. If there were any tiny asteroids inside the orbit of Mercury, they would have to be between 0.07 to 0.21 AU from the Sun (Mercury orbits at 0.387 AU). Closer in and they would evaporate and further out gravitational interactions would fling them from the Solar System. In 2013, NASA's Sun-observing STEREO spacecraft ruled out the possibility of "Vulcanoids" (fully intra-Mercurial bodies) larger than 6 km.

There are two excellent books that tell the story of Vulcan in greater detail, and from which I got much of the information for this article. *In Search of Planet Vulcan: The Ghost in Newton's Clockwork Universe* by Richard Baum and William Sheehan was published in 1997. It's a complete history of planetary discovery, full of interesting details and extremely well referenced. Sheehan is a psychiatrist living in Minnesota and has been a prolific astronomical historian and planetary observer.[6] Baum was a member of the British Astronomical Association for seventy years, serving as Director of the Terrestrial Planets Section from 1979 to 1991 and of the Mercury and Venus Section from 1991 to 2000. He passed away in 2017 at the age of 87. A more recent book, *The Hunt for Vulcan...And How Albert Einstein Destroyed a Planet, Discovered Relativity, and Deciphered the Universe* by Thomas Levinson, a professor of science writing at MIT, was published in 2015 to excellent reviews. It has the more fluid style of a professional science writer, and much more emphasis on Einstein, but both books are full of amazing detail and are consistent in their portrayals of Le Verrier, a complex, arrogant and tireless genius who was both right (Neptune) and wrong (Vulcan), for the same reason (Newtonian gravity)! ■

[6] Read more about Sheehan at https://uapress.arizona.edu/2018/06/five-questions-with-historian-bill-sheehan

Images by Members

Faint Reflection Nebulas in Vulpecula
Scott Nammacher

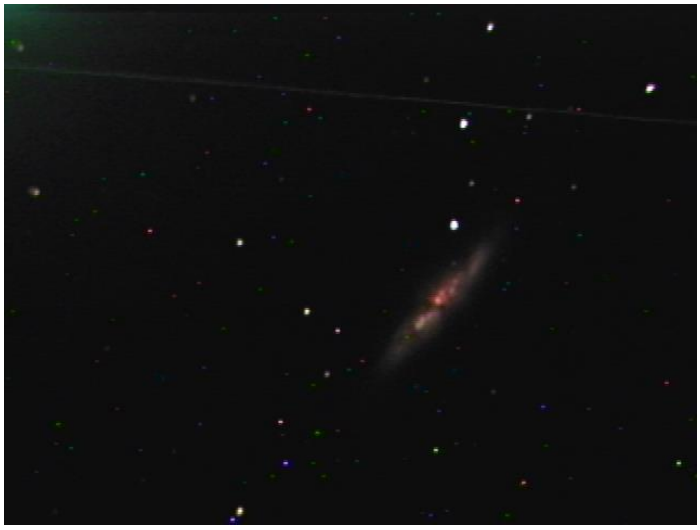
IC4955 (left) and IC 4954 are 13th magnitude reflection nebulas in Vulpecula near its border with Cygnus. Scott made this "short shot" image (40-50 minutes on each channel) with a PlaneWave 12.5, SBIG 10xme camera. He used ACP for doing the photo runs, MaximDL to capture the frames and Photoshop to process.

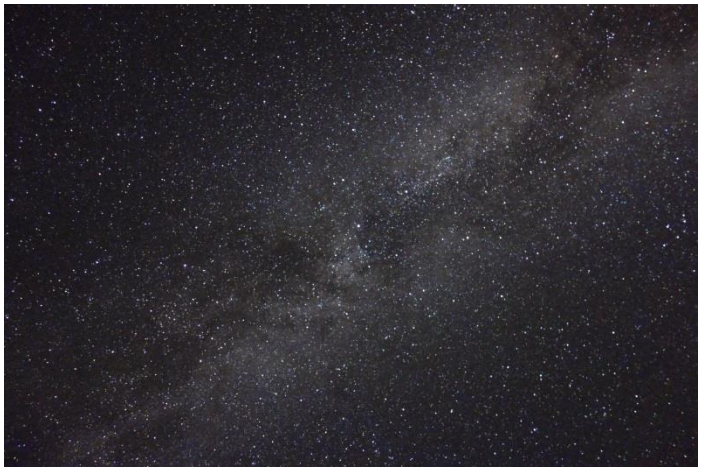
These two objects are not mentioned in Stephen O'Meara's *Hidden Treasures* or his *The Secret Deep*, nor in Philip Harrington's *Cosmic Challenge*. Sue French, in *Deep Sky Wonders*, notes that IC4954/5 reflects the light of the small open cluster Roslund 4, a collection of a few stars that have a combined magnitude of around 10.0

Transit of Mercury in hydrogen-alpha
Rick Bria

Rick used a Lunt 80-mm double-stacked solar telescope and a QHY 183m camera at the Mary Aloysia Hardey Observatory at Sacred Heart University in Greenwich.

"Cheap Shots" from Maine





These images were made at the 2019 Medomak Astronomy Retreat and Symposium (MARS) in Washington, Maine, held from July 28-August 3. Four WAA families attended MARS this year: Oliver & Marine Prache, Eric & Katharine Baumgartner, Peter & Kate Rothstein and Larry & Elyse Faltz. Telescopes on the field ranged from 80-mm refractors to a spectacular 22-inch motorized Dobsonian. Many of the 40 attendees were imaging during the four clear dark nights (out of 6), with consistent SQM readings of 21.60-21.63, in other words, dark! The Milky Way blazed overhead. Author (and my schoolmate from 2nd to 12th grades) Dava Sobel (*The Glass Universe, Galileo's Daughter, Longitude*) was the guest for the week.

I'm not an astro-imager, since I only have alt-az mounts (and insufficient patience). In Maine I observed with my 8" SCT, using a Denkmeier binoviewer and a pair of 24-mm Televue Panoptics. A highlight of the week was seeing NGC 6207, a 12.19 magnitude galaxy just off the edge of the M13 globular cluster in Hercules. I brought along my old Mallincam Color Hyper Plus CCD video camera as well as a very capable 20-megapixel Sony DSC- RX100 point-and-shoot with Zeiss lens, and one night I grabbed a few quick images.

Top: M17, the Swan (or Omega) Nebula with the Mallincam Color Hyper Plus, 28 seconds through the CPC with focal reduction to f/4.2. Single frame. 640x480 pixels.

Middle: M82 with a satellite passing above it, showing the starburst region and dust lane. 28 seconds at f/4.2. Single frame. 640 x 480 pixels.

Bottom: I mounted the Sony on top of the SCT and shot this single frame of the Milky Way in Cygnus. f/1.8, 28 mm focal length (35 mm equivalent), 30 seconds at ISO 3200. Deneb is the bright star in the middle of the frame, with the North American Nebula, NGC 7000, just below it. Original 5472 x 3648 pixels.

Larry Faltz

Research Highlight of the Month

Direct Observation of the Cosmic Web

Umehata, H, et. al, Gas filaments of the cosmic web located around active galaxies in a protocluster, *Science* 2019; 366:97-100

Most SkyWAAtch readers have seen simulations of the evolution of the universe after the period of recombination (the formation of the cosmic microwave background), based on the ΛCDM model of cosmology. The simulations show galaxies forming from gas gravitationally bound to a dark matter scaffold. The web can be inferred from the distribution of early galaxies as shown, for example, in the Sloane Digital Sky Survey (https://www.sdss.org/). Although very early galaxies have been imaged (the current record-holder is GN-z11 with a redshift $z = 11.1$) the filaments of the web have not been directly seen.

For the first time, the web has been imaged by an international consortium of astronomers who used some of the world's largest telescopes (Very Large Telescope and ALMA in Chile, Subaru and Keck in Hawaii) and new imaging spectrographs. The gas extends between clusters of proto-galaxies at z=3.09 (when the universe was only about 15% of its current age). These are hot young galaxies that are actively making stars. The ultraviolet emissions from the galaxies illuminate the hydrogen gas in the web, which radiates at Lyman-alpha wavelength. Gas from the web is presumed to be flowing into the galaxies, contributing to star formation and perhaps to the growth of supermassive black holes at their centers.

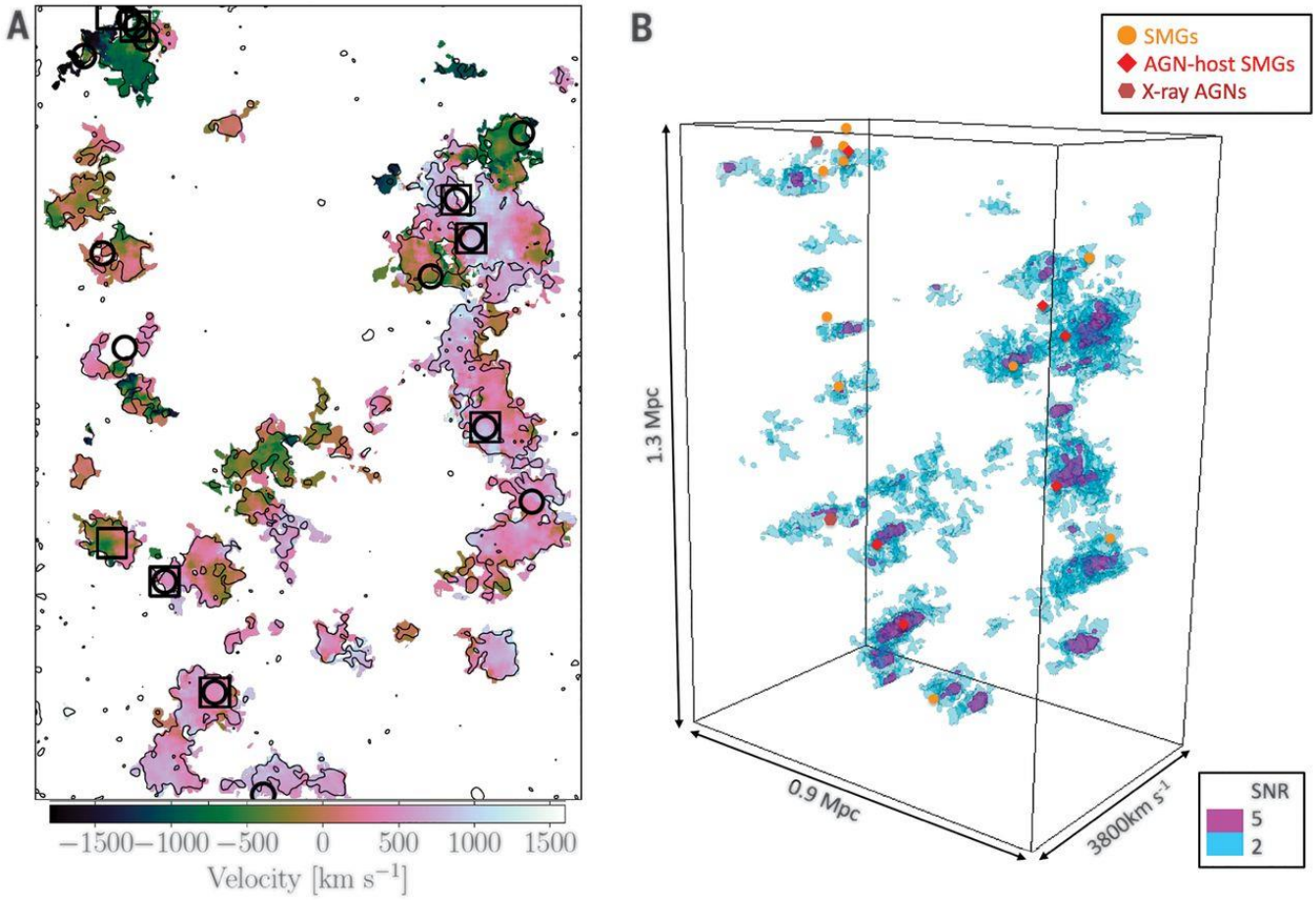


Fig 3 from Humehata, et. al. The black boxes and circles are galaxies in the protocluster. The colored material is the gas in the cosmic web.

You can read the paper in its arXiv pre-print form at https://arxiv.org/ftp/arxiv/papers/1910/1910.01324.pdf.

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 adapter, manual, new condition.	$1200	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 2018 newsletter for details. Donated to WAA.	$1000	WAA ads@westchesterastronomers.org
Explore Scientific Twilight I Mount	Manual Alt/Az, capacity 18 lb. Steel tripod. Excellent condition. Used fewer than 10 times. Great for grab-and-go viewing. Owner upgrading to an EQ mount.	$110	Eugene Lewis genelew1@gmail.com
Celestron StarSense autoalign	Brand-new condition in original packaging. Accurate auto-alignment. Works with all recent Celestron telescopes (fork mount or GEM). See info on Celestron web site. Complete with hand control, cable, both mount brackets. Printed documentation. List $359. Donated to WAA.	$175	WAA ads@westchesterastronomers.org
NEW LISTING Meade LX-70 Equatorial Mount	Dual Axis Drive and Polar Scope - Brand New. Bought during the closeout sale of these mounts. Owner thought he might like to have a light GEM, but decided to stick with alt-az mounts. Set up once in the garage to be sure it all works, and it does, but never saw first light in the field. Price paid: $365.	$275	Eugene Lewis genelew1@gmail.com
NEW LISTING Celestron 6-inch f/5 reflector OTA	Same optical tube as the famous Orion 6" StarBlast. 1¼" rack-and-pinion focuser, Celestron 25 mm eyepiece, tube rings and dovetail plate. 5x30 straight through finder. Heavy-duty dark canvas carrying case with compartments and plenty of room for accessories. Excellent condition, unblemished optics. These scopes are hard to find without a mount. An Orion StarBlast 6 with 1¼" focuser and table-top Dobsonian mount lists for $379. Meade's 6" f/5 scope, admittedly with a 2" Crayford focuser but no case, lists for $339. Donated to WAA.	$175	WAA ads@westchesterastronomer.org

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