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# The StarGazer

Newsletter of the Rappahannock Astronomy Club

No. 4 Vol. 8 February–April 2020

## Comet 2019 Y4 (Atlas)—Excerpts From an Observer’s Imaging Journal

by Myron E. Wasiuta

On the night of December 28, 2019, a robotic imaging telescope in Hawaii (part of the [Asteroid Terrestrial-impact Last Alert System](#)) discovered Comet C/2019 Y4 (Atlas). At magnitude 19, it was nothing special. It wasn’t even on a collision course with the Earth. However, two characteristics caught the attention of astronomers. First, its orbit was similar to the Great Comet of 1844—a Kreutz Sungrazer. This type of comet passes so close to the Sun that it can be tidally disrupted and become bright enough to be seen in broad daylight. Could Atlas do the same? This seemed a distinct possibility, given the second thing that drew astronomers’ notice. By the end of March 2020, it had become more than 10,000x brighter than it was 2 months earlier at discovery! This rapid and dramatic increase in brightness led to predictions that it might exceed the brightness of Venus when it rounded the Sun at the end of May 2020. This would make it a naked-eye daylight comet! Then disaster struck....

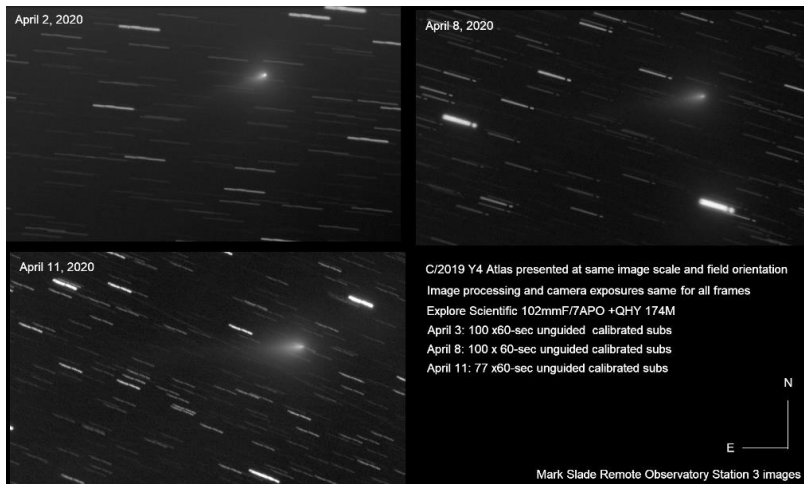


Figure 1. Comet Atlas showing appearance on three nights from early to mid-April. Note changes in nucleus as it elongates and fades. Courtesy: Myron Wasiuta

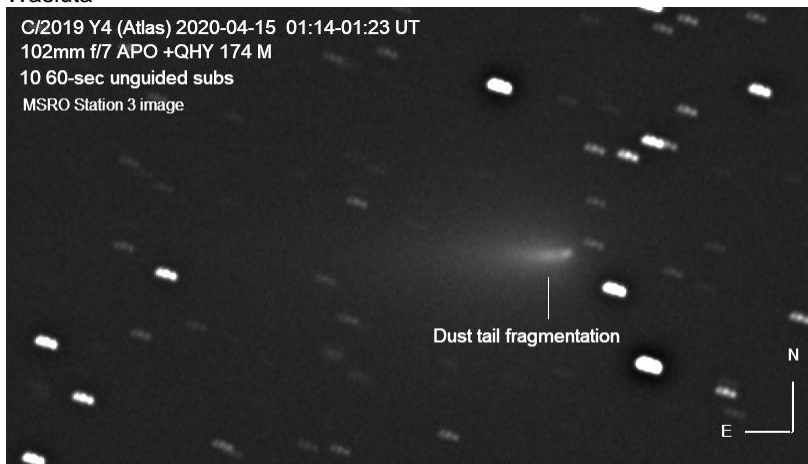


Figure 2. Comet Atlas J-shaped nucleus fragment. A large fragment has split from the nucleus as the disintegration continues. Courtesy: Myron Wasiuta

The first clues that something wasn’t well with the comet came in early April. The nucleus began to elongate and decrease in brightness (see Figure 1). Telescopes around the world began to detect discrete fragments. Images taken at our MSRO confirmed the comet was fragmenting. Specifically, our Station 3 telescope, which had been tracking the comet since early April, showed a dramatic change on the night of April 14, 2020. On this night, a prominent nuclear fragment had drifted away from the comet, giving it a bent or J-shaped head (see Figure 2). An animation of this event appears on the [MSRO Facebook](#) page.

As I continued observations with the Station 3 telescope over the next few nights, the 12-inch LX-200 of Station 2 began observations as well, and on the night of April 18, it detected a faint fragment near the comet head in the dust-tail. See Figure 3. However, this was only a prelude to things to come!

***(Continued on page 3)***

## How to Join RAClub

RAClub, located in the Fredericksburg, Virginia, area, is dedicated to the advancement of public interest in, and knowledge of, the science of astronomy. Members share a common interest in astronomy and related fields as well as a love of observing the night sky.

Membership is open to anyone interested in astronomy, regardless of his/her level of knowledge. Owning a telescope is not a requirement. All you need is a desire to expand your knowledge of astronomy. RAClub members are primarily from the Fredericksburg area, including, but not limited to, the City of Fredericksburg and the counties of Stafford, Spotsylvania, King George, and Orange. We also have several members who live outside Virginia and have joined to have the opportunity to use the Mark Slade Remote Observatory (MSRO)—one of the benefits of joining the club.

**RAClub annual membership is \$20 per family. Student membership is \$7.50.** Click [here](#) for a printable PDF application form.

The RAClub offers you a great opportunity to learn more about the stars, get advice on equipment purchases, and participate in community events. We meet once a month and hold regular **star parties** each month on the Saturday closest to the new Moon. Our website, [www.raclub.org](http://www.raclub.org) is the best source of information on our events.

### The StarGazer

February–April 2020

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Editor: [Linda Billard](#)

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[Reference: <https://www.law.cornell.edu/uscode/text/17/107> ]

Website: [www.raclub.org](http://www.raclub.org)

Groups.io: Members-only group. When you join RAC, you will receive an invitation to join from the RAC President.

#### RAClub Officers

[Glenn Faini](#) President

Vacant, Vice President

[Matt Scott](#) Treasurer

[Bart Billard](#) Secretary

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[Don Clark](#) Web Editor & Image Gallery Editor

[Don Clark](#) Internet Administrator

[Scott Busby](#) Equipment Loan

[Jerry Hubbell](#) Astrophotography

[Myron Wasiuta](#) Mark Slade Remote Observatory (MSRO)

### Upcoming Events

Our public events are cancelled until June. However, to attend a virtual club meeting, email [president@raclub.org](mailto:president@raclub.org) for an invitation.

Star Party, Caledon State Park June 10\*

### Recent Outreach Events Completed\*

Mountain View HS Science Club Presentation January 29  
Star Party† February 22

\*Note that our star parties in April and May were cancelled. Please check the website [raclub.org](http://raclub.org) for updates.

†simultaneous star parties at Caledon State Park and Belmont Observatory—Caledon events are for the public; Belmont events are for RAC members only

## President's Corner

Dear Members,

RAC is still without a Vice President. Please consider serving your club as Vice President. The more we contribute our time and talent, the better RAC will be able to serve us and the community.

RAC's Yahoo!Group has been shut down. Groups.io is how RAC's members now communicate with one another. It is a members-only group (to protect against SPAM); however, the group is public, enabling non-members to view the messages. All RAC members are encouraged to accept the Groups.io invitation that I send them.

Finally, owing to government limits imposed on businesses and our right to assemble, RAC is currently holding its meetings via Zoom Video Conferencing. I will send meeting invitations to all RAC members via the email address you provided. Non-members may also participate by sending me a request at [president@raclub.org](mailto:president@raclub.org). RAC plans to continue to make our meetings available via Zoom so those who cannot attend in person may participate.

Wishing you transparent skies and excellent seeing.

Glenn Faini  
President



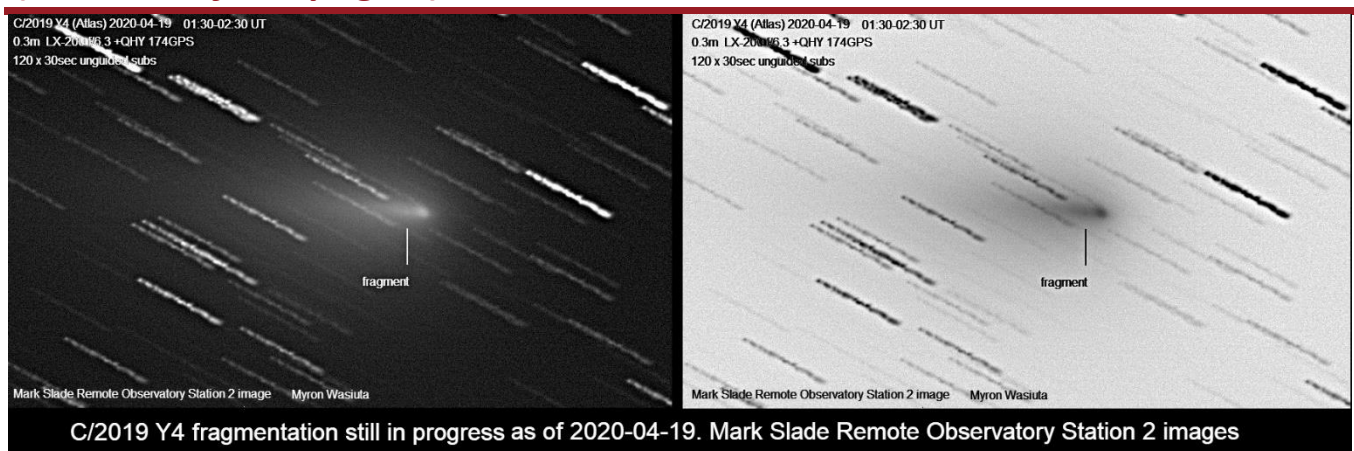
### Did You Know?

by Scott Busby

In 1850, the limit of photographic attainment was stars brighter than the second magnitude; by 1857, the limit was to the sixth magnitude. In 1858, G.P. Bond (of the Harvard Observatory) gave the details of further photographic observations of double stars, concluding with the following sentence: "Indeed in every direction the art seems to be susceptible of greater perfection, which may yet render possible its extension, to stars four or five magnitudes beyond our present limit (i.e., to the tenth or eleventh magnitudes)."

**Source:** *History and Work of the Harvard Observatory 1839–1927*, Solon I. Bailey, McGraw-Hill Book Co., 1931

## Comet 2019 Y4 (Atlas)—Excerpts From an Observer's Imaging Journal (continued from page 1)



C/2019 Y4 fragmentation still in progress as of 2020-04-19. Mark Slade Remote Observatory Station 2 images

Figure 3. Images taken with MSRO Station 2, April 20, 2020. In the tail, a faint fragment can be seen that has separated from the nucleus. Courtesy: Myron Wasiuta

On the night of April 20, 2020, the 12-inch telescope detected a double nucleus! (See Figure 4.). Figure 5 shows MSRO Stations 2 and 3, whose equipment was used for these observations.

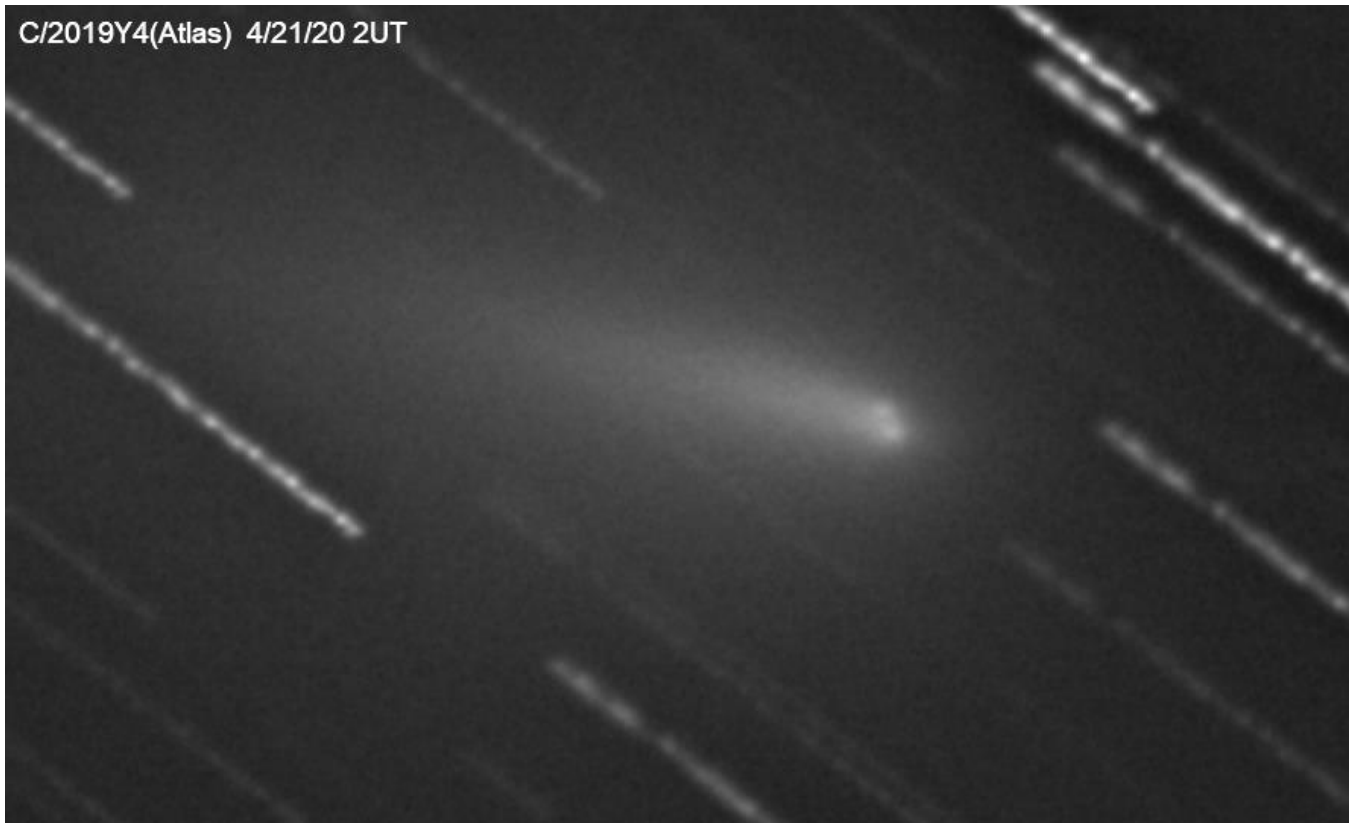


Figure 4. c2019 Y4 2020-04-21 0111-0251 UTcropped. Courtesy: Myron Wasiuta



MSRO Station 2. Courtesy: Myron Wasiuta



MSRO Station 3. Courtesy: Myron Wasiuta

As of this writing (April 24, 2020), the comet continues to disintegrate and fade. MSRO telescopes will continue to observe the comet and will post images on the [MSRO Facebook page](#). The future of this comet is uncertain, but more than likely, it will continue to fade away.

## Celestron® StarSense® Autoalign

By Ron Henke



Star Sense Autoalign. Courtesy: Celestron

StarSense takes the place of the red dot finder on the accessory ring. I still use a Telrad finder, but more on that later. The installation of StarSense is easy and can be completed in a less than 5 minutes. While the initial calibration is not difficult, it does take some time and must be followed carefully. Note that while the manual does say to plug the auxiliary cable into the Aux port, it does not say what happens if you plug the auxiliary cable into the Auto Guider port. What happens is the StarSense circuitry gets fried. Apparently, a voltage gets sent back to StarSense that it can't handle. While I haven't done this myself, I know someone who has. If StarSense is moved once installed, it will have to be recalibrated because it is trained to find the center of the field of view of the scope and a slight movement will throw that off. However, I have had the scope in and out of its carrying case several times without any problem.

StarSense is actually a small 1.2MP CMOS camera that takes four pictures of the sky and plate solves for each picture. It uses the same places in the sky each time. The numbers of stars that are plate solved for are 84 stars in the first image, 100 stars in the second, 60 stars in the third image, and 66 stars in the fourth image. The manual says you can start from any place in the sky, but I have not had good luck with this technique. Instead, I use the Telrad finder to center Polaris using MaxIm DL and the results are fine (see picture below). If the locations in the sky that StarSense uses are obstructed, StarSense can be trained to use other parts of the sky that are not obstructed.

So, what happens when I press align? With the scope centered on Polaris, the scope is slewed to the four places in the sky mentioned above and plate solved. The whole operation for the alignment of the scope/mount takes 3 minutes 37 seconds. Or, another way to look at it is, enough time to go inside and (re)fill my wine glass. The picture on the next page is the slewing to M42 after a StarSense alignment. While not perfectly centered, it is quite acceptable. Note: I used HyperStar to take this picture so it is a wide-field (f 2.2) of view. I have seen results from others using StarSense but imaging out of the back end with a focal reducer (f 6.7) and getting very similar results. One added note: All I have to see is Polaris. I do not have to see any of the other stars that it plate solves for. If StarSense can see Polaris, it can see the other stars, which means I can set up and get going earlier.

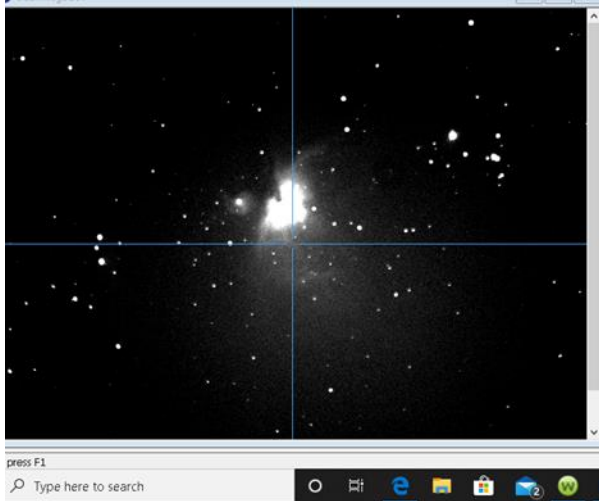


StarSense Mounted Courtesy: Ron Henke

I'm kind of a gadget guy. Okay, I am a gadget guy, and most of the time, the gadgets are useful. This is true certainly of the Celestron StarSense Autoalign. Over the last couple of years, whenever I participated in an event for the club here in Tucson or went to an evening get-together at Starizona, I saw numerous people with a StarSense device on their Celestron SCTs (see compatibility list below).

I thought, "I don't need this. I'll just keep taking 20 minutes to do my six-star alignment. Also, I'm only 68—I have years to go before kneeling down will be a problem." Well, the more I watched other people *not* have to kneel to do their alignment, the more I started to look at StarSense as not just a gadget.

So, for Christmas my wife gave me a StarSense. I bought it at the local astronomy store. (It's nice to have a really good one that's a 10-minute drive away).



Result of Slewing to M42. Courtesy: Ron Henke

Advanced VX  
CGX-L  
Astro Fi  
CPC, CPC DX  
CG-5 (w CG-5 Aux. Splitter)

What does it cost: \$389.95. Would I buy it again: Yes. The only annoying thing I can say about StarSense is the hand controller, which comes with a new one. I had difficulty reading the two line screen on the old hand controller. The screen on the new hand controller is the same size but now has four very small lines. It is difficult to read.

To end on a positive note: StarSense is a great accessory. Once it was calibrated (and pointing at Polaris) it has worked properly every time.

### Compatible Mounts

NexStar Evolution  
CGE  
CGE Pro  
NexStar SE Series  
NexStar GT (2015 models and newer w/Aux. Splitter)  
CGEM II  
CGEM, CGEM DX  
SkyProdigy  
CGX

## Follow-Up: Yerkes Observatory Saved!

By Linda Billard

The August–October 2018 issue of this newsletter featured a lead story written by Scott Busby about his “pilgrimage” to the great refractor at Yerkes Observatory. Scott reported that on March 7, 2018, University of Chicago, the owner of the complex had announced plans to wind down its activities there. As a result, the observatory would close its doors to visitors and researchers on October 1, 2018, with no prospects and no immediate plans to reopen. This was concerning not only to astronomy buffs but also to the surrounding community, neither of which wanted the complex to be replaced with condominiums or shopping venues.

*News Flash!* On March 10, 2020—2 years, almost to the day, after Scott’s visit—a [story](#) appeared announcing that the University of Chicago had donated the observatory and 50 surrounding acres to a private foundation. Local civic and business leaders created the Yerkes Future Foundation to gain control of the observatory and reopen it to the public. The foundation is seeking approval of two permits for additional parking spaces and a conditional use permit to allow mixed use buildings on the Yerkes campus. Current zoning as “parks and institutions” will not change. I guess there is some good news these days...



The 40-Inch Alvan Clark & Sons Refractor. Credit: Scott Busby

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## Seeing the Unseen: Capturing an Image a Black Hole

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By Bart Billard



Image of M87 supermassive black hole released on April 10, 2019. Source: American Physical Society (<https://april.aps.org/program/seeing-the-unseeable-capturing-an-image-of-a-black-hole>)

In early April 2019, the image above appeared on the front page of newspapers around the world following the announcement of the successful imaging of the M87 supermassive black hole. The Event Horizon Telescope Collaboration had made this first image. This April, the American Physical Society's (APS) "Virtual April Meeting" (a very large-scale analog of our recent Zoom club meetings) featured a free public science presentation on this achievement: "Seeing the Unseen: Capturing an Image of a Black Hole." The speaker, Professor Sheperd Doeleman, is an Astrophysicist at the Harvard and Smithsonian Center for Astrophysics and the Founding Director of the Event Horizon Telescope (EHT).

The Virtual April Meeting was a substitute for the canceled March meeting this year, the big annual conference held by the APS. I was impressed by clarity of the presentation and how Professor Doeleman adapted well to the online format. The presentation was intended for a general audience, and I think it was certainly on a level accessible for people interested in astronomy. In fact, I think we should try watching the lecture online as the program for one of our club meetings. It is still available to the public on Facebook or at the website shown in the caption above.

The EHT is a network of small radio telescopes distributed around the globe. The EHT collaboration included more than 200 members at 60 institutions in 20 countries/regions. Data were recorded and carefully time-stamped using atomic clocks at each observatory so that the radio waves received could be correlated and used to eventually reconstruct an image with the resolution of a telescope the size of the entire network. Combined with the rotation of the Earth over the time of each day's observations, the effective size of the network approaches the size of the Earth. This telescope network had to carry a huge amount of data, and the solution for getting the required "bandwidth" was to store the data on computer hard drives and fly crates of them on airplanes.

In the image above, I think you can faintly see light from some of the very hot disk of gases swirling around the black hole. In simulations it looks oval because of the oblique viewing angle. I see the elongated parts to the lower right and upper left of the bright ring. That ring is light from the far side of the disk of gases that is bent around the black hole in our direction. The light emitted from the disk of moving gases is concentrated in the direction of their motion to produce the brightening effect on one side of the ring. These effects are predicted by Einstein's theory of relativity, as explained in the presentation.

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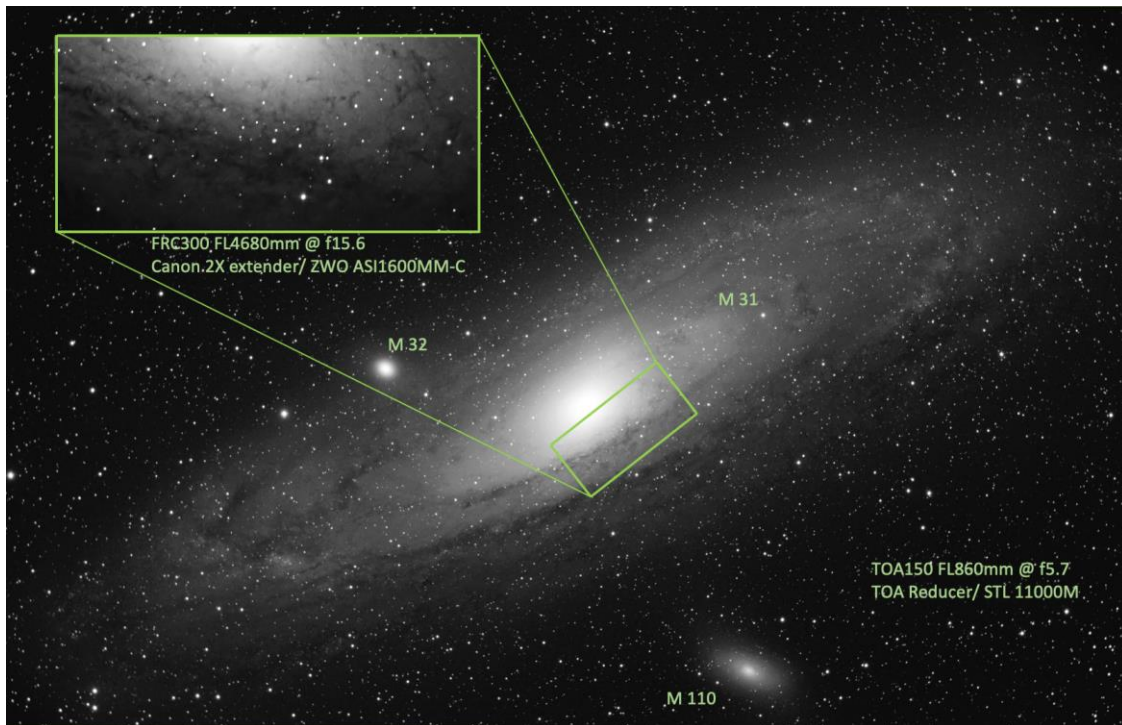
## Hunting for Globular Clusters in M110 Galaxy at Belmont Observatory

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by Scott Busby

Sometimes my Takahashi Flat-Field Ritchey-Chretien (FRC) 300-mm Cassegrain telescope really surprises me. Albeit incredible Japanese design and capability, the weather, sky transparency and seeing are ultimately responsible for how well it performs. Once in a while, everything comes together allowing me to produce some very good images and valuable scientific data.

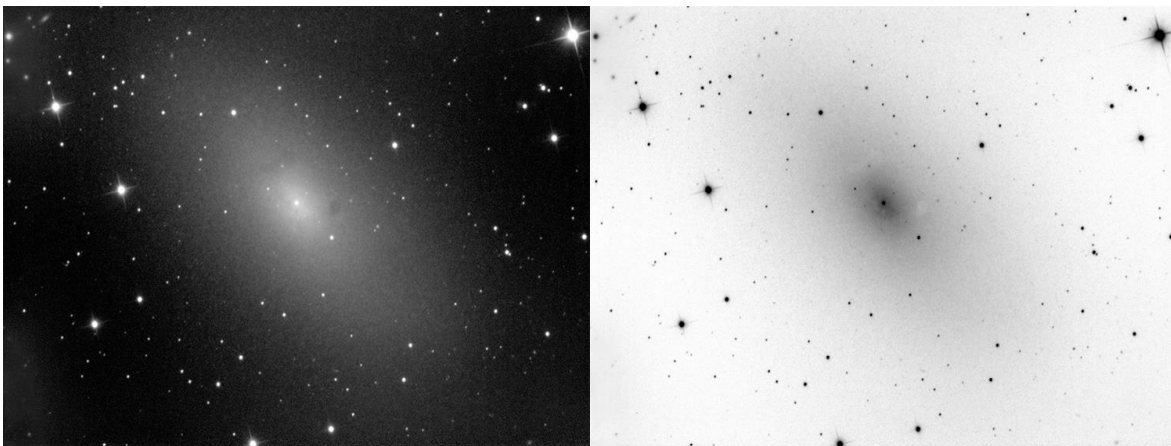
So it was back in October 2018 while I was testing the FRC300's ability to resolve nebular detail in M110, a well-known companion galaxy to M31 in the constellation Andromeda and lying about 2.69 million light years from Earth with an apparent magnitude of 8.92. As most of you already know, M110 (also known as NGC 205) is a dwarf elliptical galaxy that is a satellite of the Andromeda Galaxy<sup>3</sup> (lower center right of the image below).



M31 Belmont Observatory December 16, 2012 (Takahashi TOA150) Courtesy: Scott Busby

Although Charles Messier<sup>4</sup> never included the galaxy in his list, it was depicted by him, together with M32, on a drawing of the Andromeda Galaxy; a label on the drawing indicates that Messier first observed NGC 205 on August 10, 1773. The galaxy was independently discovered by Caroline Herschel on August 27, 1783; her brother William Herschel described her discovery in 1785. The suggestion to assign the galaxy a Messier number was made by Kenneth Glyn Jones in 1967.

M110 has a morphological classification of pec dE5, indicating a dwarf elliptical galaxy with a flattening of 50%. This galaxy is designated peculiar because there are patches of dust and young blue stars located near the center. This is unusual for dwarf elliptical galaxies in general, and the reason for this peculiarity is unclear. Unlike M32, the other companion of M31, NGC 205, does not (as of 2005) show evidence for a supermassive black hole at its center.



M110 Belmont Observatory October 8, 2018 (Takahashi FRC 300). Courtesy: Scott Busby



When I first posted my image of M110 to the Rappahannock Astronomy Club Yahoo Group page, I was doing it to show simply a well-resolved apparition of the satellite galaxy. Dr. Myron Wasiuta, Director of the Mark Slade Remote Observatory (MSRO Science) and past president of the club, took note of the photo and remarked that it was the best resolved image of M110 that he had seen. In fact, jokingly, he commented that it would be neat if I could resolve globular clusters in the little galaxy. That got me thinking that if I could find other sources indicating the presence of M110 globulars, perhaps I could then map them out.

At this point, I should comment that most amateur astronomers are familiar with what globular clusters are. A simple definition is that they are a spherical collection of stars that orbits a galactic core. I call them star balls. Globular clusters are very tightly bound by gravity, which causes their spherical shapes and relatively high stellar densities toward their centers. The name of this category of star cluster is derived from the Latin, *globulus*—a small sphere. Globular clusters are found in the peripheral boundary of our own Milky Way galaxy. However, they also seem to be inherent in other galaxies as well.

Further detailed explanation of the nature of globular clusters can best be illustrated from a few passages taken from the book *The Milky Way*, Bart J. and Priscilla F. Bok, fourth edition, Harvard University Press, Cambridge, Massachusetts, 1974.<sup>5</sup> In this book, astronomer's general understanding is best derived from observations by Harlow Shapley<sup>6</sup> and his classic investigations of 1916–1919 of globular clusters found in our own Milky Way galaxy.

Shapley first pointed out that the stars found in globular clusters differ in several respects from those found in the neighborhood of the Sun. The brightest stars are red, and they are some 3 magnitudes brighter than the brightest blue-white stars of the cluster. Early studies of the luminosity functions in globular clusters were made by Shapley nearly 100 years ago, and further studies by Allan Sandage<sup>7</sup> of the luminosity function of M3 found that from the number of stars of each absolute magnitude from  $-3$  to  $+7$ , it is possible to compute the contribution of stars of each magnitude to the total light emitted by the cluster. The value from the summation of all contributions is  $M = -8.09$ . Ninety percent of the light of the cluster comes from stars brighter than the fourth absolute magnitude, that is, brighter than the Sun, although the total number of stars like the Sun and fainter is very large.

The point in all of this, is that the combined luminance of all stars in globular clusters is significantly brighter than individual stars observed at great distances. Also, because we cannot detect and view individual stars with earthbound telescopes beyond our own galaxy, with exceptions of super novae and the Magellanic clouds,<sup>8</sup> we could however conceivably identify globular clusters and map their distributions in other nearby galaxies with large Earth-based telescopes. Here is an example of the well-known globular cluster M13.



M13 taken from Belmont Observatory, April 2020. Courtesy: Scott Busby

Based on Dr. Wasiuta's comment about surveying for and identifying globular clusters, I began immediately seeking out possible references available online, some of which were from the Palomar Digital Sky Survey (PDSS), the Sloan Digital Sky Survey (SDSS), and the SIMBAD data base. An example of information from the SDSS and SIMBAD database is shown in the illustrations below.

**Basic data :****[KLG2007] GC2 47 -- Possible Globular Cluster**

Other object types: [GL?](#) ([Ref](#), [KLG2007]), \* (Gaia)  
**ICRS** coord. (*ep*=J2000) : [00 40 28.9950846746 +41 42 17.376683963](#) (Optical) [ 0.5314 0.4261 90 ] A [2018yCat.1345....0G](#)  
**FK4** coord. (*ep*=B1950 *eq*=1950) : [00 37 45.1497795454 +41 25 49.685195055](#) [ 0.5314 0.4261 90 ]  
**Gal** coord. (*ep*=J2000) : [120.7403428300416 -21.1203030955419](#) [ 0.5314 0.4261 90 ]  
 Proper motions *mas/yr* : [4.213 3.983 \[1.044 0.903 90\]](#) A [2018yCat.1345....0G](#)  
 Fluxes (3) : [G 19.5764 \[0.0086\]](#) C [2018yCat.1345....0G](#)  
[K 16.30 \[0.09\]](#) C [2010MNRAS.402..803P](#)  
[g \(AB\) 19.76 \[0.08\]](#) C [2010MNRAS.402..803P](#)

SIMBAD  with radius  arcmin

SIMBAD  with radius  arcmin

Interactive [AladinLite](#) view

[00 40 28.995 +41 42 17.38](#)

FoV: 8.04'

2MASS  DSS  SDSS

Interactive [AladinLite](#) view

[00 40 28.995 +41 42 17.38](#)

FoV: 2.67'

2MASS  DSS  SDSS

[VizieR](#) [photometry viewer](#)

Search within radius  arcsec


[VizieR](#) [photometry viewer](#)

Search within radius  arcsec

So exactly what is SIMBAD? SIMBAD (the Set of Identifications, Measurements, and Bibliography for Astronomical Data) is an astronomical database of objects beyond the Solar System. It is maintained by the Centre de Données astronomiques de Strasbourg (CDS), France<sup>9</sup> and has a search function among several databases.



**Centre de Données astronomiques de Strasbourg**  
*Strasbourg astronomical Data Center*




Entry point to all services [t](#)



Object database [t](#)



Catalogue database [t](#)

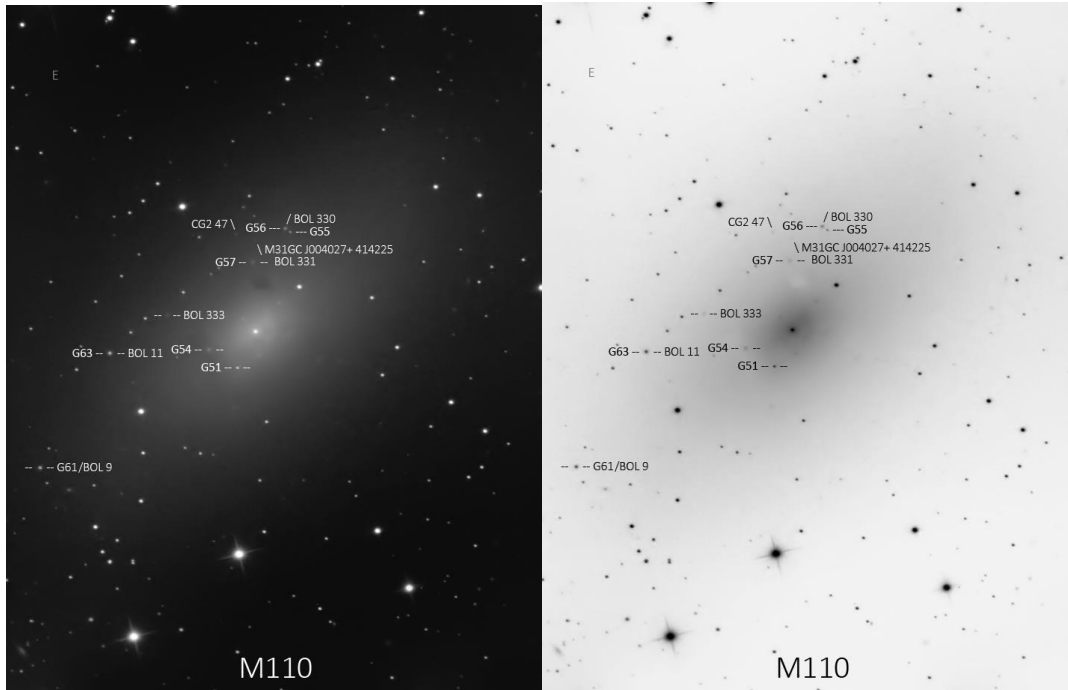


Interactive sky atlas [t](#)

SIMBAD was created by merging the Catalog of Stellar Identifications (CSI) and the Bibliographic Star Index as they existed at the Meudon Computer Centre until 1979, and then was expanded by additional source data from other catalogues and the academic literature.

The SIMBAD astronomical database provides basic data, cross-identifications, bibliography, and measurements for astronomical objects outside the Solar System. SIMBAD can be queried by object name, coordinates, and various criteria. Lists of objects and scripts can be submitted.

These basic data are all well and good, but for amateurs, they don't provide a realistic means to use them to find objects. Fortunately, SIMBAD plots the location of an object using a zoomable image view. By using star associations within the image view, we can identify the object and compare it with the same view in an image captured with our own equipment. The images below (positive/inverted) show the image of M110 taken with my Takahashi FRC300 telescope at an effective focal length of 4,680 mm and a focal ratio of f15.6. These images are annotated with the globular cluster designations derived from the CDS portal and SIMBAD interactive AladinLite view.



M110 Belmont Observatory October 8, 2018 (Takahashi FRC 300). Courtesy: Scott Busby

As you can see, I've plotted eight globular clusters in the M110 galaxy. Of course, there are more, as indicated by SIMBAD and DSS. However, these were the only ones I could positively identify in my image taken with the FRC300. The total count of globular clusters in M110 is about 25. Those other than the eight I found, were either outside the field of view of the image or not detected by my particular setup. Amazingly, there is a plethora of objects found in M110 by large telescopes in various spectral bands. So far, 1,001 objects have been found in M110. They range from individual stars (star<sup>10</sup>), carbon stars (C\*), planetary nebula (PN), globular clusters (CICl), Cepheid variables (Cepheid), red giant branch star (RGB\*), Pulsating Variable (PulsV), background galaxies (Galaxy), radio sources (Radio), UV sources (UV), X-ray sources (X), nova and nova-like objects (Nova), and molecular clouds (MolCld).

In conclusion, this is but one example of the many opportunities to use one's own telescopes and cameras for science. Certainly, the Mark Slade Remote Observatory (MSRO) is proof, with the recent data collection and interpretation of the breakup of Comet C2019 Y4 (Atlas). I should also note that when I compared images generated by my own telescope and camera configurations with those of the Palomar telescopes and Mt. Wilson instruments, it became quite obvious that the quality and capability of modern amateur telescopes approaches the same detail and quality of data achieved with these older instruments.

Sources:

1. <http://www.scopecity.com/detail.cfm?ProductID=7811&pn=Takahashi%20FRC-300%20-%20300mm%20Baker%20Ritchey%20Chretien%20Astrograph%20-%20Includes%20Tube%20Holder+Takahashi+TRC0300>

2. [https://en.wikipedia.org/wiki/Messier\\_110](https://en.wikipedia.org/wiki/Messier_110)
3. <https://space-facts.com/galaxies/andromeda/>
4. <https://www.thefamouspeople.com/profiles/charles-messier-496.php>
5. *The Milky Way*, Bart J. and Priscilla F. Bok, fourth edition, Harvard University Press, Cambridge, Massachusetts, 1974.
6. The American astronomer Harlow Shapley (1885–1972) proved that our solar system is only a peripheral member of our galaxy. He is credited with bringing Harvard Observatory into a position of preeminence in the world of astronomy.
7. <https://www.britannica.com/biography/Allan-Sandage>
8. Either of two satellite galaxies of the Milky Way galaxy, the vast star system of which Earth is a minor component. These companion galaxies were named for the Portuguese navigator Ferdinand Magellan, whose crew discovered them during the first voyage around the world (1519–22). The Magellanic Clouds were recognized early in the 20th century as companion objects to the Milky Way galaxy. When American astronomer Edwin Hubble established the extragalactic nature of what are now called galaxies, it became plain that the Magellanic Clouds had to be separate systems.
9. <https://cds.u-strasbg.fr>
10. Designation-identification codes used in the SIMBAD database.

## New Tool at Hawaii's Subaru Telescope: Prime Focus Spectrograph (PFS)

By Linda Billard

How do galaxies form and evolve? This is one of many questions that astronomers hope the Prime Focus Spectrograph (PFS) will help them answer. As you may know, spectrographs separate light into its different wavelengths, gathering information about light that is invisible to the eye. The PFS is set to come online in about 2 years at the Subaru Telescope on the summit of Mauna Kea on the Big Island of Hawaii. The project is on schedule, with the first of PFS's four spectrographs having been installed at the telescope during the second week of January.



Subaru Telescope (Mauna Kea, Hawaii) ©National Astronomical Observatory of Japan

**The Subaru Telescope, operated by the National Astronomical Observatory of Japan (NAOJ), is an 8.2-meter optical-infrared telescope that uses an adaptive optics system.<sup>1</sup> In addition, the observatory's unusual cylindrical shape is designed to reduce local air turbulence, further improving potential signal quality. The diameter of its field of view is 1.3 degrees. Subaru came online in January 1999. During its 20 years of operation, astronomers have, among other feats, used it to take the first images of a forming binary star and discovered that supernova explosions are not spherically symmetric.**

A large international group, including participants from institutions in Japan, Taiwan, Brazil, China, France, and United States, is collaborating to build the state-of-the-art instrument for installation at Subaru. PFS uses 2,400 optical fibers at the top of the existing telescope, which will allow it to take simultaneous exposures of 2,400

<sup>1</sup> Adaptive optics measures atmospheric distortions in the incoming light from an astronomical object and sends electronic signals to a deformable mirror that can change its shape rapidly to correct for these distortions. The light reflected from the telescope mirror is divided into many smaller beams or areas. When the system looks at these separate beams, some have deviated because of atmospheric turbulence. The electronic circuits in the system compute the altered shape of a mirror surface that would realign the separate beams so that they all go in the same direction. Then a signal is sent to the deformable mirror to change its shape in accordance with these electronic signals, resulting in an undistorted beam.

astronomical objects in the night sky. The data are fed to 4 spectrographs, each linked to 600 optical fibers. Testing will begin soon, and the PFS is expected to come fully online in late 2021 or early 2022.

In the United States, the PFS Northeastern Participation Group (NEPG) includes faculty from the University of Connecticut, the University of Illinois at Urbana-Champaign, Columbia University, the University of Pittsburgh, and Tufts University. Tufts Professor Danilo Marchesini is the chair of the NEPG and represents it as a member of the PFS steering committee.

Faculty participation means not only their personal involvement but substantial opportunities for other members of the university community. For example, Tufts astronomers are guaranteed 300–350 nights of access to the instrument over about 5 or 6 years for a series of research experiments and will have immediate access to the data generated. While the Tufts participants plan to study galaxy formation and actively accreting supermassive black holes, other groups will explore the origins of dark matter and dark energy, as well as the history of the Milky Way and its satellite galaxies.

To put this opportunity into perspective, it is important to remember that access to such new instruments on large telescopes is highly sought after and difficult to obtain. As part of PFS, Tufts and the other participant institutions will be able to offer expanded research opportunities to junior members of the research group (postdoctoral, graduate, and undergraduate students), potentially giving everyone the same unlimited, unrestricted access to the data.

Professor Marchesini and his faculty colleagues already have detailed plans for their nights on the PFS. Their first goal is to use it to understand how galaxies form and evolve, and in particular, how supermassive black holes at the centers of galaxies affect the evolution of the whole galaxies. They are looking at what are called the active galactic nuclei—when material falls into the supermassive black holes and emits huge amounts of radiation as they do so.

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## Transformation of the Rotunda at University of Virginia

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By Linda Billard

Anyone who has visited, studied, or taught at the University of Virginia in Charlottesville is familiar with the Rotunda building located on the original grounds of the university. The building is one of several designed by Thomas Jefferson. It became something of a memorial to students and graduates of UVA killed in war—with plaques commemorating those who died in the Civil War, World War II, and the Korean War. Originally, it served as a library, but today, doctoral students defend their dissertations in the North Oval Room, and many other events are held inside the Dome Room.



The Rotunda Planetarium. Courtesy: Dan Addison, University Communications

In October 2019, a [story](#) in the *UVAToday*, a university newsletter, reported that three graduate students in English (not Astronomy) were re-creating the night sky on the ceiling of the Dome Room. They had discovered Jefferson's original intentions for that room and were using modern digital technology to fulfill his wishes: "The concave ceiling of the Rotunda," Jefferson wrote in 1819, "is proposed to be painted sky-blue and spangled with gilt stars in their position and magnitude copied exactly." This quotes a notebook Jefferson used in his early imaginings of the University and contains sketches and lists of materials he proposed should be used. His

intention was that the stars be repositioned each day, using a lift that would elevate someone to adjust stars pinned to the Rotunda's concave ceiling. Fortunately for whoever would have been tasked with this perilous duty, the building was not completed until after Jefferson's death and so this dangerous undertaking never began.

Fast forward to academic year 2019–2020. Neal Curtis, Samuel Lemley, and Madeline Zehnder used modern day technology to achieve Jefferson's vision. The [Rotunda Planetarium](#) was displayed during student study hours Sunday through Tuesday evenings, and the Dome Room was open to the public from 6 to 10 p.m. on selected days through February 1. The students who developed the planetarium hoped to offer additional dates throughout the spring semester.

## Recent Club Events and Star Parties

By Glenn Faini, David Abbou, and Linda Billard

David Abbou gave an astronomy and space program presentation to the Mountain View HS Science Club in Stafford, VA, on January 29, 2020. There were about 20 students and 2 teachers present who had the opportunity to learn about basic astronomy, amateur astronomy, and NASA missions. He mentioned the RAC and the monthly star parties at Caledon as an avenue to becoming familiar with telescopes, constellations, and dark skies. The teachers asked him whether he could host a star party at the school before the school year ended and he had planned to try to set up an event for early May. Given our current circumstances (social distancing and the school year is being continued virtually), these plans are on hold.

February 22 was a beautiful, clear evening for a Star Party at Caledon, although it felt a lot colder than the thermometer indicated. Seeing wasn't too good at first but got better as the evening progressed. Glenn Holliday estimated that we had at least 60 guests including Cub Scouts, high school students, and various families. Glenn Faini said he counted at least seven telescopes and five RAC members in attendance. We observed Venus' gibbous phase, Betelgeuse (which didn't blow up), the Great Orion Nebula (M42), Globular Cluster M79, and Open Clusters M44 and M45. We were also thrilled to see a lone bright meteor streak through Taurus and Cetus, passing east of Venus and visibly breaking up into four or five separate meteors. The star party lasted until just after 9 p.m.

Our Caledon star parties for March, April, and May were cancelled in accordance with the Governor's executive order and the closure of the park to public events.

## Focus On: Tycho and Herodotus

By Jerry Hubbell

*(Note from the author: A version of this article was published in the March 2020 ALPO The Lunar Observer as the Focus On bi-monthly article. Part of my role as the Assistant Coordinator (Lunar Topographical Studies) is to write articles periodically on research done by ALPO contributors. To see full-size versions of the photos in this article, go to [http://moon.scopesandscapes.com/tlo\\_back.html](http://moon.scopesandscapes.com/tlo_back.html) To see the latest issue of The Lunar Observer, go to <http://moon.scopesandscapes.com/tlo.pdf>)*

This article is the last in a series on the craters in the Lunar Topographical Studies [Selected Areas Program](#) (SAP). This is a visual observing program that most beginners can easily start using a small refractor or Newtonian reflector. The observing program is designed to focus attention on areas of the Moon that have shown unusual albedo changes during the lunation period. The SAP is a great way to get familiar with some of the main features of the Moon and enjoy visually roaming over the landscape to see every tiny detail. You will find all the information needed to start this observing program in the [SAP Handbook](#).

As in the previous articles, we continue to use the [Lunar Terminator Visualization Tool \(LTVT\)](#) to do various measurements of these craters. The goal is to start using this tool to help monitor and detect the “regular and cyclical long-term variations” that may occur in these areas. To learn more about LTVT, visit the [LTVT Wiki](#). The LTVT allows you to not only measure the size of features, but also systematically measure the size of the various peaks and hills on the Moon through shadow measurements. Some of the changes in these areas involve the shifting shadows and by measuring specific locations over the long term, the apparent shift in the measured heights over time will give us information about the precision of our measurements and detect other shadow anomalies that may occur. Using the [SAP crater drawing templates](#) and the Lunar Aeronautical Charts for each crater, I will be identifying specific shadows to measure. I welcome any suggestions you may have in this regard.

In this article, I cover the craters Tycho—52 miles (86 km) and Herodotus—21 miles (35 km).

### Tycho

Figure 1 (taken from the [crater drawing outline chart](#) (SAP form) available on the ALPO website) shows the crater drawing outlines used for Tycho, and Figure 2 shows the Lunar Aeronautical Chart (LAC) view of this crater. To more easily compare the two, note that the LAC drawing is depicted rotated 180° (north up, east right).

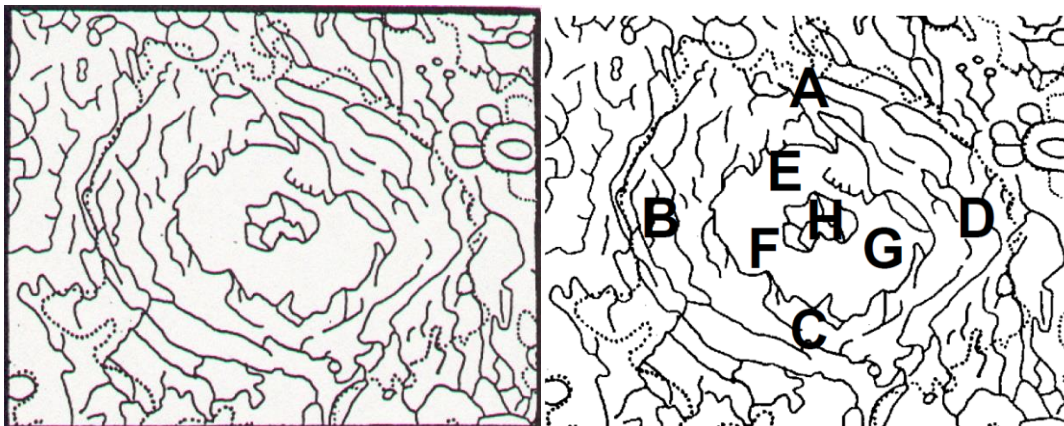


Figure 1. Outline drawing of Tycho (left) and Albedo Points for Tycho (right) (north-down, east-left)

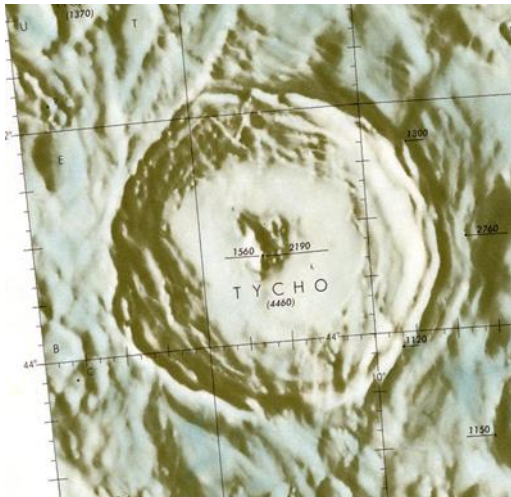


Figure 2. LAC112 chart of Tycho. (north-up, east-right)



Figure 3. 17-day Moon (Tycho), Jerry Hubbell, Mark Slade Remote Observatory (MSRO) Wilderness, Virginia, USA. 02 February 2019 0900 UT, Colongitude 122.2°. 165 mm APO refractor + 0.7x FRFF + Red Filter, QHY 163C camera, 100/150 frames, MaxIm DL, Registax 6, Photoshop. Seeing 6/10, Transparency 5/6. North/Up, East/Right.

Tycho 52 miles (86 km), was named for Danish astronomer Tycho Brahe (1546–1601), known for his very accurate and thorough astronomical observations and as a builder of astronomical instruments. He was considered the last of the naked eye astronomers. The crater is located near the center of the Southern Highlands (Selenographic coordinates 43°18'36"S, 11 21 36 W) and is the most prominent and among the brightest craters seen near and during the full Moon (Figure 3). Tycho is considered a very young crater at approximately 108 million years. In comparison, Aristarchus is 450 million years old. There are several other very large craters near Tycho in the Southern Highlands, including Maginus 99 miles (165 km), Clavius 136 miles (225 km), Longomontanus 88 miles (146 km), Deslandres 142 miles (235 km), and Stofler 76 miles (126 km).

If Tycho is examined at high power when it is near the terminator, this very young crater shows a rim structure that is very sharp, and virtually no erosion is shown in high resolution ground images and in images from lunar orbit from NASA's Lunar Reconnaissance Orbiter (LRO) (Figures 4a and 4b). Tycho's central peak is shown to good effect in Figure 4b and gives a stark view of the structure of the mountains that can be compared with ground-based images and with high magnification views in the telescope.

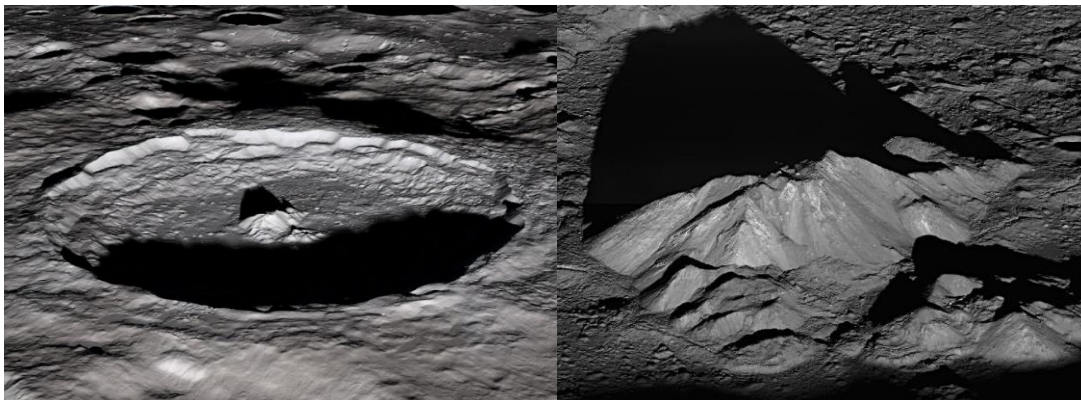


Figure 4. Tycho from Lunar Orbit taken by the LRO. Image at (left) shows the very fresh-looking lunar rim and central peak. Image b (right) shows a very sharp central peak with a boulder placed in the crater at the top. (Images courtesy NASA)

Figure 5 is a high-resolution view of crater Tycho provided by David Teske. It is an excellent example of what is possible when imaging with a modest size telescope. However, this does require excellent seeing and great technique when processing the captured data. This image easily shows features down to 2 km. It is a good exercise to compare Figure 5 with the LRO image in Figure 4a.



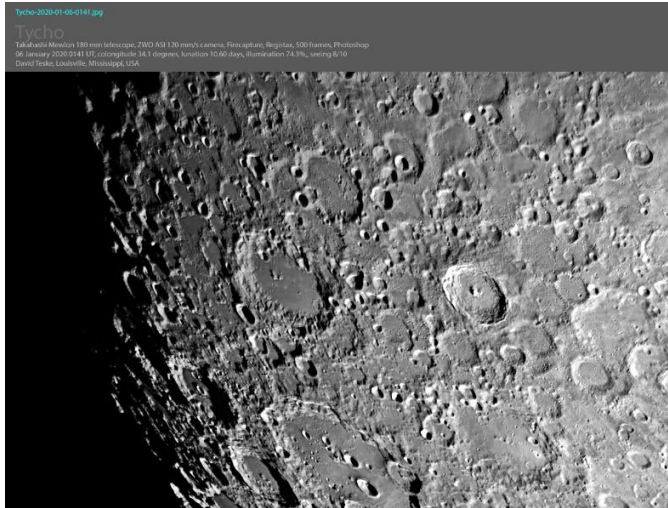


Figure 5. Crater Tycho, David Teske, Louisville, Mississippi, USA. 06 January 2020 0141 UT, Colongitude 34.1°. 180 mm Dall-Kirkham reflector telescope, ZWO ASI120mm/s CCD camera, 500 frames, Firecapture, Registax, Photoshop. Seeing 8/10, North/Up, East/Right.

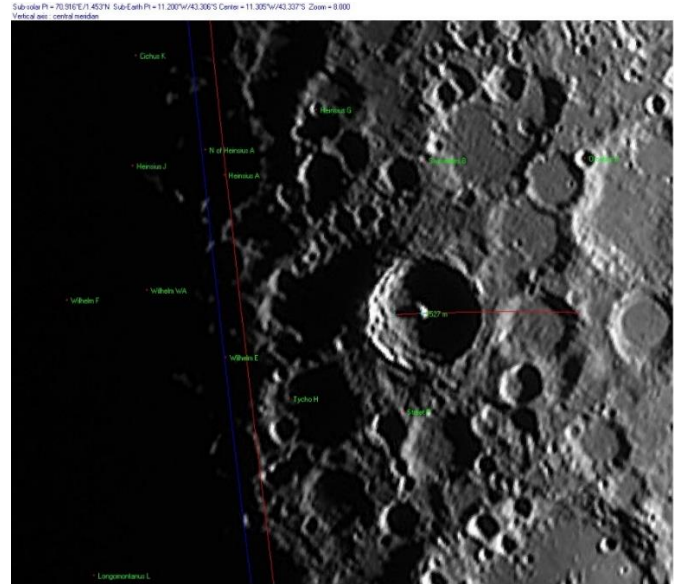


Figure 6. LTVT Measurement of Crater Tycho, Jerry Hubbell, Mark Slade Remote Observatory (MSRO) Wilderness, Virginia, USA. 21 January 2013 0122 UT, Colongitude 20.4°. 127 mm APO refractor + 2x Barlow + Red Filter, ATIK 314e camera, 200/1000 frames, Registax 6, Photoshop. Seeing 6/10, Transparency 5/6. North/Up, East/Right

The image in Figure 6 matches the image in Figure 4a in terms of the Colongitude and the way the shadow of the central peak presents itself. The measurement of Tycho’s central mountain peak can be done at different Colongitude values to refine the measurement. The LTVT measurement for Figure 6 is shown in Table 1.

Parameter*	Measured Value	LAC Value	%Difference
Crater Tycho Central Peak	≈1,527 m (5,009 ft)	≈1,560 m (5,118 ft)	-2.1%

\*This measurement is at a Colongitude of 20.4°.

Table 1. Tycho LTVT Measurements

The measurement obtained is surprisingly accurate considering all the factors involved with making it. The main factor in getting an accurate measurement is that the peak of the shadow does not fall on the crater wall and stays on the floor of the crater.

## Herodotus

The crater Herodotus 21 miles (35 km) is the smallest of all the craters in the SAP. It was named for the ancient Greek historian Herodotus (d. 425 B.C.). According to Wikipedia, Herodotus was born in the Persian Empire (modern-day Turkey). The crater Herodotus is directly adjacent to the young, bright crater Aristarchus 44 miles (33 km). Aristarchus was discussed in a previous Focus On article in this series. Located at Selenographic coordinates 23°12 0 N, 49 42 0 W, Herodotus is a crater that has been overshadowed by its much more interesting neighbor to the east. Figure 7 (taken from the [crater drawing outline chart](#) (SAP form) available on the ALPO website) shows the crater drawing outlines used for Herodotus, and Figure 8 shows the LAC view of this crater. To more easily compare with the two, note that the LAC drawing is depicted rotated 180° (north up, east right).

Herodotus appears to be a lava-filled crater owing to its smooth central plain with no discernable central peak. The central plain lies ≈1,200 meters below the crater rim according to the topographical markings on the Lunar Aeronautical Chart LAC-38 shown in Figure 8. Figure 9 shows an image of Herodotus taken by the LRO.

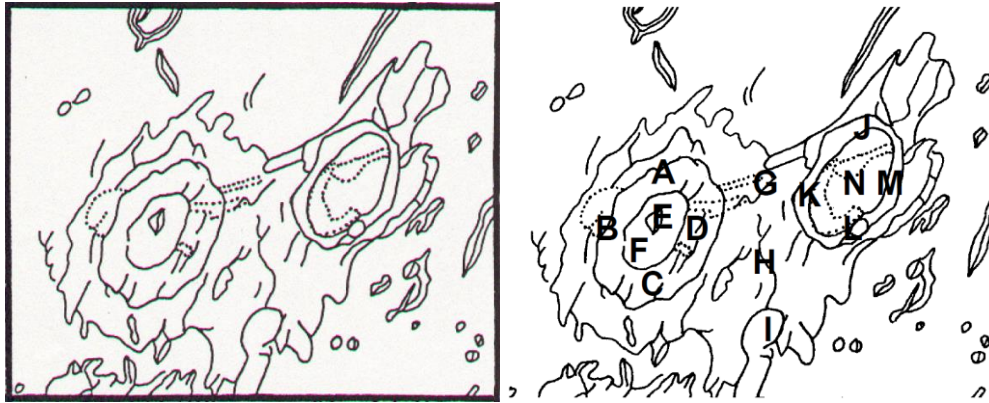


Figure 7. Outline drawing of Herodotus (left) and Albedo points for Herodotus (north-down, east-left).

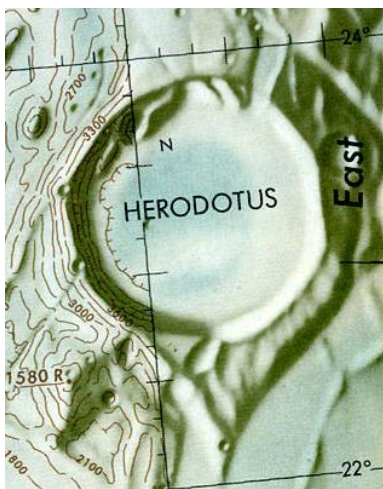


Figure 8. LAC38 chart excerpt of crater Herodotus



Figure 9. Herodotus from lunar orbit taken by the LRO. (Image courtesy NASA)

Finally, Figure 10 is a fine image of Herodotus taken by Francisco Alsina Cardinalli, from Oro Verde, Argentina. Immediately adjacent to the very bright crater Aristarchus, it provides a contrasting feature very nearly the same size as its more famous neighbor to the west. Although not the most interesting crater on the lunar surface, it still provides some interesting opportunities to observe its subtle surface markings within the walls of the crater.

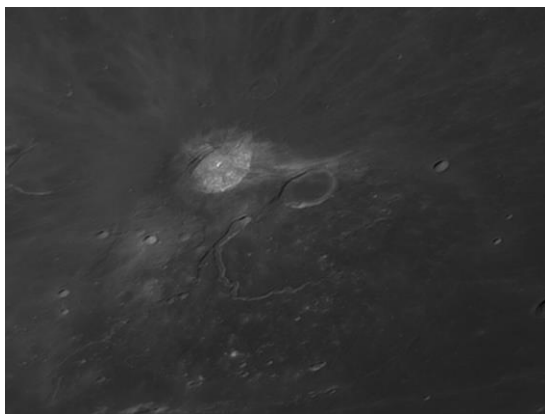


Figure 10. Crater Herodotus Adjacent to Aristarchus, Francisco Alsina Cardinalli, Oro Verde, Argentina, 19 June 2016 0540 UT, Colongitude 108.3°. 250 mm Schmidt-Cassegrain telescope, QHY5 CMOS camera + IR Filter, North/Up, East/Right

## CONCLUSION

When repeating the shadow measurements at different Colongitude values, it is important to ensure you measure from the same point on the rim of the crater. This allows you to trend the measured value for that specific point on the rim over time. Several measurements made at the same Colongitude can be averaged, and the scatter of the data can be used to estimate the precision of the measurement. You can use the program Virtual Moon Atlas (VMA) to calculate the time and date at your location for a given Colongitude value so that you can image at those times every month to gather your data. Over time, a record of the measurements will show you how your imaging technique has improved the resolution of your images.

In the next few months, I will be establishing the optimum Colongitude for each of the craters in the SAP and the selenographic longitudes and latitudes of the crater rim locations for shadow measurements. That way we all can make repeatable measurements every month and use these data to begin to understand whether we have any odd occurrences in these craters.

This article completes this series on the ALPO Lunar Section SAP. I hope you have enjoyed these articles and have started your own program of observations of these craters. I also encourage everyone to download, install, and start learning about the Lunar Terminator Visualization Tool—it is truly a great resource to better understand the topographical features of the lunar surface.

## COMPUTER PROGRAMS

Virtual Moon Atlas <https://sourceforge.net/projects/virtualmoon/>

Lunar Terminator Visualization Tool (LTVT) [http://www.alpoastronomy.org/lunarupload/LTVT/lvtv\\_20180429-HTML.zip](http://www.alpoastronomy.org/lunarupload/LTVT/lvtv_20180429-HTML.zip)

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## Highlights of Recent RAClub Presentations

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NOTE: There were no presentations at the February, March, or April meetings.

### Image of the Quarter

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Messier 51—The Whirlpool Galaxy—from Belmont Observatory, Virginia by Scott Busby



The Whirlpool Galaxy, also known as Messier 51, M51a, and NGC 5194, is an interacting grand-design spiral galaxy with a Seyfert 2 active galactic nucleus. It lies in the constellation Canes Venatici and was the first galaxy to be classified as a spiral galaxy.

This image was integrated over two nights (15/16 Apr). TT= 2 h 26 m 34 s (149 x 60s frames + 50 dark frames). On the second night, I collected an additional 35 minutes in each of the red, green, and blue channels, bringing the total integration time to about 4 hours.

Scope/mount: Takahashi FRC300/EM400T2 @ FL 2,340 mm @ f7.8  
Camera: ZWO ASI1600MM-C  
Software: Captured w/SharpCap 3.1  
Stacked w/DeepSky Stacker (DSS)  
Post-processed w/Photoshop CC