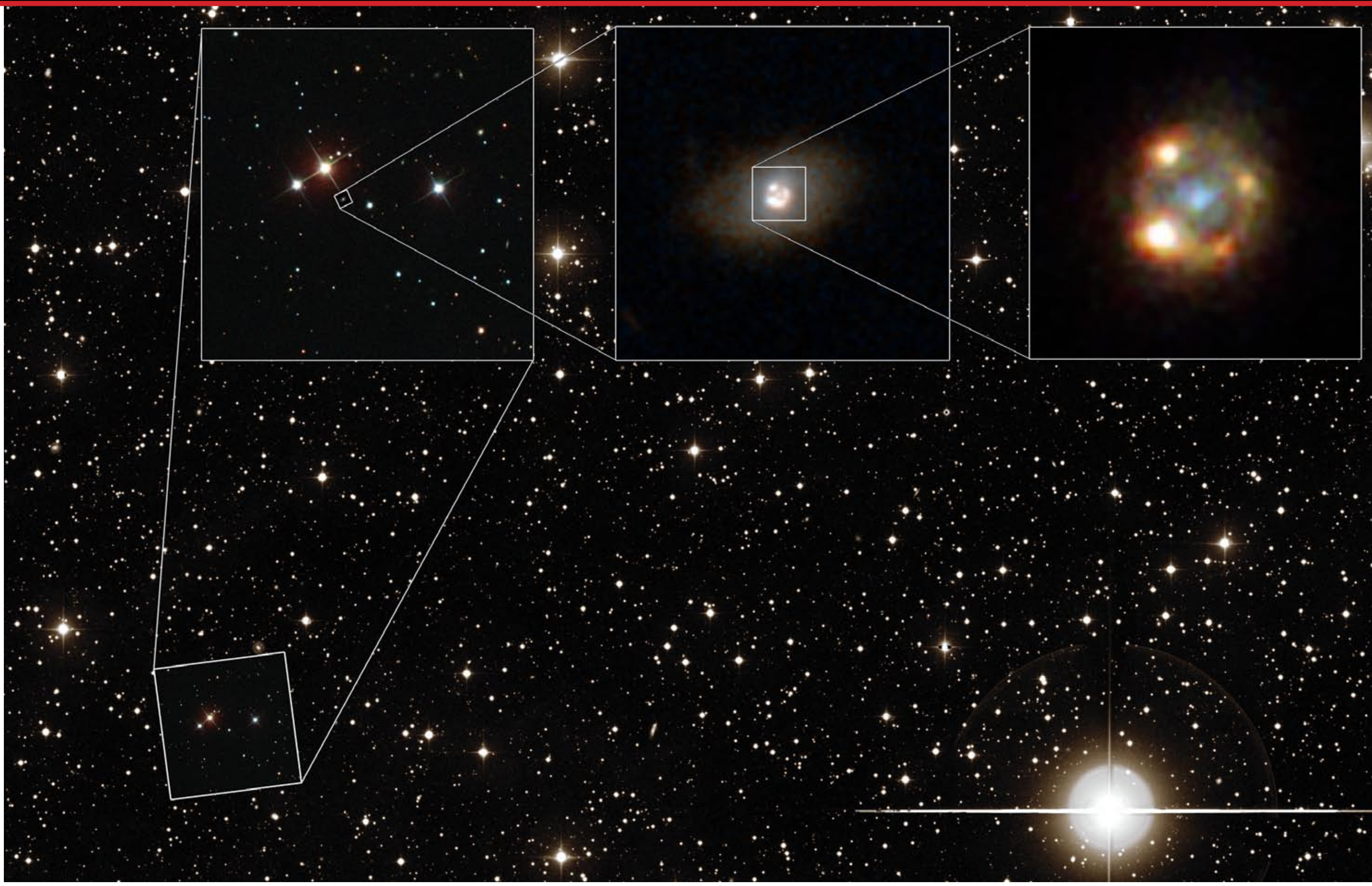
The Denver
OBSERVER
JUNE 2017



"This composite image shows the gravitationally lensed type Ia supernova iPTF16geu, as seen with different telescopes. The background image shows a wide-field view of the night sky as seen with the Palomar Observatory located on Palomar Mountain, California. The leftmost image shows observations made with the Sloan Digital Sky Survey (SDSS). The central image was taken by the NASA/ESA Hubble Space Telescope and shows the lensing galaxy SDSS J210415.89-062024.7. The rightmost image was also taken with Hubble and depicts the four lensed images of the supernova explosion, surrounding the lensing galaxy." (See "Astro Update," P.4, for more on this story.)

Text/Image credit: ESA/Hubble, NASA, Sloan Digital Sky Survey, Palomar Observatory/California Institute of Technology

JUNE SKIES

by Zachary Singer

Just as our weather is starting to get nice, we've got a good collection of objects to observe—the big show-pleaser planets are easy pickings, and we've got three interesting binary stars stashed away, too.

The Solar System

Mercury is lost in solar glare, but **Venus** is at greatest elongation early this month, and therefore rises as much as two hours before sunrise. Though it's slightly dimmer than last month, Venus remains a beacon of at least -4.2 magnitude—if you catch the planet at the end of a late-night observing session, you'll find a moon filter a great aid.

Mars is pretty much gone—a recent observation at evening twilight ("Hey, why not?") showed a tiny disk twinkling fiercely, very low above the western the horizon. As noted last month, though, Mars will be remarkable at its next opposition, in mid-2018.

Jupiter is in a great position for observing during convenient evening hours, high in the southern sky at twilight. Because it's falling behind as Earth's faster orbit sweeps us forward, Jupiter is a touch smaller and dimmer than last month, but most folks won't notice—this is a great time to show the planet to younger observers, especially now that school is out.

Saturn comes to opposition at mid-June, so it's visible all night. Because it's fairly low in our sky (like last year), it's best to observe the planet when it's highest in the south—2 AM at the beginning of the month, and midnight at month's end. Realistically, Saturn is still low even then, so the value of the "best" time is a bit iffy.

Continued on Page 6

Sky Calendar

1	First-Quarter Moon
9	Full Moon
17	Last-Quarter Moon
23	New Moon

In the Observer

The Observer is available in color PDF format from the DAS website: *http://www.denverastro.org/das/denver-observer/*

PRESIDENT'S MESSAGE *by Ron Hranac*

A Rare Opportunity: The Total Solar Eclipse, August 21^{st}

On Monday, August 21^{st}, what is arguably the most important astronomical event of 2017 will be visible in the United States: a total solar eclipse. The last time a total solar eclipse graced the lower 48 was on February 26^{th}, 1979, and that one was visible in parts of Washington, Oregon, Idaho, Montana, North Dakota, and Canada. This year's eclipse traverses the width of the entire United States, and will be visible to millions of people.

If you've never seen a total solar eclipse before, you might be inclined to say, "Observing this August's eclipse should be pretty straightforward. Take appropriate safety measures (see the Safety section) back on a comfortable lawn chair, and enjoy." A total solar eclipse is one of Mother Nature's most spectacular sights, and there is a lot more to experience than you might think! Note the use of the word "experience" in that last sentence. Read on to see why.

Path of Totality

First, the obvious. To see the August 21^{st}, 2017 total solar eclipse, you must be within the path of totality. Anywhere else, and you'll see a partial solar eclipse. Partial solar eclipses are nice, but the difference between a partial and total solar eclipse is like the difference between day and night. The path of totality for the August 21^{st} event comprises a relatively narrow strip—varying from about 62 miles to about 71 miles wide, depending on location—across the continental United States, starting in Oregon and ending in South Carolina. The closer to the center of that path you are, the longer the duration of totality.

Anatomy of a Total Solar Eclipse

There are four important parts of a total solar eclipse: first contact (partial phase begins), second contact (totality begins), third contact (totality ends), and fourth contact (partial phase ends). Start to finish, figure just under three hours. Totality itself for the August eclipse lasts between about 2 minutes and a little more than 2-1/2 minutes, also depending on location. To find out the times of each of the aforementioned parts of the eclipse, visit *http://eclipsekit.com/maps* for links to an interactive eclipse map, and apps for iOS and Android devices. Zoom in on the eclipse maps and click on the location from which you plan to observe. A box will pop up with the predicted times and other useful information.

Ready, Set...

Eclipse day has arrived! Assuming you've got your eclipse glasses and/or a properly filtered telescope or binoculars ready to go—and you've

Continued on Page 3

Society Directory

DAS Executive Board

President:
Ron Hranac
president@denverastro.org

Vice President:
Lindsey Shaw
vp@denverastro.org

Secretary:
Jeff Tropeano
secretary@denverastro.org

Treasurer:
Michael Nowak
treasurer@denverastro.org

Executive Board Members:
Brent Blake, Julie Candia, Jack Eastman, Joe Gafford, Zach Gilbert, Ed Scholes, Sorin, Dan Wray

Past President, Ron Pearson
President Emeritus, Larry Brooks

Committees

Van Nattan-Hansen Scholarship Fund:
Jeff Tropeano (Chair)
PO Box 100621
Denver, CO. 80250-0621

EGK Dark Site Committee:
Darrell Dodge, Interim Chair
darksite@denverastro.org

IDA Representative:
Dr. Robert Stencel
coloida@hotmail.com

Volunteers or Appointed Representatives

ALCor:
Darrell Dodge 303 932-1309

Newsletter Editor:
Zachary Singer 303 718-4188
editor@denverastro.org

Newsletter Proofreaders:
Darrell Dodge, Ron Hranac

Website:
Darrell Dodge
webmaster@denverastro.org

IT Coordinator:
Ken Sturrock
itdept@denverastro.org

External Outreach Coordinator:
Julie Candia
external@denverastro.org

Public Night Coordinator:
Hugh Davidson 303 679-0629

Librarian:
Eileen Barela

Telescope Loan Program:
Ed Scholes
scopeloan@denverastro.org

DAS Information Line:
(303) 871-5172

DAS Correspondence:
Denver Astronomical Society
P.O. Box 102738
Denver, Colorado 80250
president@denverastro.org

New-Member Ambassador:
Digby Kirby
odigby@gmail.com
(970) 301-2287

http://www.denverastro.org

DAS SCHEDULE

June 2017

3	Open House—DU's Historic Chamberlin Observatory—Starts at 8:30 PM
9	DAS General Meeting—DU's Olin Hall, Rm. 105—Starts at 7:30 PM
16	E-Board Meeting—At DU's Historic Chamberlin Observatory, 7:30 PM. All members welcome.
17	Member In-Reach—At DU's Historic Chamberlin Observatory, 10:00 AM.
24	Dark Sky Weekend—EGK Dark Site & Brooks Observatory
	(July 2017)
7	DAS General Meeting—DU's Olin Hall, Rm. 105—Starts at 7:30 PM
14	General Meeting—DU's Olin Hall, Rm. 105—Starts at 7:30 PM

During Open House, volunteer members of the DAS bring their telescopes to the Chamberlin Observatory's front (south) lawn, so the public can enjoy views of the stars and planets, try out different telescope designs, and get advice from DAS members. The Observatory is open, too (costs listed below), and its historic 20-inch telescope is open for observing with no reservations necessary.

Open House costs (non-members): If the skies are clear, $2/person ($5/family), $1/person in inclement weather. DU students with ID, and DAS members free.

Public Nights feature a presentation on astronomical subjects and a small-group observing session on the historic 20-inch telescope (weather permitting), at Chamberlin Observatory on Tuesday and Thursday evenings (except holidays), beginning at the following times:

March 10 - September 30 at 8:30 PM

October 1 - March 9 at 7:30 PM

Public Night costs (non-members): $4/adult, $3/child and students with ID. DAS members and DU students with ID: free.

Members of the public (non-DAS/DU, as above), please make reservations via our website (*www.denverastro.org*) or call (303) 871-5172.

DAS NEWS

Volunteer Opportunities

Wednesday, June 7, 2017, 8:00 PM-10:00 PM: *Cory Elementary School*, 1550 S. Steele St., Denver, CO 80210. Star Party (Auction) for ~ 20 students/parents**.** *Good on volunteers, but more are welcome*.

Monday, June 12, 2017, 8:30 PM-10:30 PM: *The Meadows Community*, Castle Rock (off of Founders Pkwy and Meadows Pkwy). Night Observing**.** *Good on volunteers, but more welcome*.

Thursday, June 29, 2017, 8:30 PM-10:30 PM: *Outdoor Discovery Camps*, 6005 Ron King Trail, Littleton**.** Girls and Science Camp Week (10 total, 11 - 14 yrs). Night Observing.

To volunteer, please contact Julie Candia at:
***external@denverastro.org*—and thanks!**

June General Meeting

Bruce Bookout will present, "Navigating the Ancient Sky: Cosmologies of Native American Tribes," on **Friday, June 9th, at 7:30 PM.**

As an adjunct professor, Bruce has taught a range of classes from basic Astronomy, Astrophysics and ArcheoAstronomy. He has also served as the Director of the Rocky Mountain Star Stare for the last seven years and is a primary outreach member for the Colorado Springs Astronomical Society.

The meeting will be held at **DU's Olin Hall, Room 105**, and all present will be invited to a reception following the meeting at DU's Historic Chamberlin Observatory. Coffee and light refreshments will be served.

June In-Reach DAYTIME EVENT: Solar Viewing and Eclipse Prep

June 17th, 10:00 AM-2:00 PM: In-Reach at Chamberlin Observatory

"In-Reach" means events just for DAS members (and their guests). It's a chance to stargaze together, to learn from one another, and to build a stronger amateur astronomy community. All skill levels are welcome from novice to expert! No reservations are needed—just show up!

Ongoing activities throughout the day:

» Viewing the Sun with a variety of safe methods
» Solar safety demonstrations with "burning plastic eyeballs"
» Daytime viewing of the Moon & Venus
» Build-your-own equipment crafts: sun funnels, finder filters, pinhole projectors, and more! Materials provided at cost: $0.25-$5
» Resources for the upcoming Aug. 21 total solar eclipse
» Tours, telescope help, snacks, and social time!

Assuming good weather, all of our activities will be running concurrently, with drop-in activity stations rather than scheduled presentations. Bring your own telescope and solar filter, or borrow a scope and filter to practice with—and get a lesson on how to do it safely! Mentoring will be available for those who want help learning new skills. Some snacks provided, but please bring your own lunch.

If cloudy, we will still have as many activities as possible, including equipment-building crafts, tours, snacks and social time. Viewing is weather-dependent.

Please contact Leo Sack (*SackLT@gmail.com*) with questions.

President's Message

Continued from Page 2

applied sunscreen on your exposed skin—find a comfortable place to sit and enjoy what's about to transpire. Place a large white poster board (or old white towel or sheet) on the ground nearby. More on this later.

A few minutes before first contact, look around at the shadows cast by various objects including trees, the horizon in all directions, get an idea of what the temperature feels like, and listen for natural sounds such as birds chirping. Now look at the Sun using your eclipse glasses or other filter, or your filtered telescope. You should see a round disk about the size of the full Moon. Are there any sunspots visible?

First Contact

If you're with a group that includes experienced solar eclipse observers, the latter most likely will be looking for the precise start of first contact—the beginning of the partial phase of the eclipse. It's a little tough to do with just eclipse glasses, but a good solar telescope will make it easier. Don't be surprised if one or more people holler, "First contact!" when it happens. The eclipse is underway.

For about the next hour or so, the Moon will pass in front of the Sun and take progressively bigger "bites" out of the solar disk. Every now and then, look at the shadows around you, especially under trees. You'll see that what were previously undefined speckles of sunlight poking through the leaves will now look like a whole lot of tiny crescents, just like the partial phase of the eclipse you've been enjoying through your eclipse glasses or solar telescope. You won't likely notice any difference in the ambient brightness or temperature until the Sun is more than about 90 percent eclipsed. While the eclipse is in the partial phase, take a peek through a solar telescope with modest magnification and see if you can spot lunar mountains on the edge of the Moon's disk as it crosses the Sun.

As totality approaches, note that the shadows around you are getting sharper. The ambient light will take on a somewhat eerie appearance, too. Look at the western horizon as second contact approaches; you should see it somewhat darker while the remainder of the horizon in other directions looks more or less the same as before. That darker western horizon is the Moon's umbral shadow approaching at something like 1000 mph, give or take.

Starting about two minutes or so before second contact, keep an eye on that white poster board you laid on the ground earlier for something called shadow bands. This is an atmospheric phenomenon that occurs just before and immediately after totality. Shadow bands resemble shimmering, narrow shadows visible on light surfaces (similar to ripples on water), and generally last only a few seconds.

When the Moon has nearly covered the Sun's disk, you'll see what is called Baily's Beads. That's sunlight peeking through valleys and similar rugged terrain on the limb of the Moon. Just as second contact starts, the last bit of light from the Sun's photosphere peeks through a lunar valley or two, creating the diamond ring effect.

Second Contact

As totality begins, observe the reaction

Continued on Page 5

ASTRO UPDATE

Selected Summaries of Space News

By Don Lynn

Black Hole Imaged

The radio data for the first resolved image of a black hole has been taken (actually of the *surroundings* of a black hole, since black holes suck in all light and can't be seen directly). A series of radiotelescopes across the globe simultaneously took data of the center of our Milky Way galaxy, where a supermassive black hole is known to reside. The combination of high frequency radio and huge telescope aperture (effectively the size of the Earth) will provide extremely high resolution. Don't expect to see the image until next year, as it will take that long to process the data.

Hidden Galaxy Activity

A study using NuSTAR (high-energy X-ray space telescope) and three other space telescopes shows that during the merger of two galaxies, so much material falls toward the central black hole that the extremely bright activity there is hidden. It becomes progressively more hidden as the merger proceeds. The study observed 52 galaxies, half of them late in a merger with another galaxy. It found that only high-energy X-rays were penetrating the infalling material, while low-energy X-rays and other wavelengths were getting blocked in the mergers.

Interesting Exoplanet

A newly discovered exoplanet, LHS 1140b, is a prime candidate for observation to try to detect an atmosphere during its transits. (A transit is when a small body, like a planet, passes in front of something larger, like star, and only partially blocks the far object's light.)

Because the planet was detected both by transiting and by its gravitational tug on its star, astronomers were able to calculate its diameter, mass and density. It's about 40% larger than Earth, 6.6 times Earth's mass, and considerably denser than Earth—and therefore a rocky (rather than gas) planet. It orbits in the habitable zone—that is, where light from its star, LHS 1140, should keep the planet's surface in the temperature range where liquid water can exist.

Theoretically, small dim stars like LHS 1140 should be so active soon after forming, that they blow away the atmosphere from any close-in planets. But a planet larger than Earth, such as this one, should remain hot and outgassing longer than the star's active period, so it could still have an atmosphere. The system is at least 5 billion years old, and lies about 40 light-years away.

And Another Exoplanet...

Combining observations from the Hubble and Spitzer Space Telescopes of an exoplanet named HAT-P-26b reveals that it has an atmosphere made primarily of hydrogen and helium, like our gas-giant planets. It is 437 light-years away, orbiting a star roughly twice as old as the Sun. The atmosphere is relatively clear of clouds and contains a strong spectral signal of water vapor. The observations were made as the planet transited its star, and the difference from the spectrum of the star alone was extracted, yielding that of the starlight shining through the planet's atmosphere.

The *metallicity* of the atmosphere (the term is used by astronomers, to mean everything heavier than helium, metal or not) was measured, and found to be more like that of Jupiter, even though the planet's size is more like Neptune (which has much higher metallicity than Jupiter). Planet-formation theorists will have to go back to the drawing board to figure that one out.

Threading Saturn's Rings

Cassini (Saturn orbiter) took its first plunge (of 22 planned) through the gap between the innermost ring and Saturn's cloud tops. Mission managers thought that the area was fairly free of material, but just to be sure, they turned the spacecraft so that any such particles would hit the dish antenna rather than any sensitive instruments.

Even less dust was encountered than when Cassini previously flew through the ring plane just outside the outermost bright ring. The spacecraft hit that little bit of dust, nothing larger than smoke particles, at 77,000 mph (124,000 km/h), but suffered no damage. In fact, controllers plan not to lead with the dish on the remaining plunges, because there was so little dust this time.

New science, yet to follow during the upcoming dives: radio occultations to probe the planet's atmosphere, sampling the upper atmosphere, mapping Saturn's gravitational field, scanning the rings with radar, and measuring the mass of the rings. The mission is planned to end on September 15 by crashing into the planet.

Comet Oxygen Explained

A chemical engineer who has been studying the effects of particles colliding with electronics has provided an explanation of why the Rosetta spacecraft found unexpected amounts of molecular oxygen around comet 67P. (Molecular oxygen usually disappears in space because it reacts with hydrogen or carbon to form other compounds.) The new finding shows that water released by the comet becomes ionized by the Sun's ultraviolet light, and then these water ions are swept up by solar wind and smashed back into the comet's surface. There, they react with surface material to release molecular oxygen.

Now that we know molecular oxygen can be produced this way (instead of by biological processes, as on Earth), the presence of molecular oxygen may not be as good an indicator of life as has been thought.

Supernova and Hubble Constant

A Type Ia supernova has been discovered that happens to lie almost exactly behind a massive nearer galaxy, resulting in a gravitational lens yielding four images of that same supernova. **(See cover photo.)** This is the first time a Type Ia has been seen in a gravitational lens.

The images are seen with different time delays that depend on the geometry of the light paths and on the Hubble Constant (the expansion rate of the Universe). So astronomers are analyzing the observations of the supernova taken over time, and will soon have a new derivation of the Hubble Constant that is independent of any of the other methods of calculating it. This should be interesting, because two of the most reliable methods of calculating the Hubble Constant disagree with each other by more than 7%, even though all known errors in measurement cannot account for this large of a discrepancy.

President's Message

Continued from Page 3

of others around you. The experience can be breathtaking; I've seen people cry, heard gasps of amazement and loud cheers. Random chatter comes to a stop. What about your own reaction?

It's time to remove your eclipse glasses and enjoy the next couple minutes or so of totality. This is the only time you can look at the Sun safely without the need for eye protection. The Sun's corona—its outermost, wispy looking atmosphere, can now be seen. Wow!

You don't have much time, but here are some other things to observe while the Sun is totally eclipsed. It will be like twilight came out of nowhere. A few brighter stars and some planets will appear. The temperature will have dropped somewhat, birds will stop chirping, and streetlights may switch on. Look quickly at the horizon all around you for what I call the 360-degree sunset effect. While you're taking all of this in, be sure to enjoy the eclipsed Sun itself. Look around the limb of the Sun. Depending on solar activity, you might be able to spot some reddish prominences poking out, which are normally visible only through a special hydrogen-alpha solar telescope. Also look at the shape and size of the corona. How many solar radii does it extend from the Sun?

Third Contact

Totality ends with the appearance of the diamond ring effect. Look quickly at your white poster board to see if shadow bands appear shortly after totality ends. Look toward the east; depending on your local geography, you might be able to see the Moon's shadow racing away from you. Time to get those eclipse glasses back on. Next is Baily's Beads, followed by the closing act's partial phase. As before, enjoy the partial phase for the next hour to hour-and-a-half.

Keep an eye on ambient brightness, the temperature, and shadows around you. Birds will start chirping again, the streetlights will switch off, and the character of the ambient light will start to look more normal over the next several minutes. Take a peek through the eyepiece of a solar telescope. Can you see lunar mountains on the limb of the Moon?

Chatter will pick up with everyone amazed at the spectacle just seen and surprised at how quickly it occurred. A few folks will start tearing down their equipment and packing up, but my recommendation is to continue to enjoy this eclipse until it's completely over.

Fourth Contact

As the Moon slips away, taking progressively smaller bites out of the Sun, watch out for fourth contact. As was the case with first contact, it will be easier using a solar telescope to spot the precise moment when the Moon is no longer in front of the Sun.

The eclipse has ended. After all of this, you'll see why I used the word "experience" earlier. This will be an event you'll long remember.

Solar Eclipse Observing Safety

Observing the Sun requires some suitable precautions. First: Never look at the Sun without appropriate eye protection, because of the risk of permanent eye damage or blindness. Solar eclipse glasses and similar specialty filters (including those designed for telescopes or binoculars for solar observing) reduce the amount of light passing through to about 1/1000th of 1 percent. In all cases, always follow the manufacturer's instructions that accompany the eclipse glasses or other type of solar filter. *Never* try to look through an unfiltered telescope or binoculars at the Sun, even with eclipse glasses on (the strongly focused sunlight at the eyepiece will melt or burn the eclipse glasses, potentially causing eye damage). Eclipse glasses are intended for looking at the Sun directly, not through a telescope or binoculars.

Commonly available, commercially manufactured eclipse glasses are made with plastic or cardboard frames, and typically use a specialized Mylar-like material for the lenses that has been tested and certified to be safe. #14 welder's glass is also safe to use, and generally can be ordered from a welding supply shop. Never use stacked photographic film or similar "tricks," because those likely won't filter out all wavelengths of light properly and may cause eye damage.

Most solar filters for telescopes (or binoculars) are designed to be placed over the objective (front), or open end, not at the eyepiece. In years past, some cheap telescopes came with a solar filter that could be threaded onto the eyepiece. Never use those types of filters (in fact, you should throw them in the trash), because heat buildup can crack them. If you happen to be looking through the eyepiece when that happens, severe eye damage could occur. The only type of safe solar filter that can be used on the eyepiece end of a telescope (and then only on refractor telescopes) is known as a Herschel wedge.

Proper filters must be used during all of the partial phases of a total solar eclipse (even looking at the Sun when it's as much as 99 percent eclipsed without a filter is unsafe), and at all times during an annular or partial solar eclipse. **The only time it is safe to look at the Sun naked-eye is during the very brief few minutes of totality.** For more on eclipse viewing safety, see *https://eclipse2017.nasa.gov/safety*.

**** This article was originally written for the AstroBox Eclipse Kit. Our thanks to Sorin for allowing us to reproduce it here. ****

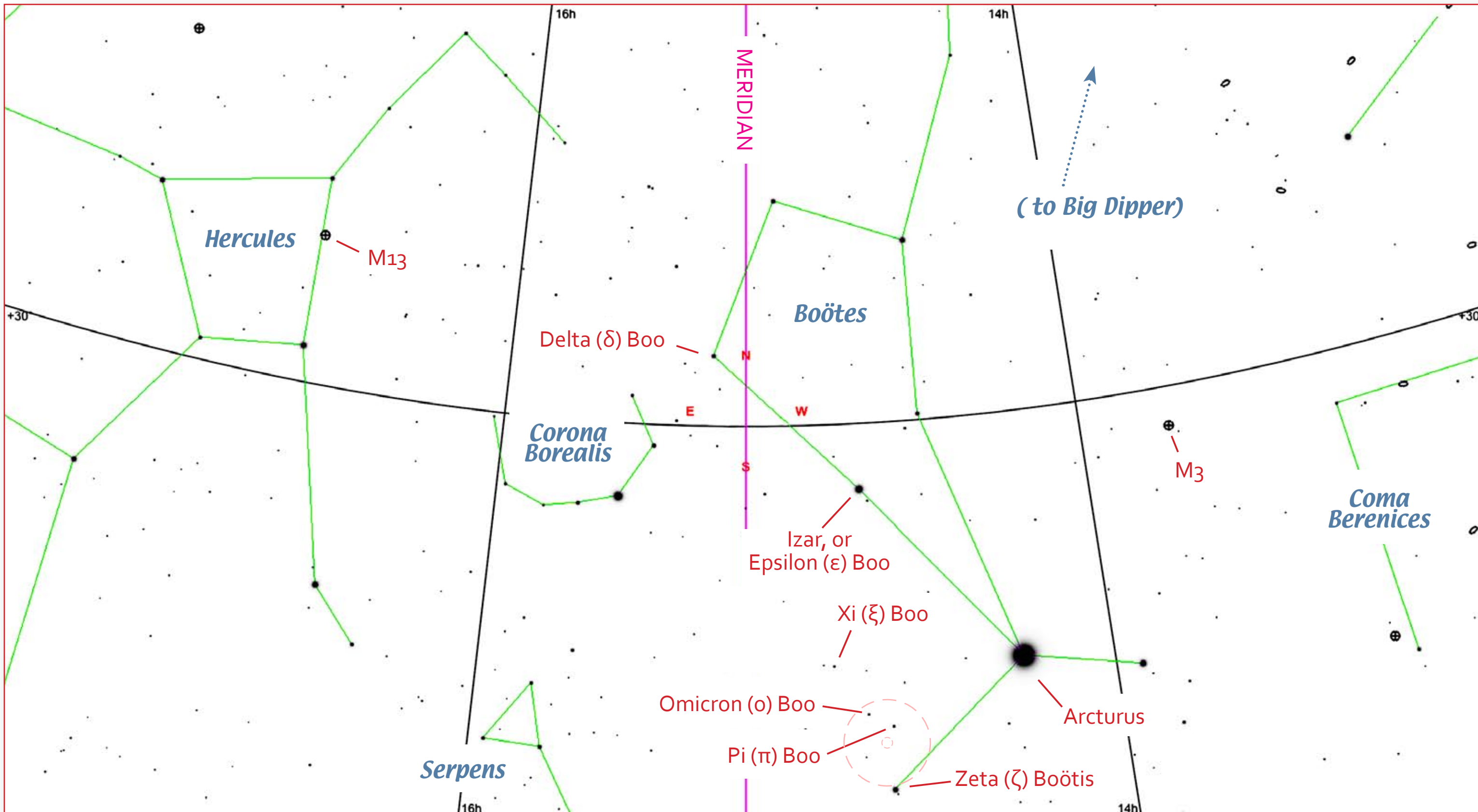
ABOUT THE DAS

Membership in the Denver Astronomical Society is open to anyone wishing to join. The DAS provides trained volunteers who host educational and public outreach events at the University of Denver's Historic Chamberlin Observatory, which the DAS helped place on the National Register of Historic Places. First light at Chamberlin in 1894 was a public night of viewing, a tradition the DAS has helped maintain since its founding in 1952.

The DAS's mission is to provide its members a forum for increasing and sharing their knowledge of astronomy, to promote astronomical education to the public, and to preserve DU's Historic Chamberlin Observatory and its telescope in cooperation with the University of Denver. The DAS is a long-time member in good standing of the Astronomical League and the International Dark Sky Association.

The DAS is a 501 (c)(3) tax-exempt corporation and has established three tax-deductible funds: the Van Nattan-Hansen Scholarship Fund, the DAS General Fund, and the Edmund G. Kline Dark Site Fund.

******JOIN US!** More information about DAS activities and membership benefits is available on the DAS website at *www.denverastro.org*.



Viewing due south and 80° up in Denver at 10:30 PM in mid-June. ***Note Telrad circles showing correct initial placement for finding Pi (π) Boötis, and position of the outer ring next to Zeta (ζ) Boo.*** **(Telrad's mid-sized, 2°, circle is omitted for clarity.) Other objects, like M3, are included for reference.**

Object positions, constellation and meridian lines charted in SkySafari, and then enhanced.

June Skies

Continued from Page 1

As last year, the rings are spread wide and make quite a spectacle, whether seeing conditions are perfect or not.

Uranus is technically visible, but its small blue dot is low on the horizon while the sky is still dark, and washed out by pre-dawn light when it's higher. (Mid-month, it's just 12° up at 3:30 AM, and just 23° up an hour later, when the sky begins to brighten.) "Oops."

In contrast, **Neptune** is about 30° up at 3:30 AM mid-month. If you want to get up to see it, the planet is now roughly halfway between Hydor, or Lambda (λ) Aquarii, and 4th-magnitude Phi (φ) Aquarii.

Stars and Deep Sky

This month, we're going for some binary star systems in the constellation Boötes: Along with their visual appearance, they make for interesting comparisons—some are like our own Sun, and some are strikingly different. In dark country skies, all three should be visible to the naked eye, so you won't sweat too much finding them. In the city, they remain lovely in a telescope, but light pollution will make the first two more challenging to find—good practice for folks learning to star-hop. (In less-perfect skies, sometimes the third one gets hidden, too, but it's very easy anyway.) Folks with go-to telescopes, of course, can find them from pretty much anywhere.

Our first stop, then, is **Pi (π) Boötis**, sometimes written as π Boo for short, located at **14h 42m, +16° 21'**. At first glance, an observer using low power may see only a single white star, because with a separation of just 5.6" (just under 1/600th of a degree!), there may not be enough magnification to split the pair. Try at least 100x, and don't be afraid to go to 200x, even with a smaller telescope—my 6-inch can easily separate Pi Boo at these magnifications with a *reasonably* steady sky (that is, "average conditions" for Denver); in larger 'scopes, you may find 200x more aesthetically pleasing, as well. (On good nights, 60x or less might do the job, making for a less-impressive image but good practice viewing tight binary stars.)

Under appropriate magnification, you'll see a pretty, white pair, which might remind more-experienced observers of a dimmer version of Castor, a bright binary star in Gemini. Ironically, Pi Boo has double the *intrinsic* brightness of Castor, but at a distance of about 300 light-years from Earth, it's some six times farther from us than Castor, and so appears dimmer. The brighter star in Pi's pair is a hot, Class B star, with about 100 times our own Sun's actual intensity—at Pi Boo's distance, our Sun would be invisible to the naked eye, needing *large* binoculars or a telescope to be seen.

Because of Pi Boo's distance, that "tight split" between the pair translates to a physical separation of more than 500 astronomical units (AU), or *more than 12 times the average distance between Pluto and our home star*. Before we get into directions for finding Pi Boo, let me suggest that once there, you'll want to take a good long look to appreciate the pair's color, brightness, and separation—it will make an interesting comparison with our next target…

Starting Directions:

All our targets this month will be simple to spot in dark skies, once we locate two bright stars in Boötes: Arcturus, or Alpha (α) Boo, and Izar, or Epsilon (ϵ) Boo. Arcturus isn't just the brightest star in Boötes, it outshines every other star for

Continued on Page 7

June Skies

Continued from Page 6

at least 60° in all directions. It sits very high and due south at 10:30 PM as the month begins, and moves a degree westward each night after, but it will remain obvious. (To confirm you've got Arcturus, follow the curve of the Big Dipper's handle away from the bowl—the handle arcs directly toward Arcturus. Note that this year, Jupiter lies along that same arc, about 30° southwest of Arcturus, so don't let bright Jupiter throw you a curve!)

Though the traditional outline of Boötes is supposed to represent a herdsman, in modern times, the constellation's shape is usually described as a "kite"—Arcturus lies at its bottom. Our other reference star, Izar, sits halfway up the eastern side of the kite's body (see chart). Conveniently, Izar is also Boötes' next-brightest star—on poor nights, especially in the city, Arcturus and Izar may be the only stars you see in the constellation.

—

Now that you're oriented, getting to Pi Boo isn't hard—look for the bright star that makes up the eastern "tail" of the kite, Zeta (ζ) Boo—it's almost as far from Arcturus as Izar is, and makes a right angle with them. Next, follow the imaginary line from Zeta to Izar, and you'll see a pair of stars about a degree apart, and less than 3° from Zeta—Pi is one of them! If you can't see the pair, don't worry—just put your Telrad on Zeta, placing the star on the Telrad's outer (4°) ring, and *on the side opposite from Izar*, and the pair will be near the center of your *finderscope's* field. **This arrangement is shown in the chart.**

In the finderscope, the magnified pair will be obvious (even in the city). The "other" star of the pair, Omicron Boo, will distinguish itself by the presence of a nearby, dimmer companion that makes a crude right angle off the line from Pi to Omicron—that is, Pi is the star *without* the companion.

One last note about finding Pi—if you want to find it in the city, our "jumping-off" point, Zeta, is sometimes visible, and *sometimes not*. If it isn't, its position can be estimated: It's two Telrad widths, or 8°, from Arcturus—*let's go star-hopping!* Remember the right angle from Izar to Arcturus and Zeta, then slide the Telrad away from Arcturus toward where Zeta should be—stop when there's about the same distance between the Telrad and Arcturus as there is across the Telrad (so each is 4°). If you're in the ballpark, a look inside your finderscope will show Zeta near the edge of its field—if not, you're probably not far off, so try going a little farther, or gently circle the area a little. Then slide your Telrad "up" (parallel to the line from Arcturus to Izar) about a half-Telrad width—the Pi-Omicron pair should be in your finderscope, and you can take it from there.

Visually speaking, our next target is a beautiful object, and it appears very close to Pi, so finding it won't be tough—it's **Xi** (ξ) **Bootis**, or Xi Boo, at **14h 52m, +19° 02'**. At first glance, Xi looks a great deal like a yellow version of Pi: The separation between its stars is currently 5.4", about the same as Pi's, and the visual magnitudes of the brighter star in each pair are very close, too.

You'll soon see, though, that Xi's dimmer star (the pair's "secondary") is about two magnitudes fainter than its bright primary, creating a pleasing contrast between them. The colors of Xi's pair differ from each other, as well: To my eye (under our recent hazy skies), the bright star is cream-colored, and the secondary's hue lies somewhere between "wheat" and "gold;" available sources have described the duo as "bright yellow," and "red-violet," respectively. Xi will be harder to split than Pi when the same magnification is used, because of the brightness difference in Xi's pair—but Xi is wonderful to look at, and perhaps more so after viewing the pearly whiteness of Pi.

Apart from Xi's beauty, there's science, as well: Xi's apparent proximity to Pi in our sky is an illusion. Though Xi lies more-or-less along the same line of sight as Pi from our point of view (they shine less than 4° from each other), Xi is much closer to Earth than Pi is—Xi lies only 22 light-years from Earth, or just 7% of Pi's distance from us. And that's what makes this comparison interesting, because even though these two systems *look* so much alike (apart from their color), they can't possibly be similar!

Since the apparent brightness of a star (or anything else) gets dimmer with increasing distances, the farther pair (Pi) must be inherently brighter than the closer pair (Xi) to appear roughly the same brightness to us here on Earth. If we could position both star systems at the same distance from us, to compare them fairly, then Xi could be seen as it really is, more than five magnitudes dimmer than Pi.

You may find it humbling, though, when you hear that this "dim" star system is of a similar class to our Sun, and just a shade less luminous than our star! When you look at Xi, imagine that our Sun would be a touch brighter, and *slightly* less yellowish, if seen at Xi's distance, and that the separation to the dimmer companion is "only" about 40 AU, the mean distance from our Sun to Pluto—in that respect, Xi makes a great model for our own system. (By extension, imagine how huge and powerful Pi's pair must be to put on a similar show from so much farther away…)

One last idea about Pi and Xi: The colors of the stars here correspond with their expected actual brightnesses. Much as dialing down a tungsten bulb makes it dimmer and more yellow, and dialing the power down further turns the filament orange and then red, so too goes the color for stars—powerful ones burn hot, bright, and white (or even blue); and the dimmer ones are yellow (like our Sun), orange, or red. Xi and Pi fit this pattern well.

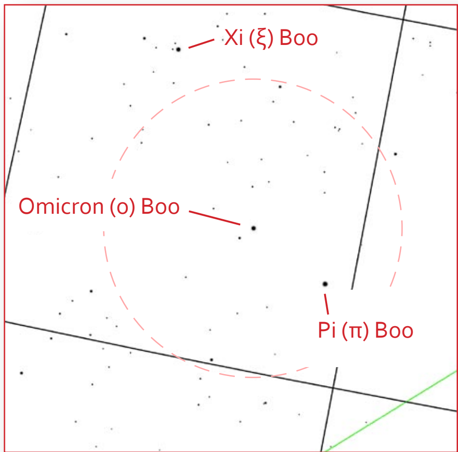
To find Xi in a dark sky, look for a star of roughly similar brightness to Pi and Omicron, and just "above" them, when "up" runs the same direction as from Arcturus to Izar—there's no other star of similar brightness within 2° of Xi, so it should be recognizable. Aim your Telrad to Xi's vicinity, then look into your finderscope—Xi isn't just the brightest star in its immediate neighborhood, it also noticeably yellow-hued.

In light-polluted skies, Xi won't be visible to naked eyes, but your finderscope can get you there from Pi and Omicron **(See chart, page 8)**: Imagine these three stars positioned on a clock face, with Omicron at the hub, and Pi sitting where the tip of a short "hour" hand would be when pointing to "6 o'clock." You'll find Xi at the end of a long "minute" hand, when that hand is pointing just past 1 on the clock. Now that you know where to expect Xi, center the finderscope's crosshairs on Omicron, and then sweep the finder towards the "1 o'clock" position—Xi isn't far, so just a small movement should bring it into the finderscope's field (wide finderscope fields may even include Xi when centering Omicron).

Last up, we've got **Delta** (δ) **Boötis**, up in the "top left" of the kite, at **15h 16m, +33° 15'**. Delta serves up a bit of a twist—at 125 light-years, it's much farther from us than Xi, but Delta's primary still outshines Xi's by a wide margin. No problem, you say—it must be hotter and brighter, like Pi. Well, intrinsically bright, yes—but *hotter,* no—its surface is cooler than Xi's!

Continued on Page 8

June Skies *Continued from Page 7*



Center Omicron (o) Boo in your finderscope, and Xi (ξ) Boo will be nearby.

Delta's trick is that its primary is experiencing the onset of old age—and as stars of its mass do when they run low on their hydrogen fuel, it has squeezed its insides hard enough to fuse helium instead, swelling greatly in the process. Though its outer gas envelope is cooler than Xi's (or our Sun's), and each square mile of its surface is dimmer, the star radiates far more energy overall by having a much larger surface—Delta's primary is a giant, at least 10 times our Sun's diameter.

Delta's secondary is somewhat sunlike, though it's dimmer than the Sun. The sheer size of the Delta system is striking, especially after observing Pi and Xi—unlike those two, with their 5 or 6 arc-second separations, Delta's pair appear almost 20 times farther from each other in a telescope. At Delta's distance, that wide spread works out to a physical separation of 3,800 AU; with that large orbit, the stars take more than 100,000 years to circle each other.

The wide split also means that this is a great target for observers with smaller telescopes (which usually use lower magnification than large ones). The separation is so great that pretty much any 'scope will split it, and lower powers enhance the perception of contrasting colors in the pair. At low power in a small 'scope, the giant may appear yellow or orange, and its companion blue or purple. In a larger instrument, the colors will be subtle—I saw "wheat" for the primary and an iffy "white or possibly subtle purple" for the secondary, at 38x in my 12-inch. (On another night, the secondary was "lavender," but the effect only existed at that low power, and disappeared as I used stronger eyepieces.)

Happily, putting your telescope on 3rd-magnitude Delta Boo is a breeze—it often remains visible in suburban Denver. Just glance up the kite's side from Arcturus to Izar, and keep going a similar distance in the same direction, until you hit Delta!

In poor skies, where Delta can't be seen, you can imagine where it "should" be by noting that Izar is roughly in-between Delta and Arcturus. A rough estimate with the Telrad will put Delta nicely in your finderscope, where it will be the brightest star in the field. As an extra aid to confirmation, you'll see a noticeable, if artfully uneven, quadrilateral with Delta in one of its corners. (And if the sky is so bad that you can't see Izar to guide with, go get some hot chocolate instead—there's always tomorrow!)

—See you next month.

The Denver Astronomical Society
P.O. Box 102738
Denver, Colorado 80250