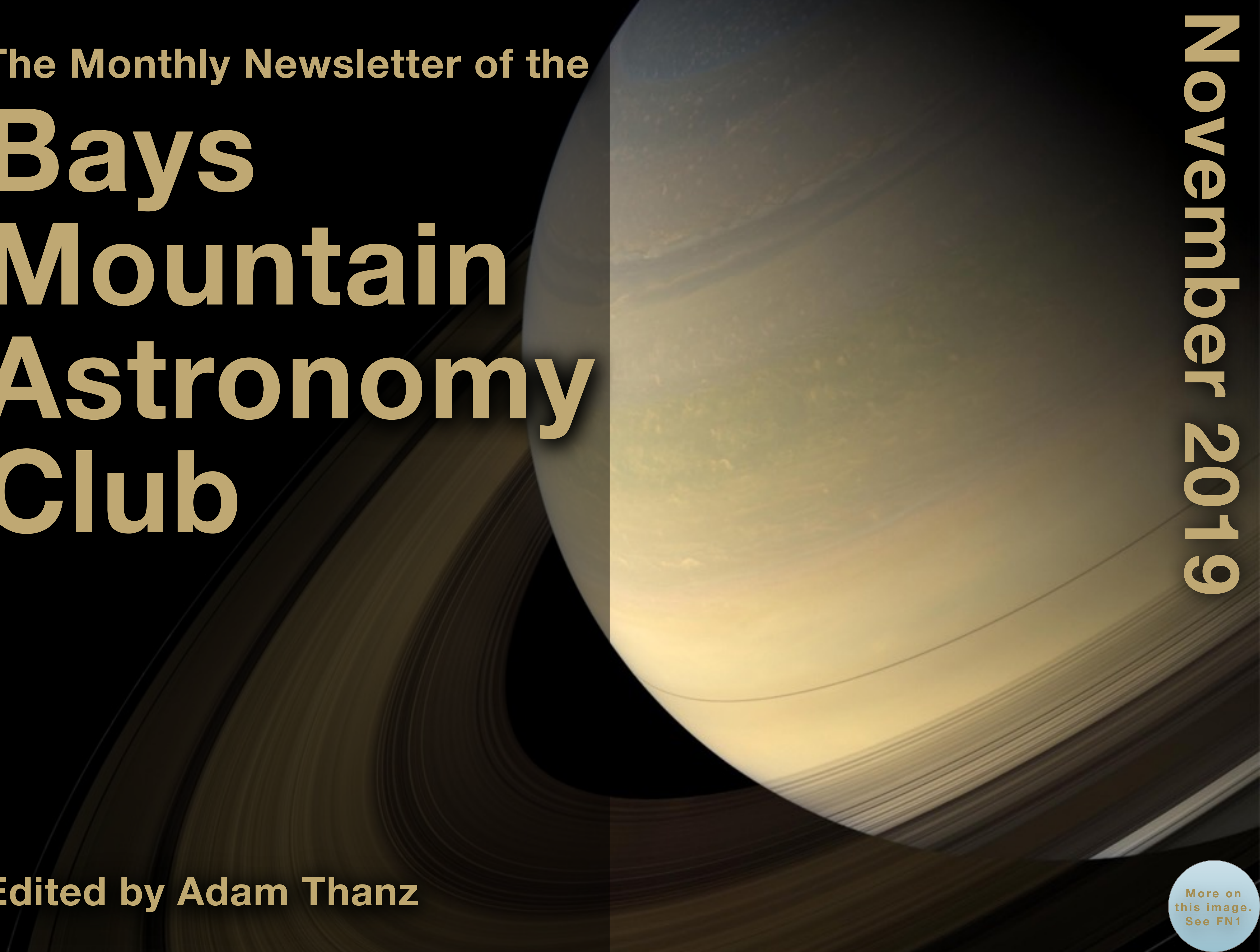
The Monthly Newsletter of the

Bays Mountain Astronomy Club

November 2019



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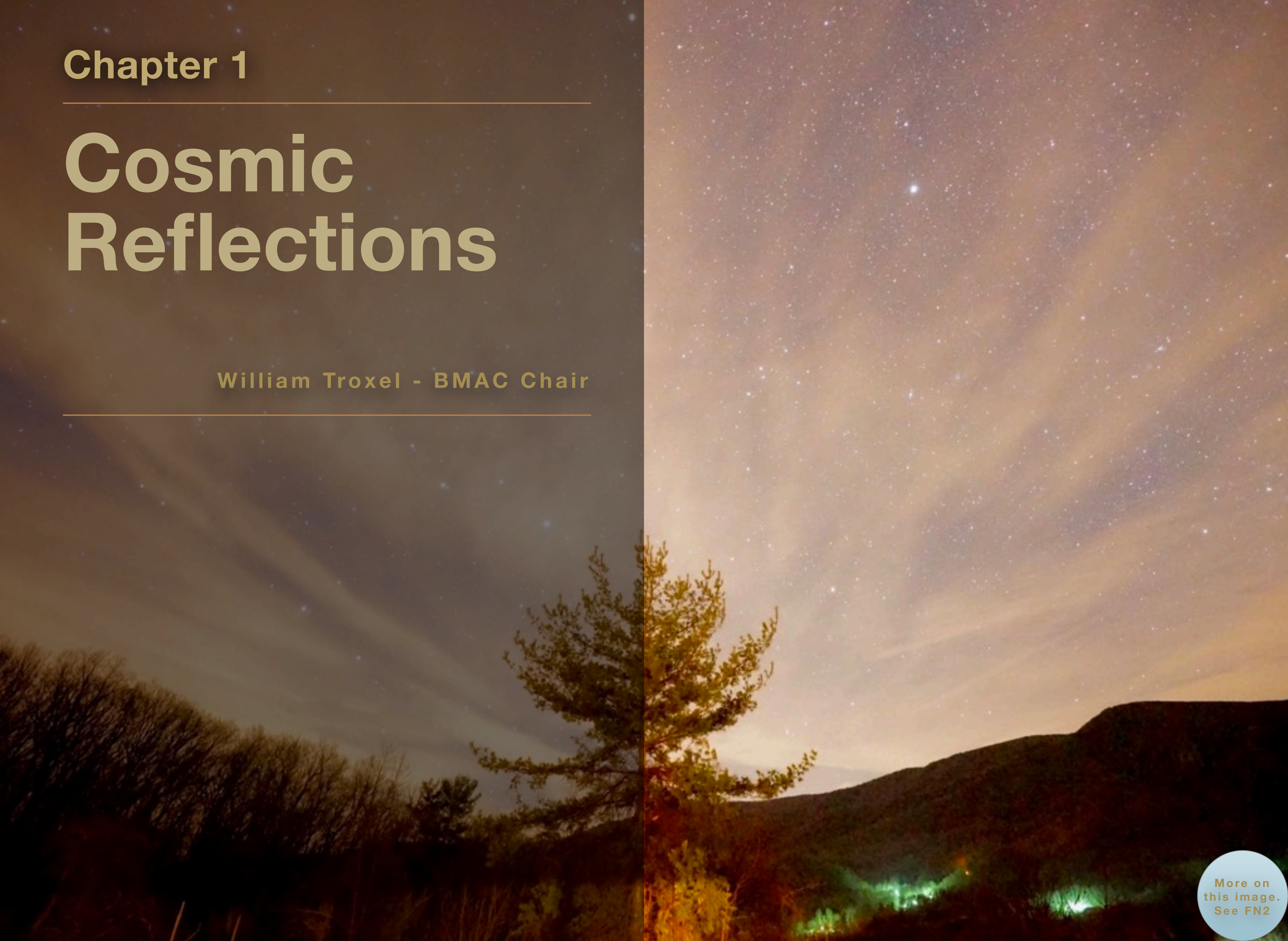
Edited by Adam Thanz

Chapter 1

Cosmic Reflections

William Troxel - BMAC Chair



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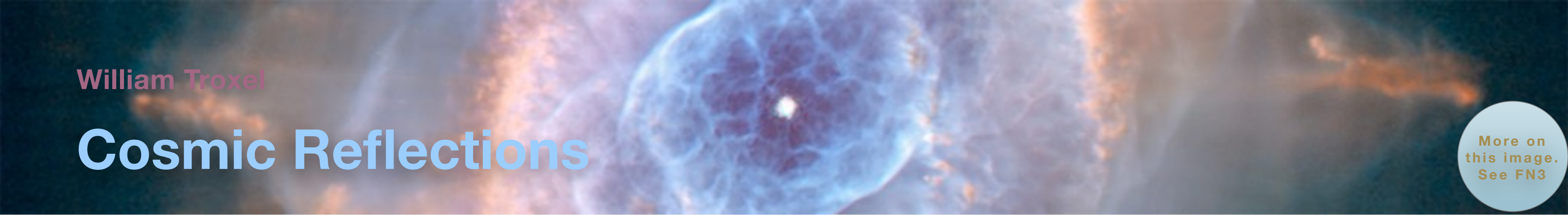


William Troxel

Cosmic Reflections

Greetings BMACers. It is hard to believe that November is already here. I want to thank everyone for coming out to help with the clean up of the observatory. The job of cleaning always goes much quicker when many people come out and help. Thanks to Shaun for sharing the aerial shots of the club cleaning and working around the observatories. You can see them later in the newsletter. You all know that October is the month we get ready for the Annual StarFest and also the first month of the weekly fall public star gazing.

Our meeting in October was focused on the members being able to get to do some observing, which I am happy to report that we were able to enjoy. Before we got into the observing, we had one of the 1st of the what I call “The Four Tens.” The program's purpose is have four short, mini presentations no longer than 10 min. each using no computers and just using creativity. We only had enough time for one presentation because we were waiting for it to get dark enough for us to see the night sky. I want to thank Christa Cartwright for being the first of our mini presentation speakers. She used a really fun activity that we all participated in to learn about a secondary mirror's purpose inside a Newtonian reflecting telescope. This is the kind of thing I was hoping would be the focus of “The Four Tens.” I hope you will consider being one of “The Four Tens” speakers in the future. I want everyone to have fun with it. The goal is to use creativity, not computers and for everyone to get used to giving a short presentation in front of a crowd.

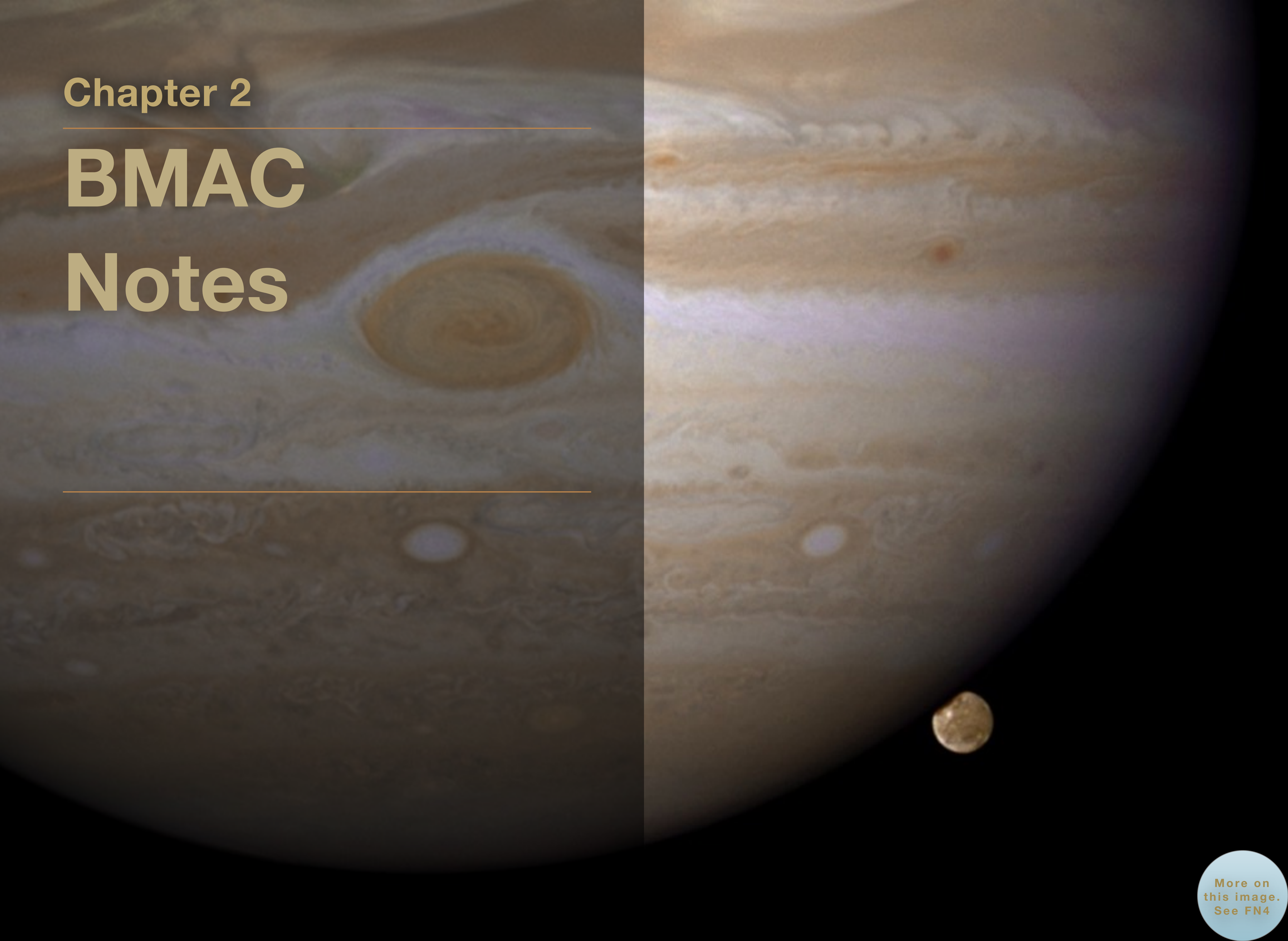
The November meeting will be "learning activities" that we'll all be able to participate in teams. It will be lots of fun and details will be provided at the meeting.

I hope everyone enjoyed StarFest. I know I did. I think it gets better each year. If you did not get to attend this one, I encourage you to consider next year. I also want to thank every one of the members who helped out during the event.

Until next time…. Clear skies.

Chapter 2

BMAC Notes



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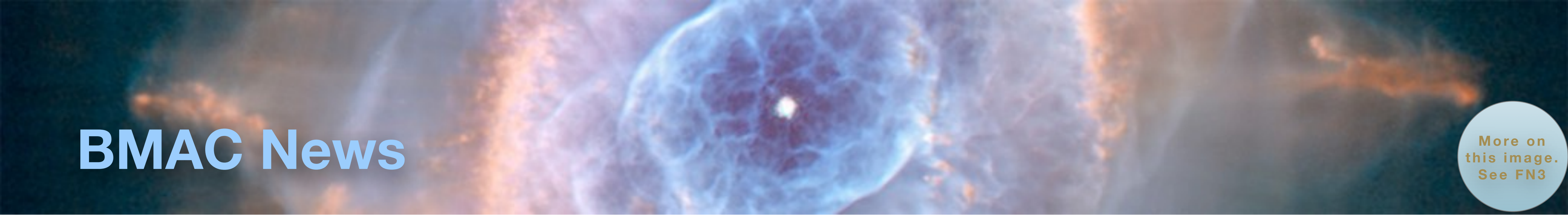


Regional Gathering of Amateur Astronomers, aka BoBfest, 1-25-2020

BoBfest 2020 will be at the Catawba Science Center in Hickory, NC.

Presentations! Vendors! Exhibitors! Door Prizes! Astronomy, Gastronomy, and Gizmology!

If you have a topic you would like to present, please let me know!

Brian Hissom, BoBfest Committee

Catawba Valley Astronomy Club

brianhissom@gmail.com, 980-241-0955

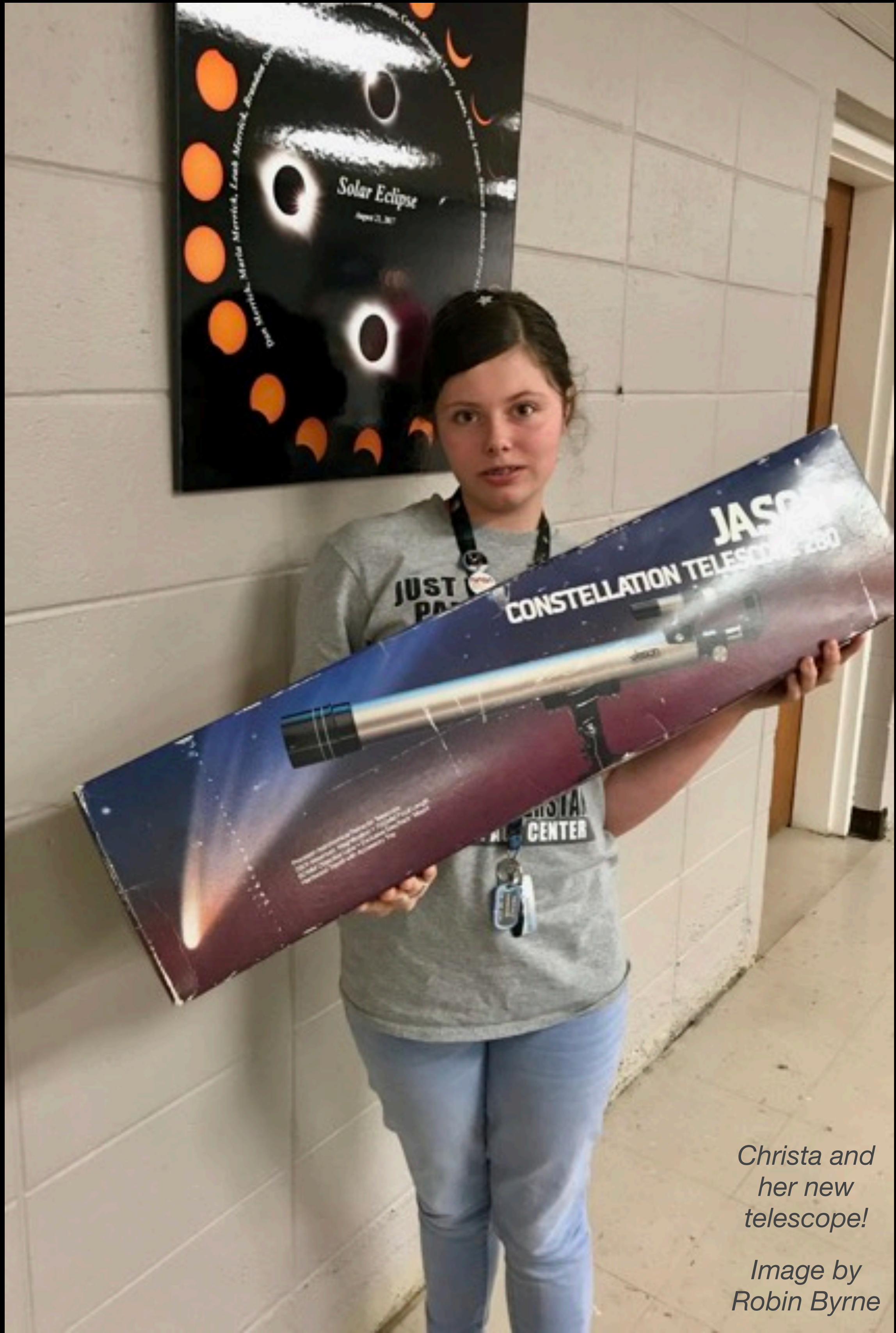
Scope for Sale

Starblast 114m self-tracking scope. It's in perfect shape.

Contact Ezra Wilson at writer3655@gmail.com

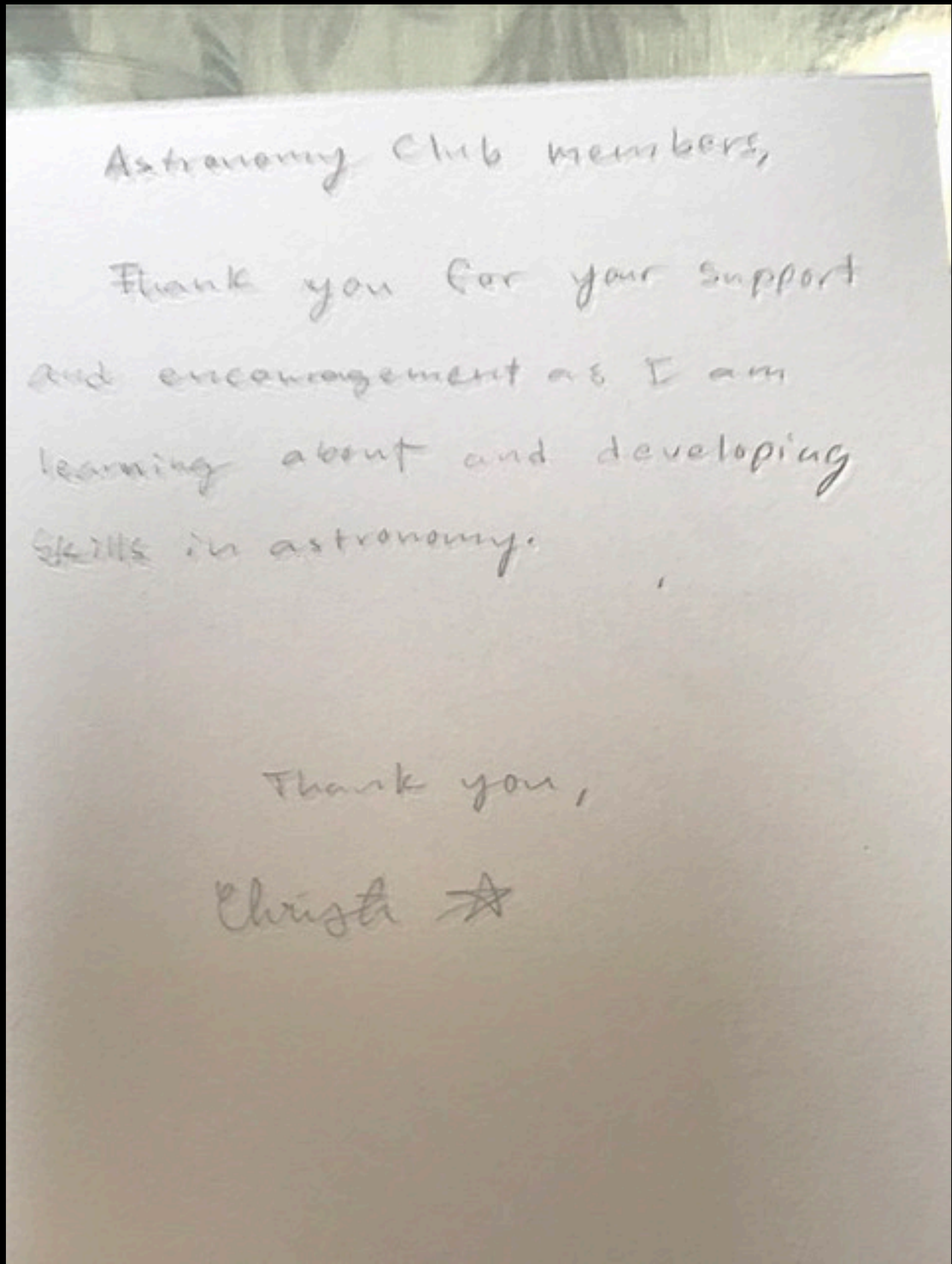
Our September 2019 speaker, Dr. Richard Ignace from ETSU talking about massive stars.

Image by Robin Byrne



Christa and her new telescope!

Image by Robin Byrne


Astronomy Club members,

Thank you for your support and encouragement as I am learning about and developing skills in astronomy.

Thank you,

Christa ☆

Observatory cleaning at BMP!

Image by Shaun Beamish

StarFest 2019

I'm happy to say that this year's StarFest event went quite well. Registration increased to 93 this year. There were a number of past delegates that wanted to attend, but had last minute schedule conflicts. I feel we would have had over 100 otherwise.

The speakers were really well received as they all had presentations representing the theme of "Exploring the Spectrum." A special hands-on workshop was added that demonstrated the radio jove receiver kit that Dr. Chuck Higgins brought.

We also sported a number of new attendees this year which is great. They became aware of Bays Mountain Park & Planetarium and the BMAC and how special they are to the community. I want to thank the club members that attended as they helped with a few behind-the-scenes chores that helps StarFest run smoothly.

Following is just a few images from the event.

StarFest 2019

BMAC Chair, William Troxel introduces the first keynote speaker. Image by Adam Thanz.

StarFest 2019

Dr. Chuck Higgins on radio astronomy. Image by Adam Thanz.

StarFest 2019

The Twilight Soirée.
Image by Adam Thanz.

StarFest 2019

Dr. Erin Smith spoke of the James Webb Space Telescope. Image by Adam Thanz.

StarFest 2019

The Panel Discussion.
Image by Robin Byrne.

StarFest 2019

Dr. Chuck Higgins leads a workshop on using the Radio Jove receiver. Image by Robin Byrne.

StarFest 2019

Edgar Bowlin III leads the Mercury transit activity during the public planetarium show. BMAC member Christa Cartwright is holding a scale model of Mercury. Image by Robin Byrne.

StarFest 2019

The group photo.
Image by Adam Thanz.

StarFest 2019

Dr. Tyson Littenberg spoke of gravity waves. Image by Robin Byrne.

StarFest 2019

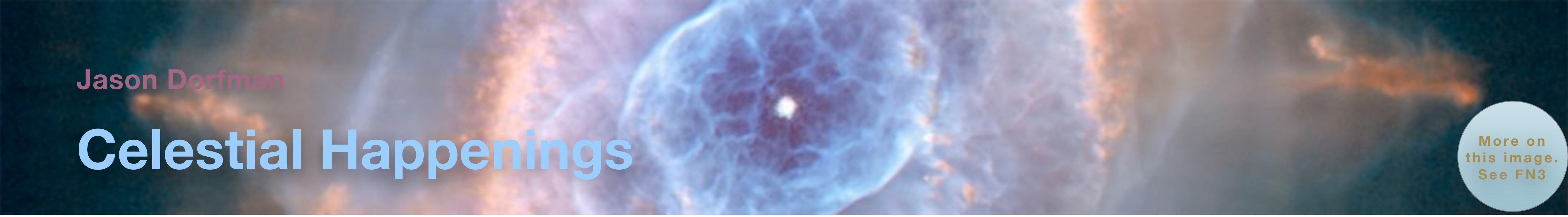
Dr. Stephen Reynolds on high energy astrophysics. Image by Adam Thanz.

Chapter 3

Celestial Happenings

Jason Dorfman

More on this image. See FN5



Jason Dorfman

Celestial Happenings

Mercury Transits the Sun

On the 11th of this month, the small, rocky world of Mercury will cross directly in front of the Sun. This transit of Mercury is the fourth of only 14 that will occur this century, making it a somewhat rare celestial event. Though the last Mercury transit was just 3.5 years ago, the next will not occur until November 13, 2032, 13 years from now. Read on to learn a bit about the orbital mechanics of transits, why the timing of Mercury transits seems so complex, and where and when to see the upcoming transit.

What is a transit?

A transit occurs when a planet or Moon is between the Sun and Earth (Inferior Conjunction) and is also crossing through the Earth's orbital plane (the Ecliptic). Ignoring smaller Solar System objects like asteroids, there are only three objects that can be seen to transit the Sun from Earth - Mercury, Venus and the Moon. For the Moon, we don't normally call them Lunar Transits, but instead refer to them as Solar Eclipses. Venus and Mercury are the only two planets that transit the Sun because their orbits are within Earth's orbit. If the orbital planes of Venus, Mercury and the Moon were parallel with Earth's orbital plane, then we would see transits every time these objects reached inferior conjunction. Obviously, this is not the case and is why transits are rare events.

The orbit of Mercury is tilted 7 degrees with respect to Earth's orbit. Because of the tilt of its orbit, Mercury sometimes lies above the ecliptic and sometimes below. There are two points along its orbit in which it crosses through the plane of Earth's orbit. These are called Orbital Nodes. The point where Mercury crosses from below the ecliptic to above the ecliptic (moving north) is known as the Ascending Node and where it crosses from above to below the ecliptic (moving south) is called the Descending Node. It is only when Mercury is crossing through one of these two orbital nodes that a transit can occur. Currently, Mercury crosses through the descending node within a few days of May 8 and through the ascending node within a few days of November 10.

However, for a transit to occur, the Earth must also be in the right place. If we draw a line connecting the two orbital nodes for Mercury, we see the line of intersection of Mercury's orbital plane with the orbital plane of Earth. This line is called, as you can probably guess, the Line of Nodes and passes through the Sun. The Earth must be positioned where the Line of Nodes intersects its orbit when Mercury crosses through the ecliptic plane for a transit to occur. (See images 1 & 2)

Periodicity of Mercury Transits

So, how often does this unique alignment happen? If you look at a timetable for past and future Mercury Transits, you'll see that they are separated by 3.5, 7, 9.5, 10, or 13 years. This odd set of time intervals seems a bit complex at first, but, if you'll bear with me, we can find the patterns that led to these intervals. Let's start by looking at how often May transits occur and November transits occur, separately. Mercury orbits the Sun every 87.969 days and the Earth every 365.256 days. Beginning with the 13 year interval, thirteen orbits of Earth corresponds to nearly 54 orbits of Mercury, but is short from a perfect fit by 2.01 days. If we consider a longer period of 33 years (two 10 year intervals + a 13 year interval), we get a closer fit which corresponds to 137 orbits of Mercury minus just 1.67 days. If we add another 13 year interval to this 33 year period (46 years), we get an even better orbital alignment between the two planets. After 46 orbits of Earth, Mercury orbits the Sun 191 times plus only 0.34 days. The path across the Sun of Mercury is also similar for both May and November transits separated by this 46 year period. Based upon this, the 46 year period has become a useful way to organize the transits of Mercury into a series similar to the Saros series for solar and lunar eclipses. The upcoming transit belongs to series 6, while the next one belongs to series 4.

Due to the procession of Mercury's orbit, a given series will only contain a limited number of transits, which is different for May transits than November transits. For May transits, Mercury is traveling at close to its minimum velocity, having just passed through Aphelion or its greatest distance from the Sun about a month earlier. The relative position of Mercury with respect to the Sun shifts about 200" with each transit, which results in a fewer number of transits for the May series. They last about 10 cycles or 414 years. For November transits, however, Mercury is traveling at close to its maximum velocity, as they occur just a few days before the planet reaches perihelion. A November transit series last about twice as long as a May series because the relative position of Mercury with respect to the Sun shifts by only about 100" with each transit. There are usually about 6 transit series happening concurrently and, because the November series last twice as long, November transits occur twice as often as May transits. Returning to the original intervals between transits, we can now say that they are all due to longer harmonics between the orbits of Mercury and Earth, which is a somewhat complex pattern due to Mercury's highly elliptical orbit.

Transit Details for November 11, 2019

For the upcoming transit, First Contact is at 7:35 a.m. EST. This is when the edge of the planet just reaches the eastern edge of the

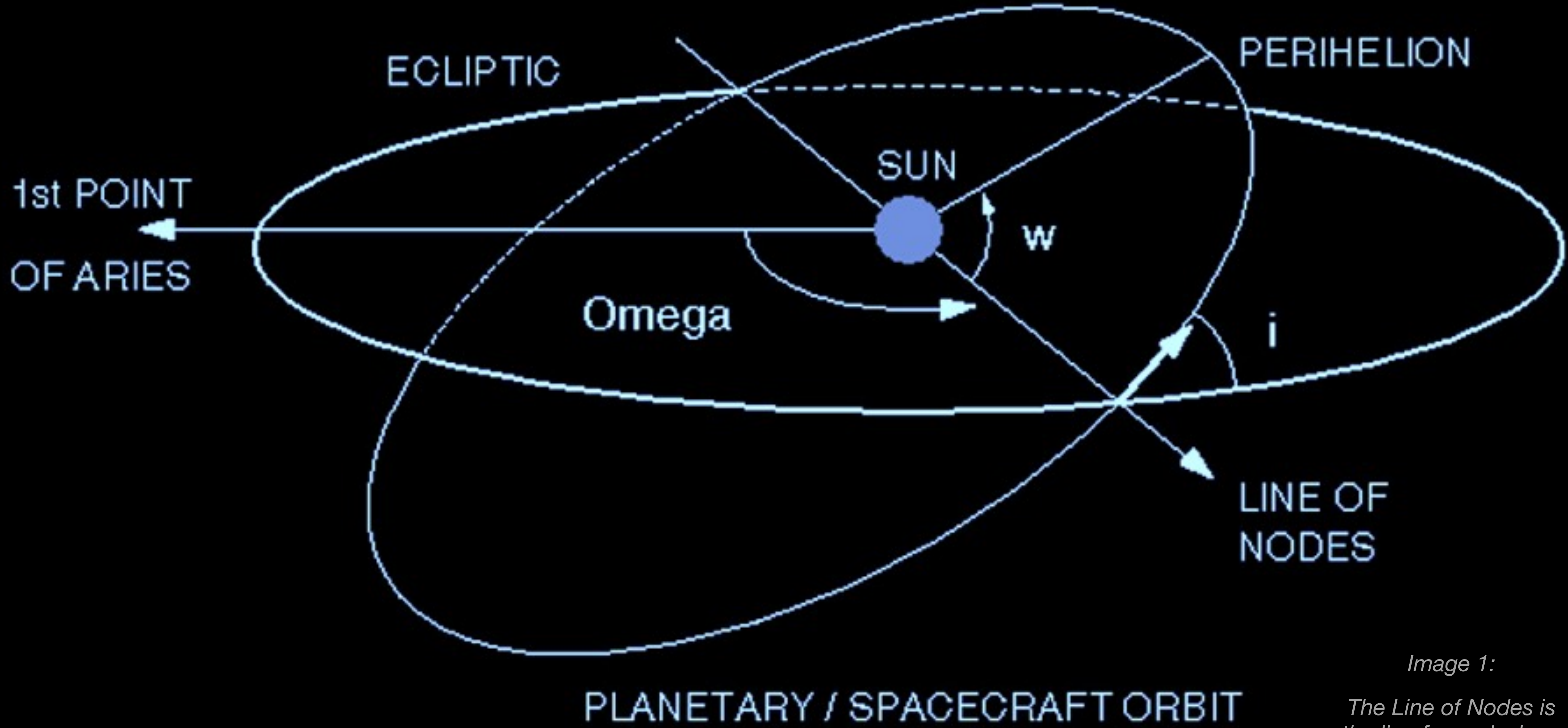


Image 1:

The Line of Nodes is the line formed where the plane of Earth's orbit is intersected by the orbital plane of another object. (ESA)

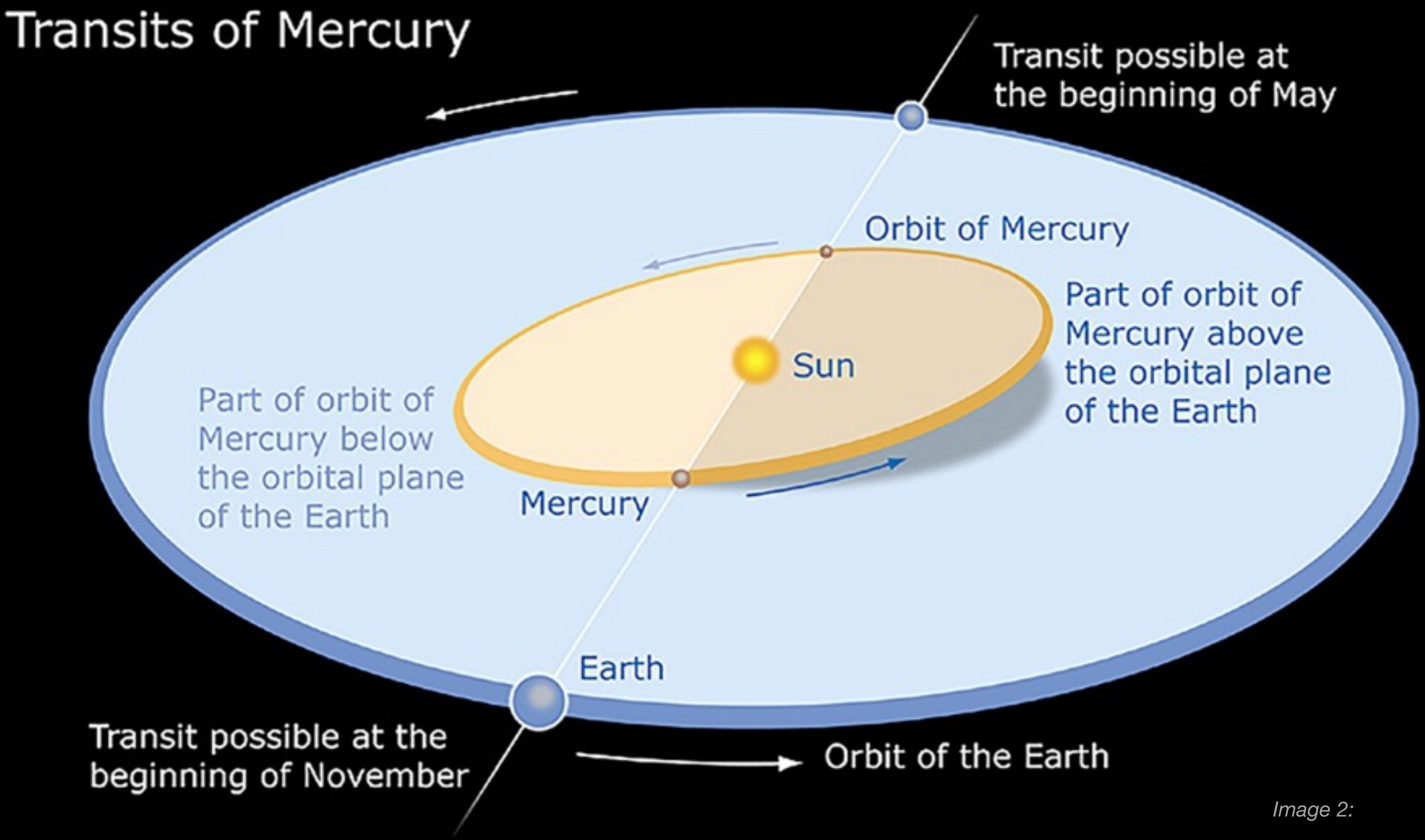


Image 2:

The Sun, Earth and Mercury are in alignment along the Line of Nodes when a transit occurs.

Sun. The point of first contact is technically impossible to see because there's no way to see the black disk of Mercury next to the bright disk of the Sun. What you will see just after that is the planet begin to take a growing bite out of the Sun's edge. Look for this about 25 degrees south of east or about 8 o'clock, if the Sun were a clock face. Two minutes later, Mercury will have completely crossed the edge and will be visible against the Sun's disk — this is known as Second Contact and happens at 7:37 a.m. EST. Over the next 5.5 hours, you'll see Mercury as a small circle with a sharp edge slowly making its way across the face of the Sun. It will appear different from any sunspots, which have rough, feathered edges to them. As we saw earlier, for November transits, Mercury is nearing perihelion and thus closer to the Sun. As a result, Mercury is farther from Earth and appears as a smaller disk than during May transits. Mercury will appear to 1/194 the size of the Sun. The angular size of Mercury will be about 10" while the Sun will be 1937". The point of Greatest Transit occurs at 10:19 a.m. EST. The transit will last until just after 1 p.m. EST with Third Contact at 1:02 p.m. and Fourth Contact at 1:04 p.m. See the included images for the path of Mercury across the Sun and where the transit will be visible from around the world.

Public Observing at Bays Mountain

There will be a special observing event at the Bays Mountain Observatories for the transit. The event begins at 10 a.m., after the transit has started, because we must wait for the Sun to climb high enough to be visible above the Eastern tree-line. We will observe the rest of the transit until it ends just after 1 p.m. Because Mercury will be just a small circle against the Sun's disk, a magnified view through filtered telescopes will allow you to see the planet's disk more easily. We will be observing with both white light and hydrogen alpha filters. Please join us! If you are a volunteer and would like to help out with observing or bring your own properly filtered telescope or binoculars, please plan on showing up around 9 a.m. at the observatories. Of course, this is all weather dependent. The event will be canceled if it's too cloudy or there is rain.

References:

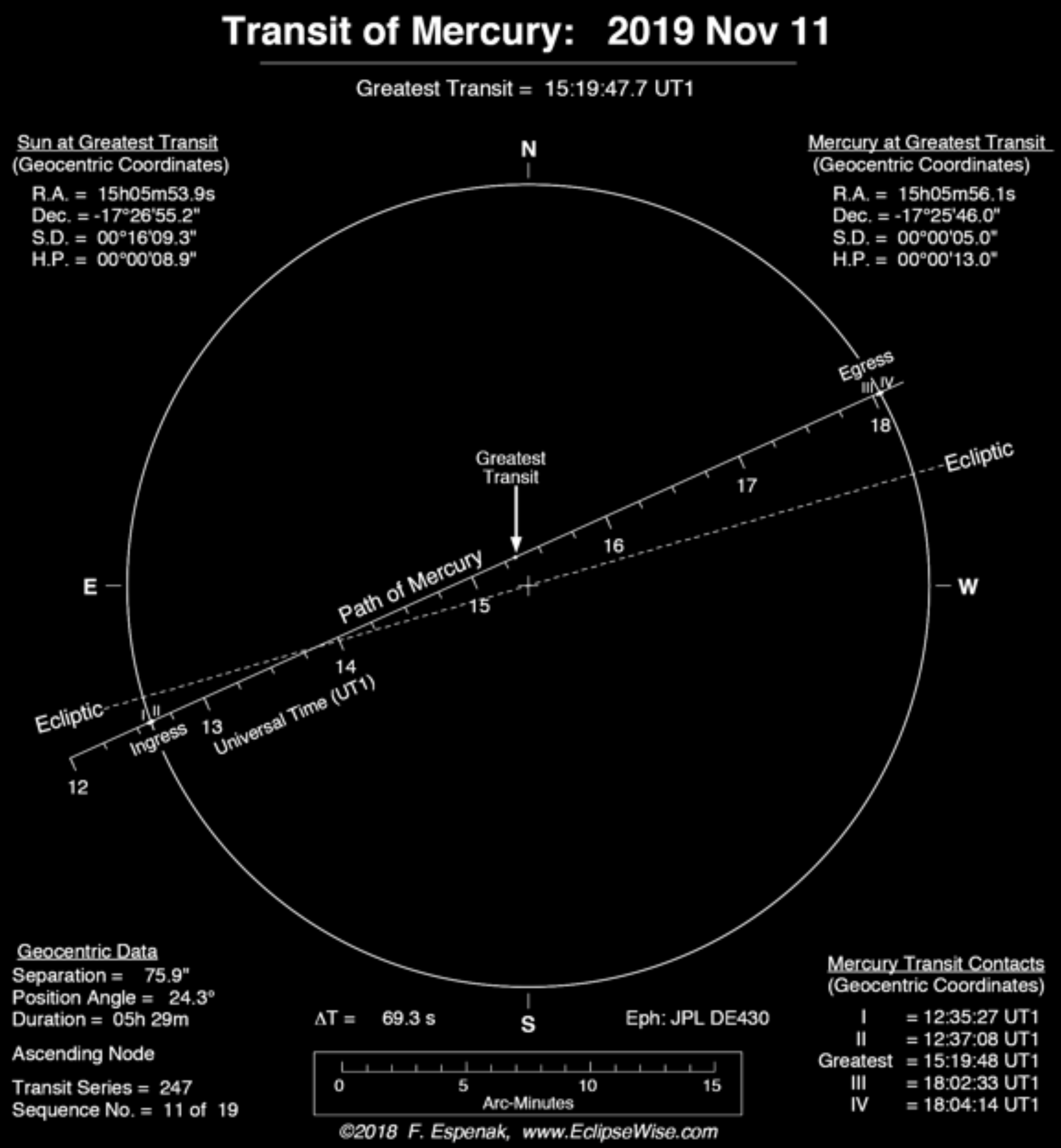
Seven Century Catalog of Mercury Transits: 1601 CE to 2300 CE, https://eclipses.gsfc.nasa.gov/transit/catalog/MercuryCatalog.html (October 15, 2019)

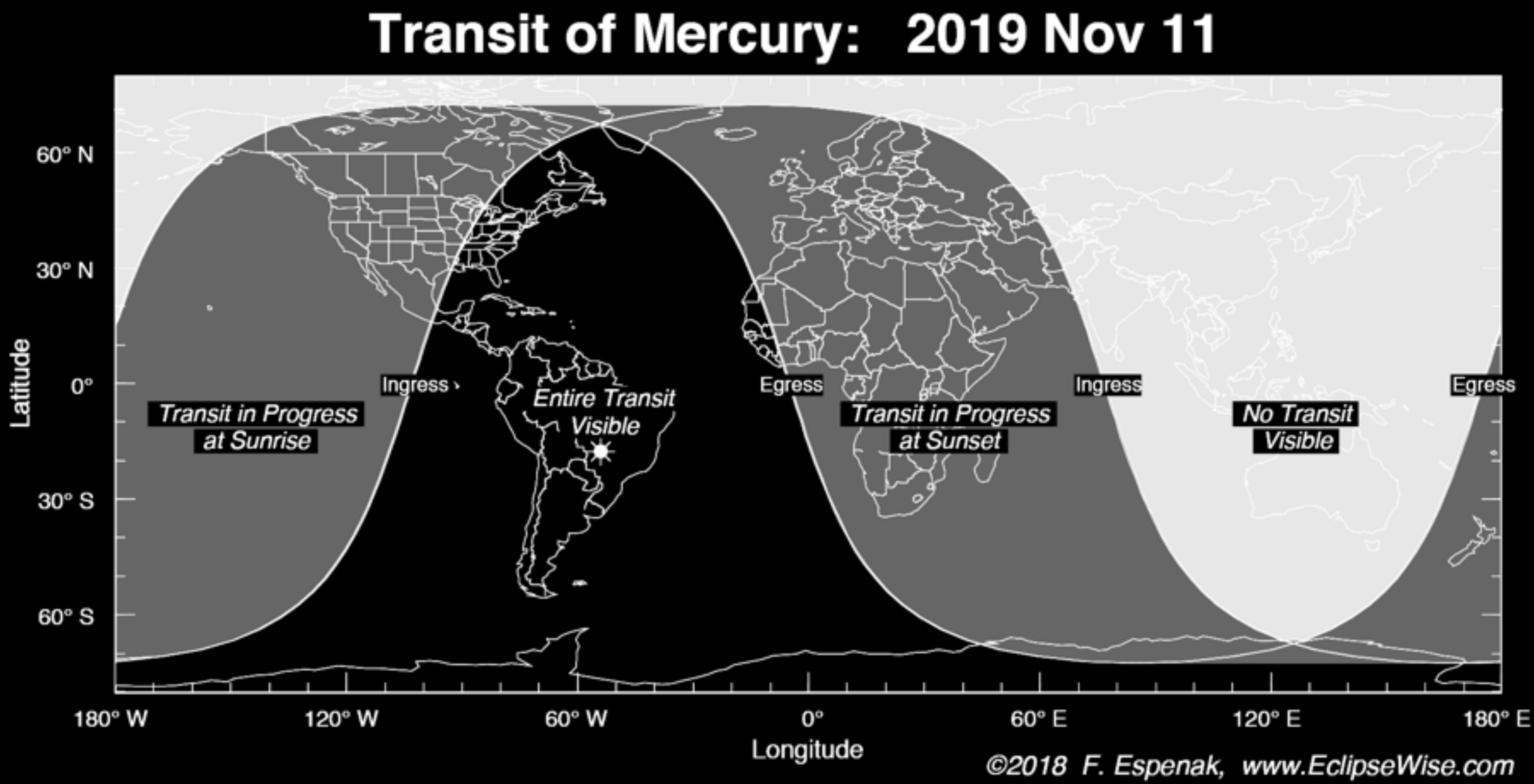
https://en.wikipedia.org/wiki/Transit_of_Mercury (October 15, 2019)

https://en.wikipedia.org/wiki/Transit_of_Venus (October 15, 2019)

https://en.wikipedia.org/wiki/Orbital_node#Node_distinction (October 15, 2019)

Espenek, Fred, 2019, 2019 Transit of Mercury, http://www.eclipsewise.com/oh/tm2019.html (October 15, 2019)


Transit of Mercury: 2019 Nov 11
Greatest Transit = 15:19:47.7 UT1
Sun at Greatest Transit
(Geocentric Coordinates)
R.A. = 15h05m53.9s
Dec. = -17°26'55.2"
S.D. = 00°16'09.3"
H.P. = 00°00'08.9"
Mercury at Greatest Transit
(Geocentric Coordinates)
R.A. = 15h05m56.1s
Dec. = -17°25'46.0"
S.D. = 00°00'05.0"
H.P. = 00°00'13.0"
N
E
W
S
Greatest Transit
Path of Mercury
Ecliptic
Ecliptic
Egress
III IV
I II
Ingress
Universal Time (UT1)
12
13
14
15
16
17
18
Geocentric Data
Separation = 75.9"
Position Angle = 24.3°
Duration = 05h 29m
Ascending Node
Transit Series = 247
Sequence No. = 11 of 19
ΔT = 69.3 s
Eph: JPL DE430
0
5
10
15
Arc-Minutes
©2018 F. Espenak, www.EclipseWise.com
Mercury Transit Contacts
(Geocentric Coordinates)
I = 12:35:27 UT1
II = 12:37:08 UT1
Greatest = 15:19:48 UT1
III = 18:02:33 UT1
IV = 18:04:14 UT1


Transit of Mercury: 2019 Nov 11
60° N
30° N
0°
30° S
60° S
Latitude
Ingress
Egress
Ingress
Egress
Transit in Progress
at Sunrise
Entire Transit
Visible
Transit in Progress
at Sunset
No Transit
Visible
180° W
120° W
60° W
0°
60° E
120° E
180° E
Longitude
©2018 F. Espenak, www.EclipseWise.com

Chapter 4

The Queen Speaks

Robin Byrne

Robin Byrne

Happy Birthday Edmond Halley

This month marks the 363rd birthday of a man solely associated with comets, but who did so much more. Edmond Halley was born November 8, 1656 in Haggerston, England near London. The son of a wealthy business man, Halley attended St. Paul's School in London. In 1673, Edmond entered Queen's College, Oxford, where he was introduced to John Flamsteed. Unlike many of the people we have honored in this column, Halley actually studied to become an astronomer, partly from Flamsteed's encouragement.

At this time, Flamsteed was compiling a catalog of northern stars. Halley decided to do the same for southern stars. In November of 1676 Halley left school and set sail for St. Helena, Britain's southernmost territory. By January 1678 he had positions of 341 stars. The catalog of these stars was the first to be published containing positions of southern stars determined using a telescope. Halley's reputation was set. Because of his work on the catalog, he was given an MA degree from Oxford, and in 1678 Halley was elected a fellow of the Royal Society.

In 1684, Halley first met Isaac Newton. It was at Halley's insistence that Newton agreed to publish his Principia. However, at the time, the Royal Society was having financial troubles, so Halley paid for all the publication costs out of his own pocket.

Halley was involved in many scientific endeavors. In 1686, Halley published the first meteorological chart of prevailing winds around the world. In 1693, he published tables relating mortality and age, which set the standard for life insurance actuarial tables. From 1698-1700, Halley commanded the war ship "Paramour Pink" on the first sea voyage devoted solely to science - observing variations in compass readings in the South Atlantic. Halley also noticed the positions of the stars Sirius, Procyon and Arcturus had changed since earlier observations. He had discovered 'proper motion' of stars. Prior to this discovery, it was assumed that the stars were fixed in their positions in the sky.

It wasn't until 1705 that Halley's name became associated with the study of comets. In his book A Synopsis of the Astronomy of Comets, Halley described parabolic orbits of 24 comets and showed that 4 comets (from 1456, 1531, 1607, and 1682) were so similar they must be the same comet. He predicted the comet would return in 1758. Many were skeptical of this prediction.

Edmond Halley, early 18th Cen.

Although Halley did not live to see its return (he died in 1742), the comet did return and has continued to return every 76 years.

Edmond Halley was responsible for many ‘firsts,’ but it is Halley’s Comet that has made his name so well known. It is fitting that each generation has a chance to remember this great astronomer upon the return of ‘his’ comet.

References:

The New Encyclopedia Britannica

A Biographical Dictionary of Scientists. Trevor Williams, Ed.

Chapter 5

Space Place

More on this image. See FN6

David Prosper

The Messenger Crosses the Sun: Mercury Transit 2019

Did you know that there are two other objects in our skies that have phases like the Moon? They're the inner planets, found between Earth and the Sun: Mercury and Venus. You can see their phases if you observe them through a telescope. Like our Moon, you can't see the planets in their "new" phase, unless they are lined up perfectly between us Earthlings and the Sun. In the case of the Moon, this alignment results in a solar eclipse; in the case of Mercury and Venus, this results in a transit, where the small disk of the planet travels across the face of the Sun. Skywatchers are in for a treat this month, as Mercury transits the Sun the morning of November 11!

You may have seen the transit of Venus in 2012; you may have even watched it through eclipse glasses! However, this time you'll need a solar telescope to see anything, since eclipse glasses will only reveal the Sun's blank face. Why is that? Mercury is the smallest planet in our Solar System, and closer to the Sun (and further away from Earth) during its transit than Venus was in its 2012 transit. This makes Mercury's disk too small to see without the extra power of a telescope. Make absolutely certain that you view the transit via a telescope equipped with a safe solar filter or projection setup. Do NOT combine binoculars with your eclipse glasses; this will instantly burn a hole through the glasses – and your eyes! While most people don't have solar telescopes handy, many astronomy clubs do! Look for clubs hosting Mercury transit observing events near you at bit.ly/findnsn (USA) or at bit.ly/awbtransit (worldwide).

What a fun opportunity to see another planet during the day! This transit is expected to last over five hours. Folks on the East Coast will be able to watch the entire transit, weather permitting, from approximately 7:35 a.m. EST until around approximately 1:04 p.m. EST. Folks located in the middle of North America to the west coast will see the transit already in progress at sunrise. The transit takes hours, so if your weather is cloudy, don't despair; there will be plenty of time for skies to clear! You can find timing details and charts via eclipse guru Fred Espenak's website: bit.ly/mercurytransit2019

Mercury's orbit is small and swift, and so its position in our skies quickly changes; that's why it was named after the fleet-footed messenger god of Roman mythology. In fact, if you have a clear view of the eastern horizon, you'll be able to catch Mercury again this month! Look for it before dawn during the last week of November, just above the eastern horizon and below red Mars.

More on this image. See FN8

Wake up early the morning of November 24th to see Mars, the Moon, and Mercury form a loose triangle right before sunrise.

Discover more about Mercury and the rest of our Solar System at nasa.gov.

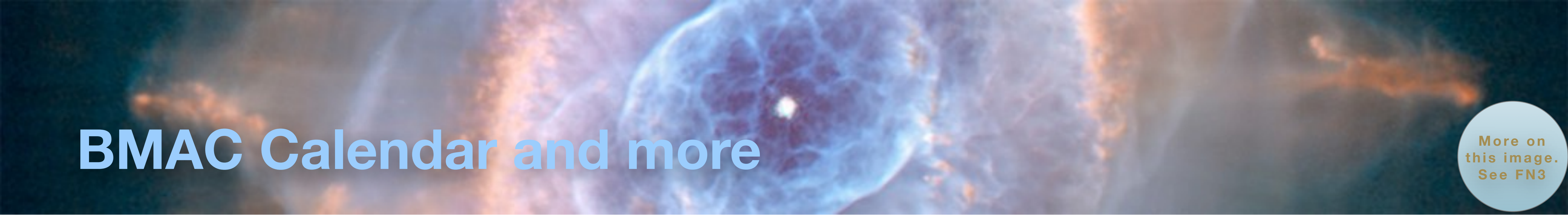
This article is distributed by NASA Night Sky Network. The Night Sky Network program supports astronomy clubs across the USA dedicated to astronomy outreach. Visit nightsky.jpl.nasa.org to find local clubs, events, and more!

Chapter 6

BMAC Calendar and more

More on this image. See FN7

BMAC Calendar and more



Date	Time	Location	Notes
BMAC Meetings			
Friday, November 1, 2019	7 p.m.	Nature Center Discovery Theater	Program: The November meeting will be "learning activities" that we'll all be able to participate in teams. It will be lots of fun and details will be provided at the meeting.; Free.
Friday, December 6, 2019	7 p.m.	Nature Center Discovery Theater	Program: TBA; Free.
Friday, February 7, 2020	7 p.m.	Nature Center Discovery Theater	Program: TBA; Free.
SunWatch			
Every Saturday & Sunday March - October	3-3:30 p.m. if clear	At the dam	View the Sun safely with a white-light view if clear.; Free.
StarWatch			
Oct. 19, 26, Nov. 2, 2019	7 p.m.	Observatory	View the night sky with large telescopes. If poor weather, an alternate live tour of the night sky will be held in the planetarium theater.; Free.
Nov. 9, 16, 23, 30, 2019	6 p.m.		
Special Events			
Monday, November 11, 2019	10 a.m.-1 p.m.	Observatory	Mercury Transit Public Viewing. Volunteers can help by using solar telescopes to view the Sun and the planet Mercury transiting across its surface. If poor weather, the event is cancelled.
January ?, 2020	6:30 p.m.	TBA	Annual BMAC Dinner. *The Saturday a week later is the snow date.*

Bays Mountain Astronomy Club

853 Bays Mountain Park Road

Kingsport, TN 37650

1 (423) 229-9447

www.BaysMountain.com

AdamThanz@KingsportTN.gov

Annual Dues:

Dues are supplemented by the Bays Mountain Park Association and volunteerism by the club. As such, our dues can be kept at a very low cost.

$16 /person/year

$6 /additional family member

Note: if you are a Park Association member (which incurs an additional fee), then a 50% reduction in BMAC dues are applied.

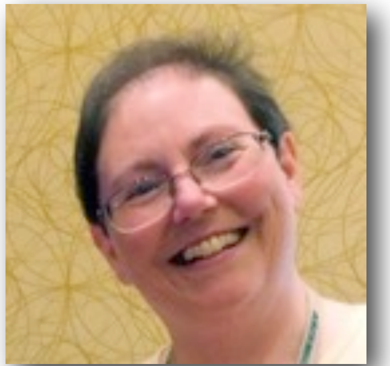
The club's website can be found here:

https://www.baysmountain.com/astronomy/astronomy-club/#newsletters

Regular Contributors:

William Troxel

William is the current chair of the club. He enjoys everything to do with astronomy, including sharing this exciting and interesting hobby with anyone that will listen! He has been a member since 2010.



Robin Byrne

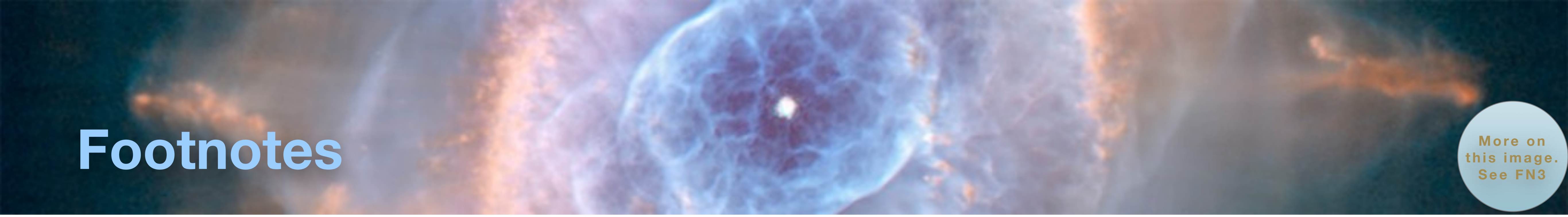
Robin has been writing the science history column since 1992 and was chair in 1997. She is an Associate Professor of Astronomy & Physics at Northeast State Community College (NSCC).

Jason Dorfman

Jason works as a planetarium creative and technical genius at Bays Mountain Park. He has been a member since 2006.

Adam Thanz

Adam has been the Editor for all but a number of months since 1992. He is the Planetarium Director at Bays Mountain Park as well as an astronomy adjunct for NSCC.



Footnotes:

1. The Rite of Spring

Of the countless equinoxes Saturn has seen since the birth of the solar system, this one, captured here in a mosaic of light and dark, is the first witnessed up close by an emissary from Earth … none other than our faithful robotic explorer, Cassini.

Seen from our planet, the view of Saturn's rings during equinox is extremely foreshortened and limited. But in orbit around Saturn, Cassini had no such problems. From 20 degrees above the ring plane, Cassini's wide angle camera shot 75 exposures in succession for this mosaic showing Saturn, its rings, and a few of its moons a day and a half after exact Saturn equinox, when the sun's disk was exactly overhead at the planet's equator.

The novel illumination geometry that accompanies equinox lowers the sun's angle to the ring plane, significantly darkens the rings, and causes out-of-plane structures to look anomalously bright and to cast shadows across the rings. These scenes are possible only during the few months before and after Saturn's equinox which occurs only once in about 15 Earth years. Before and after equinox, Cassini's cameras have spotted not only the predictable shadows of some of Saturn's moons (see PIA11657), but also the shadows of newly revealed vertical structures in the rings themselves (see PIA11665).

Also at equinox, the shadows of the planet's expansive rings are compressed into a single, narrow band cast onto the planet as seen in this mosaic. (For an earlier view of the rings' wide shadows draped high on the northern hemisphere, see PIA09793.)

The images comprising the mosaic, taken over about eight hours, were extensively processed before being joined together. First, each was re-projected into the same viewing geometry and then digitally processed to make the image "joints" seamless and to remove lens flares, radially extended bright artifacts resulting from light being scattered within the camera optics.

At this time so close to equinox, illumination of the rings by sunlight reflected off the planet vastly dominates any meager sunlight falling on the rings. Hence, the half of the rings on the left illuminated by planetshine is, before processing, much brighter than the half of the rings on the right. On the right, it is only the vertically extended parts of the rings that catch any substantial sunlight.

With no enhancement, the rings would be essentially invisible in this mosaic. To improve their visibility, the dark (right) half of the rings has been brightened relative to the brighter (left) half by a factor of three, and then the whole ring system has been brightened by a factor of 20 relative to the planet. So the dark half of the rings is 60 times brighter, and the bright half 20 times brighter, than they would have appeared if the entire system, planet included, could have been captured in a single image.

The moon Janus (179 kilometers, 111 miles across) is on the lower left of this image. Epimetheus (113 kilometers, 70 miles across) appears near the middle bottom. Pandora (81 kilometers, 50 miles across) orbits outside the rings on the right of the image. The small moon Atlas (30 kilometers, 19 miles across) orbits inside the thin F ring on the right of the image. The brightnesses of all the moons, relative to the planet, have been enhanced between 30 and 60 times to make them more easily visible. Other bright specks are background stars. Spokes -- ghostly radial markings on the B ring -- are visible on the right of the image.

This view looks toward the northern side of the rings from about 20 degrees above the ring plane.

The images were taken on Aug. 12, 2009, beginning about 1.25 days after exact equinox, using the red, green and blue spectral filters of the wide angle camera and were combined to create this natural color view. The images were obtained at a distance of approximately 847,000 kilometers (526,000 miles) from Saturn and at a Sun-Saturn-spacecraft, or phase, angle of 74 degrees. Image scale is 50 kilometers (31 miles) per pixel.

The Cassini-Huygens mission is a cooperative project of NASA, the European Space Agency and the Italian Space Agency. The Jet Propulsion Laboratory, a division of the California Institute of Technology in Pasadena, manages the mission for NASA's Science Mission Directorate, Washington, D.C. The Cassini orbiter and its two onboard cameras were designed, developed and assembled at JPL. The imaging operations center is based at the Space Science Institute in Boulder, Colo.

For more information about the Cassini-Huygens mission visit http://saturn.jpl.nasa.gov/. The Cassini imaging team homepage is at http://ciclops.org.

Image Credit: NASA/JPL/Space Science Institute

2. Leo Rising

A sky filled with stars and a thin veil of clouds.

Image by Adam Thanz

3. The Cat's Eye Nebula, one of the first planetary nebulae discovered, also has one of the most complex forms known to this kind of nebula. Eleven rings, or shells, of gas make up the Cat's Eye.

Credit: NASA, ESA, HEIC, and The Hubble Heritage Team (STScI/AURA)

Acknowledgment: R. Corradi (Isaac Newton Group of Telescopes, Spain) and Z. Tsvetanov (NASA)

4. Jupiter & Ganymede

NASA's Hubble Space Telescope has caught Jupiter's moon Ganymede playing a game of "peek-a-boo." In this crisp Hubble image, Ganymede is shown just before it ducks behind the giant planet.

Ganymede completes an orbit around Jupiter every seven days. Because Ganymede's orbit is tilted nearly edge-on to Earth, it routinely can be seen passing in front of and disappearing behind its giant host, only to reemerge later.

Composed of rock and ice, Ganymede is the largest moon in our solar system. It is even larger than the planet Mercury. But Ganymede looks like a dirty snowball next to Jupiter, the largest planet in our solar system. Jupiter is so big that only part of its Southern Hemisphere can be seen in this image.

Hubble's view is so sharp that astronomers can see features on Ganymede's surface, most notably the white impact crater, Tros, and its system of rays, bright streaks of material blasted from the crater. Tros and its ray system are roughly the width of Arizona.

The image also shows Jupiter's Great Red Spot, the large eye-shaped feature at upper left. A storm the size of two Earths, the Great Red Spot has been raging for more than 300 years. Hubble's sharp view of the gas giant planet also reveals the texture of the clouds in the Jovian atmosphere as well as various other storms and vortices.

Astronomers use these images to study Jupiter's upper atmosphere. As Ganymede passes behind the giant planet, it reflects sunlight, which then passes through Jupiter's atmosphere. Imprinted on that light is information about the gas giant's atmosphere, which yields clues about the properties of Jupiter's high-altitude haze above the cloud tops.

This color image was made from three images taken on April 9, 2007, with the Wide Field Planetary Camera 2 in red, green, and blue filters. The image shows Jupiter and Ganymede in close to natural colors.

Credit: NASA, ESA, and E. Karkoschka (University of Arizona)

5. 47 Tucanae

In the first attempt to systematically search for "extrasolar" planets far beyond our local stellar neighborhood, astronomers probed the heart of a distant globular star cluster and were surprised to come up with a score of "zero".

To the fascination and puzzlement of planet-searching astronomers, the results offer a sobering counterpoint to the flurry of planet discoveries announced over the previous months.

"This could be the first tantalizing evidence that conditions for planet formation and evolution may be fundamentally different elsewhere in the galaxy," says Mario Livio of the Space Telescope Science Institute (STScI) in Baltimore, MD.

The bold and innovative observation pushed NASA Hubble Space Telescope's capabilities to its limits, simultaneously scanning for small changes in the light from 35,000 stars in the globular star cluster 47 Tucanae, located 15,000 light-years (4 kiloparsecs) away in the southern constellation Tucana.

Hubble researchers caution that the finding must be tempered by the fact that some astronomers always considered the ancient globular cluster an unlikely abode for planets for a variety of reasons. Specifically, the cluster has a deficiency of heavier elements that may be needed for building planets. If this is the case, then planets may have formed later in the universe's evolution, when stars were richer in heavier elements. Correspondingly, life as we know it may have appeared later rather than sooner in the universe.

Another caveat is that Hubble searched for a specific type of planet called a "hot Jupiter," which is considered an oddball among some planet experts. The results do not rule out the possibility that 47 Tucanae could contain normal solar systems like ours, which Hubble could not have detected. But even if that's the case, the "null" result implies there is still something fundamentally different between the way planets are made in our own neighborhood and how they are made in the cluster.

Hubble couldn't directly view the planets, but instead employed a powerful search technique where the telescope measures the slight dimming of a star due to the passage of a planet in front of it, an event called a transit. The planet would have to be a bit larger than Jupiter to block enough light — about one percent — to be measurable by Hubble; Earth-like planets are too small.

However, an outside observer would have to watch our Sun for as long as 12 years before ever having a chance of seeing Jupiter briefly transit the Sun's face. The Hubble observation was capable of only catching those planetary transits that happen every few days. This would happen if the planet were in an orbit less than 1/20 Earth's distance from the Sun, placing it even closer to the star than the scorched planet Mercury — hence the name "hot Jupiter."

Why expect to find such a weird planet in the first place?

Based on radial-velocity surveys from ground-based telescopes, which measure the slight wobble in a star due to the small tug of an unseen companion, astronomers have found nine hot Jupiters in our local stellar neighborhood. Statistically this means one percent of all stars should have such planets. It's estimated that the orbits of 10 percent of these planets are tilted edge-on to Earth and so transit the face of their star.

In 1999, the first observation of a transiting planet was made by ground-based telescopes. The planet, with a 3.5-day period, had previously been detected by radial-velocity surveys, but this was a unique, independent confirmation. In a separate program to study a planet in these revealing circumstances, Ron Gilliland (STScI) and lead investigator Tim Brown (National Center for Atmospheric Research, Boulder, CO) demonstrated Hubble's exquisite ability to do precise photometry — the measurement of brightness and brightness changes in a star's light — by also looking at the planet. The Hubble data were so good they could look for evidence of rings or Earth-sized moons, if they existed.

But to discover new planets by transits, Gilliland had to crowd a lot of stars into Hubble's narrow field of view. The ideal target was the magnificent southern globular star cluster 47 Tucanae, one of the closest clusters to Earth. Within a single Hubble picture Gilliland could observe 35,000 stars at once. Like making a time-lapse movie, he had to take sequential snapshots of the cluster, looking for a telltale dimming of a star and recording any light curve that would be the true signature of a planet.

Based on statistics from a sampling of planets in our local stellar neighborhood, Gilliland and his co-investigators reasoned that 1 out of 1,000 stars in the globular cluster should have planets that transit once every few days. They predicted that Hubble should discover 17 hot Jupiter-class planets.

To catch a planet in a several-day orbit, Gilliland had Hubble's "eagle eye" trained on the cluster for eight consecutive days. The result was the most data-intensive observation ever done by Hubble. STScI archived over 1,300 exposures during the observation. Gilliland and Brown sifted through the results and came up with 100 variable stars, some of them eclipsing binaries where the companion is a star and not a planet. But none of them had the characteristic light curve that would be the signature of an extrasolar planet.

There are a variety of reasons the globular cluster environment may inhibit planet formation. 47 Tucanae is old and so is deficient in the heavier elements, which were formed later in the universe through the nucleosynthesis of heavier elements in the cores of first-generation stars. Planet surveys show that within 100 light-years of the Sun, heavy-element-rich stars are far more likely to harbor a hot Jupiter than heavy-element-poor stars. However, this is a chicken and egg puzzle because some theoreticians say that the heavy-element composition of a star may be enhanced after if it makes Jupiter-like planets and then swallows them as the planet orbit spirals into the star.

The stars are so tightly compacted in the core of the cluster – being separated by 1/100th the distance between our Sun and the next nearest star — that gravitational tidal effects may strip nascent planets from their parent stars. Also, the high stellar density could disturb the subsequent migration of the planet inward, which parks the hot Jupiters close to the star.

Another possibility is that a torrent of ultraviolet light from the earliest and biggest stars, which formed in the cluster billions of years ago may have boiled away fragile embryonic dust disks out of which planets would have formed.

These results will be published in The Astrophysical Journal Letters in December. Follow-up observations are needed to determine whether it is the initial conditions associated with planet birth or subsequent influences on evolution in this heavy-element-poor, crowded environment that led to an absence of planets.

Credits for Hubble image: NASA and Ron Gilliland (Space Telescope Science Institute)

6. Space Place is a fantastic source of scientific educational materials for children of all ages. Visit them at:

http://spaceplace.nasa.gov

7. NGC 3982

Though the universe is chock full of spiral-shaped galaxies, no two look exactly the same. This face-on spiral galaxy, called NGC 3982, is striking for its rich tapestry of star birth, along with its winding arms. The arms are lined with pink star-forming regions of glowing hydrogen, newborn blue star clusters, and obscuring dust lanes that provide the raw material for future generations of stars. The bright nucleus is home to an older population of stars, which grow ever more densely packed toward the center.

NGC 3982 is located about 68 million light-years away in the constellation Ursa Major. The galaxy spans about 30,000 light-years, one-third of the size of our Milky Way galaxy. This color image is composed of exposures taken by the Hubble Space Telescope's Wide Field Planetary Camera 2 (WFPC2), the Advanced Camera for Surveys (ACS), and the Wide Field Camera 3 (WFC3). The observations were taken between March 2000 and November 2009. The rich color range comes from the fact that the galaxy was photographed invisible and near-infrared light. Also used was a filter that isolates hydrogen emission that emanates from bright star-forming regions dotting the spiral arms.

Credit: NASA, ESA, and the Hubble Heritage Team (STScI/AURA)

Acknowledgment: A. Riess (STScI)

8. This photo from the 2016 transit event shows Mercury a bit larger, as it should; it was taken at a higher magnification through a large 16 inch telescope! Credit: J. A. Blackwell