The Denver
OBSERVER
JULY 2017

These six images, showing Ultra Luminous InfraRed Galaxies, or ULIRGs, display odd shapes and smears due to the distorting effects of gravitational lensing, and in some cases, galactic collisions as well. These galaxies lie between 8 and 11.5 billion light-years from Earth, and are far more brilliant than our own Milky Way (counting the infrared spectrum). The lensing further concentrates their light, making them brighter still. ("Astro Update," starting on p.4, has more on this—see *"Ultra-Bright Galaxies Explained."*)

Image Credit: NASA, ESA, and J. Lowenthal (Smith College)

JULY SKIES

by Zachary Singer

This month, we're heading low into the southern sky to check out the constellation Scorpius. Our targets include a beautiful and interesting binary star, and two open clusters that are related to each other. First though, the solar system for July:

The Solar System

For most of the month, **Mercury** is visible in the west about 30 minutes after sunset. After about the first week, the planet will be at least 6° above the horizon at that time each evening, climbing to 8° mid-month and then sinking again. The planet's disk spans about 5" at the beginning of the month, dimming slightly but growing to 8" by month's end. Realistically, it should make a lovely naked-eye object, but because the ground will still be radiating summer heat at that hour, telescopic views near the horizon are likely to be especially poor.

Venus is a brilliant morning object, sitting at least 20° up in the east by 5 AM all month. Its disk spans 18" and is almost 2/3 illuminated as July begins, though the planet will *look* more like a slightly fat lemon wedge… By July's end, the illuminated area will be clearly gibbous, if slightly smaller.

Mars is lost in solar glare this month, and will reappear as a morning object this fall. (You might catch a glimpse of the Red Planet during totality of this August's solar eclipse—Mars will then be a 2nd-magnitude dot about 10° northwest of the Sun.)

Jupiter is viewable in the southwest sky this month, but it won't last. As July begins, the planet is still 35° up an hour after sunset. By

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Sky Calendar

8	Full Moon
16	Last-Quarter Moon
23	New Moon
30	First-Quarter Moon

In the Observer

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

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ASTRO UPDATE

Selected Summaries of Space News

by Don Lynn

Cold Nebula Explained

The Boomerang Nebula is called the coldest known object in the Universe. The nebula is so cold that the Cosmic Microwave Background, at 2.7° C above absolute zero, is warming it. New observations with ALMA (radio telescope array in Chile) show how it got that cold: Apparently, a small star plunged through the red giant star at the heart of the nebula, and gravitational interaction from this is throwing a huge amount of gas and dust out of the red giant at very high speed. The gas cools as it expands, and cools very strongly because it is moving so fast. The red giant is also throwing out, at lower speed and higher temperature, a proto-planetary nebula, which is buried inside the gravitationally thrown gas. The Boomerang is about 5,000 light-years away in Centaurus.

Universe Explained (Maybe Partly)

Nearly all the reactions between subatomic particles are symmetric between matter and antimatter. This brings up the questions of why the Universe exists, and why it contains essentially all matter and no antimatter. Both should have been created in nearly equal amounts shortly after the Big Bang, and they should annihilate each other whenever they touch, leaving no Universe. A few reactions are known with what is called CP violation, that is, they favor either matter or antimatter, but such reactions are so rare that they can't explain our Universe.

New experiments at the Japanese neutrino detector Super-Kamiokande have shown CP violation in neutrino oscillation. The experiments have not been run long enough to claim conclusive identification of CP violation; this may take nine more years. And it's probably not enough violation to explain why the Universe is filled with matter, but it's a step in the right direction.

Hubble Constant Discrepancy Explained (Maybe)

The Universe's structure consists of gigantic strands of gas and galaxy clusters, arranged in a "cosmic web." Between the strands lie large voids, containing much less gas and far fewer stars and galaxies. A new study shows we live in such a void, in fact the largest void known, with a radius of about 1 billion light-years. The study also states that our location in such a region should distort any measurements of the Hubble

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DAS SCHEDULE

July 2017

7	DAS General Meeting—DU's Olin Hall, Rm. 105—Starts at 7:30 PM
14	E-Board Meeting—At DU's Historic Chamberlin Observatory, 7:30 PM. All members welcome.
15	Member In-Reach—At DU's Historic Chamberlin Observatory, 7:30 PM.
22	Dark Sky Weekend—EGK Dark Site & Brooks Observatory
29	DAS Picnic/Solar In-Reach—DU's Historic Chamberlin Observatory—Starts at 4:00 PM
29	Open House—DU's Historic Chamberlin Observatory—Starts at 8:30 PM
	(August 2017)
4	DAS General Meeting—DU's Olin Hall, Rm. 105—Starts at 7:30 PM
11	E-Board Meeting—At DU's Historic Chamberlin Observatory, 7:30 PM. All members welcome.

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, July 19, 2017, 4:00-5:30 PM: *Lecture about the Solar Eclipse at the Denver Public Library*. Requesting DAS table with general info. about the Society, Chamberlin, etc.

Saturday, August 5, 2017, TBD: *Jeffco Planetarium, Lakewood*. They are deciding night observing vs. solar viewing.

Sunday, August 6, 2107, 10:00 AM-4:00 PM: *DMNS Free Eclipse Day, Denver*. DAS table and solar viewing.

Monday, August 7, 2017, 5:30-6:30 PM: *Eloise May Library, Denver (S. Parker Rd.)*. Solar observing and eclipse info.

Tuesday, August 15, 2017, 6:30-8:00 PM. *Belmar Library, Lakewood*. Solar observing and eclipse info.

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

July General Meeting

"How to Observe 2017's Total Solar Eclipse"

Presentation Description: On Monday, August 21st, what is arguably the most important astronomical event of 2017 will be visible in the United States: *a total solar eclipse*. If you've never seen a total solar eclipse before, you might think, "Observing this year's eclipse should be pretty straightforward. Take appropriate safety measures, sit back on a comfortable lawn chair, and enjoy." Actually, though, 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! Whether you're an eclipse veteran or a beginner, join us at our July general membership meeting for a comprehensive presentation by Denver Astronomical Society's Ron Hranac on how to observe August's eclipse, with an emphasis on the *experience* of the event.

Bio: Ron Hranac is President of the Denver Astronomical Society (www.denverastro.org), a member of its Executive Board, and has been interested in astronomy since elementary school. An avid meteorite collector, Ron lectures monthly about meteorites at the University of Denver's historic Chamberlin Observatory as part of Denver Astronomical Society's Public Night volunteer outreach program. He has been a guest lecturer in DU's astronomy program, at the Denver Museum of Nature and Science, and in area schools and similar venues, sharing his enthusiasm about rocks from space and astronomy in general. Ron is a veteran of several partial solar eclipses and two total solar eclipses.

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.

July In-Reach: Improving Chamberlin Tours / Telescope Tutorials

Saturday, July 15th, 7:30-10:30 PM: In-reach, Chamberlin Observatory

"In-Reach" events are just for DAS members (and guests of members). 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! There is no cost and no reservations are needed — just show up!

Agenda for July 15:

7:30—Trap Doors & Hidden Treasures: Making Tours of Chamberlin Observatory Hands-On and Exciting (presented by Leo Sack)

8:15—Telescope Tutorials: Practical workshops on telescope set-up and operation:

Sub-groups: **Newtonians & Dobsonian Mounts** (presented by Zach Singer); **Refractors & Equatorial Mounts** (presented by Jack Eastman); **Cassegrains & Computerized Mounts** (presented by Digby Kirby).

8:45—Stargazing on the South Lawn. Bring your own scope or borrow one for the evening!

All Evening—Snacks and social time inside Chamberlin. Get to know your fellow club members!

If cloudy, we will still meet to discuss telescope set-up, maintenance, and stargazing resources. Regardless of weather, the first floor of the building will be open for restrooms and as a gathering space.

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

DAS Picnic and Solar In-Reach

Saturday, July 29th, 4:00-6:00 PM: The annual DAS Summer Picnic is a fun, member- and guest-only event held every July on the North Lawn of DU's Historic Chamberlin Observatory.

**** This Year, we'll combine the picnic with a special In-Reach Solar Observing event for DAS members and guests to get ready for the August 21st Total Solar Eclipse.** Participants are invited to bring their solar equipment. **

The DAS E-Board provides picnic meats, fixings, utensils and soft drinks. Members are invited to bring potluck items such as chips and dips, salads, fruit, casseroles, and desserts.

Please bring your own lawn chairs as the metal ones from the observatory are not very comfortable!

After the picnic, we'll set up telescopes in Observatory Park and ready the observatory's 20-inch 1894 Alvan Clark-Saëgmuller refractor for the **July Open House, which begins at 8:30 pm.**

Public Night Speaker Needed

Speaker(s) needed for Public Night Team 6. If interested, please contact Digby Kirby, Acting Team 6 Lead, odigby@gmail.com, or phone him, (970) 301-2287.

THE SHAPE OF THE SOLAR SYSTEM

NASA Space Place

By Marcus Woo

When Stamatios (Tom) Krimigis was selected for the Voyager mission in 1971, he became the team's youngest principal investigator of an instrument, responsible for the Low Energy Charged Particles (LECP) instrument. It would measure the ions coursing around and between the planets, as well as those beyond. Little did he know, though, that more than 40 years later, both Voyager 1 and 2 still would be speeding through space, continuing to literally reshape our view of the solar system.

The solar system is enclosed in a vast bubble, carved out by the solar wind blowing against the gas of the interstellar medium. For more than half a century, scientists thought that as the sun moved through the galaxy, the interstellar medium would push back on the heliosphere, elongating the bubble and giving it a pointy, comet-like tail similar to the magnetospheres—bubbles formed by magnetic fields—surrounding Earth and most of the other planets

"We in the heliophysics community have lived with this picture for 55 years," said Krimigis, of The Johns Hopkins University Applied Physics Laboratory in Laurel, Maryland. "And we did that because we didn't have any data. It was all theory."

But now, he and his colleagues have the data. New measurements from Voyager and the Cassini spacecraft suggest that the bubble isn't pointy after all. It's spherical.

Their analysis relies on measuring high-speed particles from the heliosphere boundary. There, the heated ions from the solar wind can strike neutral atoms coming from the interstellar medium and snatch away an electron. Those ions become neutral atoms, and ricochet back toward the sun and the planets, uninhibited by the interplanetary magnetic field.

Voyager is now at the edge of the heliosphere, where its LECP instrument can detect those solar-wind ions. The researchers found that the number of measured ions rise and fall with increased and decreased solar activity, matching the 11-year solar cycle, showing that the particles are indeed originating from the sun.

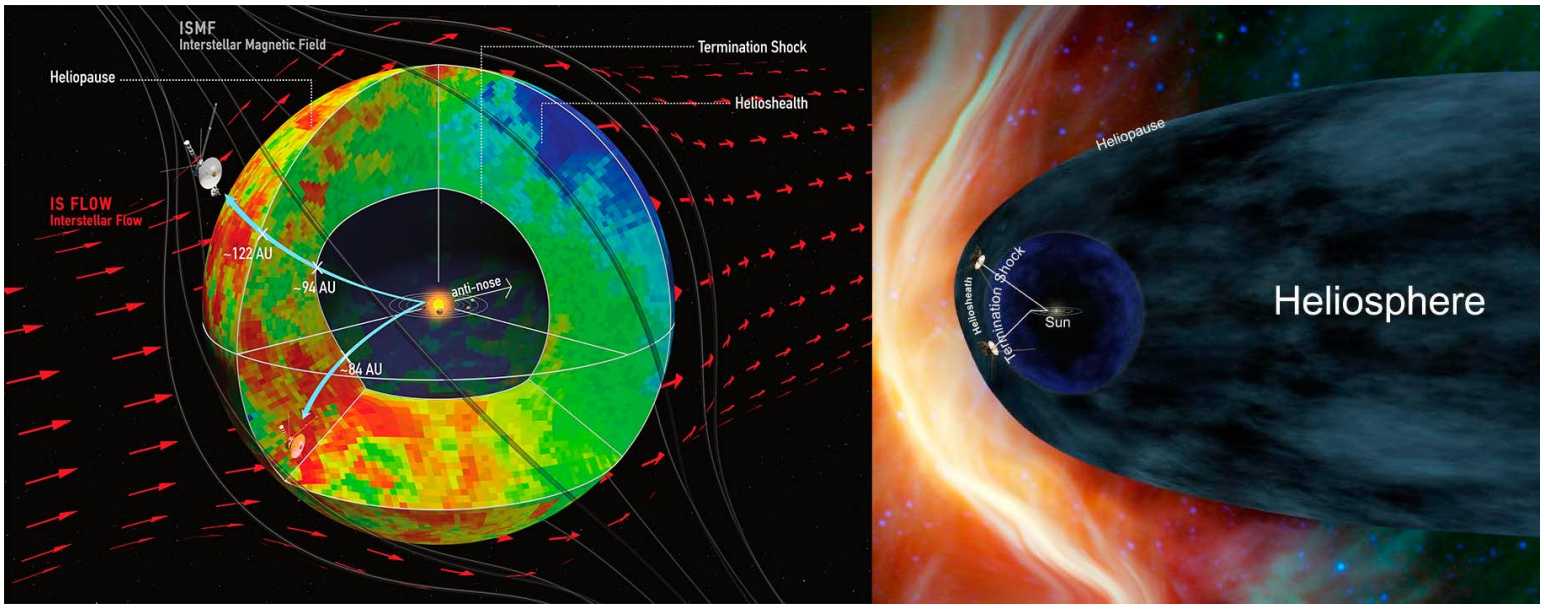
Meanwhile, Cassini, which launched 20 years after Voyager in 1997, has been measuring those neutral atoms bouncing back, using another instrument led by Krimigis, the Magnetosphere Imaging Instrument (MIMI). Between 2003 and 2014, the number of measured atoms soared and dropped in the same way as the ions, revealing that the latter begat the former. The neutral atoms must therefore come from the edge of the heliosphere.

If the heliosphere were comet-shaped, atoms from the tail would take longer to arrive at MIMI than those from the head. But the measurements from MIMI, which can detect incoming atoms from all directions, were the same everywhere. This suggests the distance to the heliosphere is the same every which way. The heliosphere, then, must be round, upending most scientists' prior assumptions.

It's a discovery more than four decades in the making. As Cassini ends its mission this year, the Voyager spacecraft will continue blazing through interstellar space, their remarkable longevity having been essential for revealing the heliosphere's shape.

"Without them," Krimigis says, "we wouldn't be able to do any of this."

To teach kids about the Voyager mission, visit the NASA Space Place: https://spaceplace.nasa.gov/voyager-to-planets



New data from NASA's Cassini and Voyager show that the heliosphere — the bubble of the sun's magnetic influence that surrounds the solar system — may be much more compact and rounded than previously thought. The image on the left shows a compact model of the heliosphere, supported by this latest data, while the image on the right shows an alternate model with an extended tail. The main difference is the new model's lack of a trailing, comet-like tail on one side of the heliosphere. This tail is shown in the old model in light blue.

Image credits: Dialynas, et al. (left); NASA (right)

This article is provided by NASA Space Place. With articles, activities, crafts, games, and lesson plans, NASA Space Place encourages everyone to get excited about science and technology. Visit *spaceplace.nasa.gov* to explore space and Earth science!

Astro Update

Continued from Page 2

Constant (the speed with which the Universe is expanding) made using supernovae, but should *not* affect measurements using the Cosmic Microwave Background. That's important, because the most authoritative methods of measuring the Hubble Constant disagree by over 7%, a larger discrepancy than could previously be explained. More work is needed, but the void may help account for the Hubble Constant disparities.

Ultra-Bright Galaxies Explained

There is a class of galaxies that is very bright in infrared, known as ULIRGs (Ultra Luminous InfraRed Galaxies). A new study of the brightest of these, ones up to 100 times brighter than your everyday ULIRG, found that the first 12 of them observed were each lensed by the gravity of a galaxy cluster that happened to lie in front. (Gravitational lensing bends light rays to form images, as predicted by General Relativity, and makes the farther object appear much brighter than normal.)

Though it's thought that most ULIRGs aren't gravitationally lensed (they're bright because they are undergoing massive star formation), it now seems that essentially all of the *brightest* ULIRGs *are* lensed. The study will continue observing more very bright ULIRGs. Astronomers also hope to find the cause of ULIRGs' massive star formation. (*See cover photo.*)

Rarity of Venusian Volcanoes Explained

A new study of Venus data shows that the intense heat at the surface is sufficient to soften the planet's crust into the consistency of Play-Doh. This would prevent tectonic plates from forming and lessens the chances of cracks forming in the crust. These factors greatly reduce the frequency of volcanoes formation, explaining why very few volcanoes have been identified in the radar images of Venus.

Flashes Explained

In 1993, the Galileo spacecraft did a flyby of Earth and spotted bright flashes on Earth. At the time, they were attributed to reflections of the Sun off water. Now the DSCOVER spacecraft is monitoring the Earth (as well as solar ejections) and has seen the same kind of flashes, but not always over water. The measured angles proved the flashes were indeed reflections of the Sun, but the flashes occurring over dry land had to be reflecting off ice crystals. The scientists who published this result suggest that we try to look for such flashes from exoplanets.

Bad Image Explained

Analysis of a wobbly picture taken in October 2014 by the Lunar Reconnaissance Orbiter shows that the radiator on the left-hand Narrow Angle Camera was struck by a meteoroid. The spacecraft suffered no permanent damage, and recovered stability before that same image was entirely scanned. The particle was probably just under a millimeter in size, but hit at 4 miles/sec (7 km/s).

Gravitational Wave

LIGO scientists have announced the third-ever detection of a gravitational wave. Like the first two, it was the result of two black holes merging. This one came from 3 billion light-years out, more than twice as far as the earlier waves. As with the first two events, the merging black holes were over 20 times the Sun's mass, larger than theorists expected. They were also of more unequal masses than previously; the resulting single black hole was 49 times the Sun's mass, in-between the masses of the other resulting black holes.

Hot Planet

An exoplanet named KELT-9b has been found to be the hottest gas-giant planet known, with a dayside temperature of more than 7800°F (4300°C), hotter than most stars. It's 2.8 times the mass of Jupiter, but only half as dense, since the heat causes it to swell. Just 300 million years old, KELT-9b lies extremely close to its star, orbiting in only 2 Earth days, and it's tidally locked, so one side always faces its star. The planet is probably shedding matter because of the close-by stellar radiation, forming a comet-like tail which will be looked for in future observations.

Type II Supernova

A Type II supernova, designated SN 2017eaw, has been discovered in galaxy NGC 6946 by an amateur astronomer. NGC 6946 is also known as the Fireworks Galaxy, because supernovas—10 in the past 100 years—keep exploding in it.

A *failed* supernova was discovered in the same galaxy: A massive star that should have exploded as a supernova at the end of its life, instead faded away to undetectability sometime in the last few years. It apparently formed a black hole without going through the explosion, surprising many theorists, but confirming the ideas of others.

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ABOUT THE DENVER ASTRONOMICAL SOCIETY

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*.

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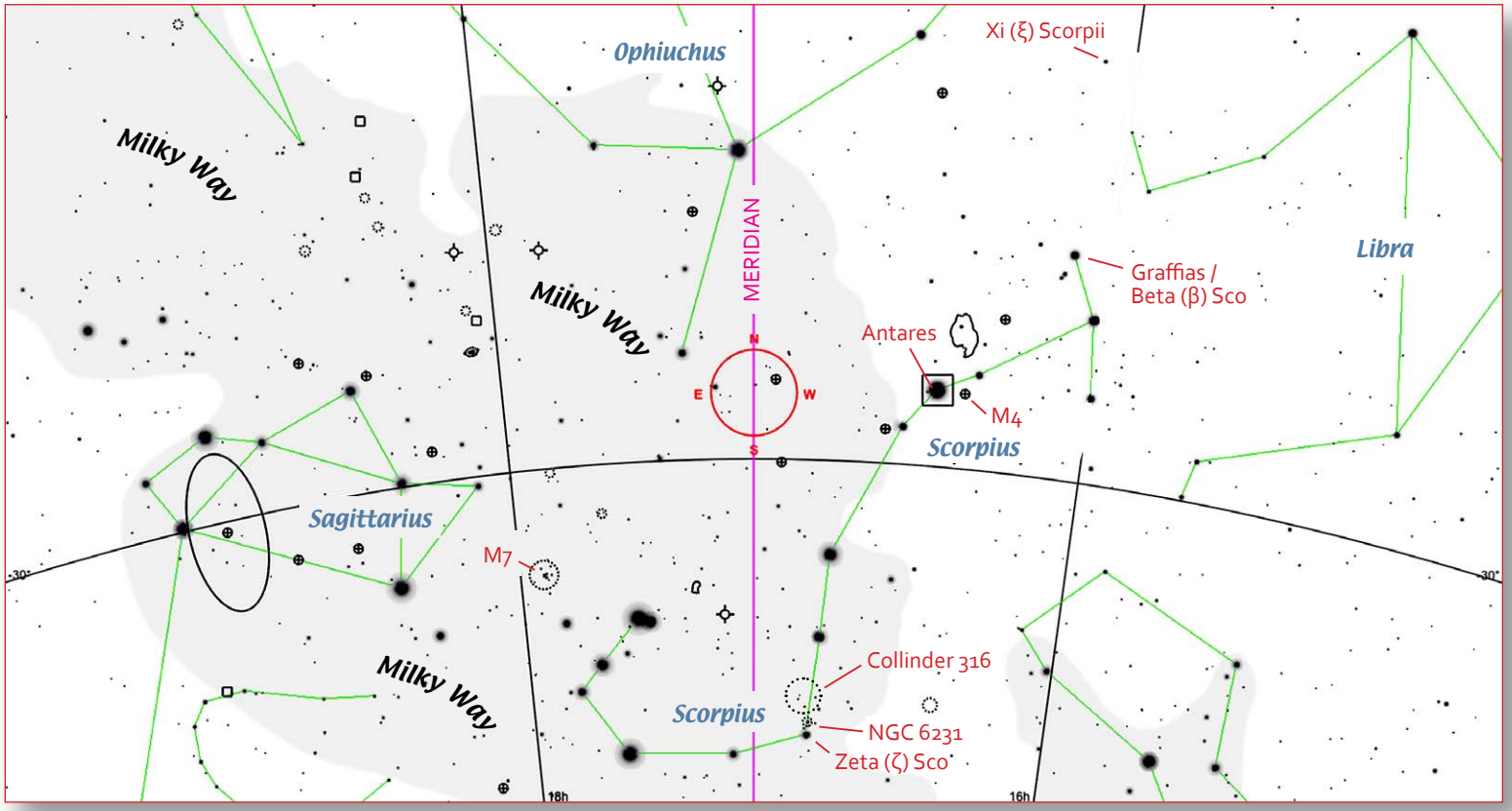

View due south in Denver skies at 10:30 PM in mid-July; center of chart is roughly 25° above the horizon. Central circle is 4°, included for scale. Some objects not in "Monthly Skies," like M4, are included for reference. (Planets not shown.) ***See detail chart on p. 7 for close-up of area near Zeta (ζ) Sco.***

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

July Skies

Continued from Page 1

the end of the month, though, waiting an hour after sunset leaves the planet only 20° up—so you'll have to trade off between observing then (when the planet's low altitude will blur the image) or earlier (when Jupiter is higher, but twilight lessens image contrast).

Happily, "Surf's up!" at **Saturn** this month: The Ringed Planet was at opposition in mid-June, so it's highest just before midnight (local Daylight Time) as the month begins, and around 9:45 PM as August approaches.

A late-night view a couple of weeks ago was stunning—we had remarkably steady skies, and the Cassini Division in the rings was distinct, as were bands in Saturn's atmosphere. Seeing isn't usually that good under Denver's choppy air, but Saturn is always a crowd-pleaser, regardless. (Since Saturn is still relatively low in our sky, do your best to see it when it's at its highest in the south.)

Although **Uranus** is too low to be worthwhile as July begins, by the end of the month, it's at least 33° up in the east at 2:30 AM. To find the planet, center 4th-magnitude Omicron Piscium (o Psc) in your finderscope, and 6th-magnitude Uranus will share the field, glowing about a degree northward.

Finally, there's **Neptune**, which is almost 30° up by 2:30 AM at the *beginning* of July, and more than 40° up at that hour as August begins. Look for the pale blue, 8th-magnitude planet in your finderscope, near 6th-magnitude 81 Aquarii (81 Aqr). 81 makes a noticeable pair with similar-looking 82 Aqr (they're ½° apart); to roughly center 81 and 82 in your finderscope, aim halfway between Hydor, aka Lambda (λ) Aqr, and Phi (φ) Aqr. All through July, Neptune appears closer to 81 Aqr than 82 does.

Stars and Deep Sky

A Quick Intro to the Constellation Scorpius

Now that we're done with the solar system, welcome to Scorpius! I'm happy to say that all three of our targets this month are appropriate for both beginners and more-advanced observers—and we'll cover both levels in our discussion, so don't worry if you're in the "other" group, whichever it is! (If you know how to find Scorpius, then feel free to skip a few paragraphs down to "Let's Get Going," below.)

Unlike some constellations, Scorpius is relatively bright and has a distinctive shape—it really does resemble a scorpion. If you're not sure where to find it, just look *due south* and about 20° up, around 10:30 PM in mid-July. (It will slide to the west a little later in the evening, and likewise, later in the month; earlier in the month, it lies a bit eastward, instead.)

Look for Antares, a noticeably bright, orange-red star (it's often confused with Mars); you'll find two somewhat dimmer stars flanking it, in the upper part of the scorpion's "body," near the "claws." (*See chart.*) Once you've got Antares (sometimes listed as Alpha [α] Scorpii), notice how the scorpion's body curves down and eastward from there, eventually looping around and upward again towards the "stinger." From the claws (at Graffias) across to the stinger, the constellation spans about 20° of sky. (You can measure this angle by making a fist with both hands and holding them together at arms' length in front of you—look across your knuckles from the outer edge of one hand to the other.)

Let's Get Going

Now that we're oriented, our first target is the bright star **Graffias**, also known as **Beta (β) Scorpii**, or **Beta Sco** for

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July Skies

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short. Located at the top of the scorpion's claws at **16h 07m, -19° 51'**, Graffias is a beautiful binary in almost any telescope. At first, it looks simple—two stars of unequal brightness, about 14" apart. Despite their 400-500 light-year distance from us, they still boast a visual magnitude of +2.6 and +4.9 (our Sun would be no better than 10th-magnitude at their distance, and only dimly visible in a 9x50 finderscope). On a decent night in Denver, the duo splits easily at 60x, and very easily at 120x.

At Beta Sco's distance, the 14" of sky between the pair works out to a physical separation of more than 2,000 astronomical units (AU), or at least 50 times Pluto's average distance from our Sun—from that, it's calculated that they take at least 16,000 years to orbit each other. Both are very hot (and short-lived) Class B stars, but even the lesser one has at least 10 times our Sun's mass, and both will therefore eventually go supernova.

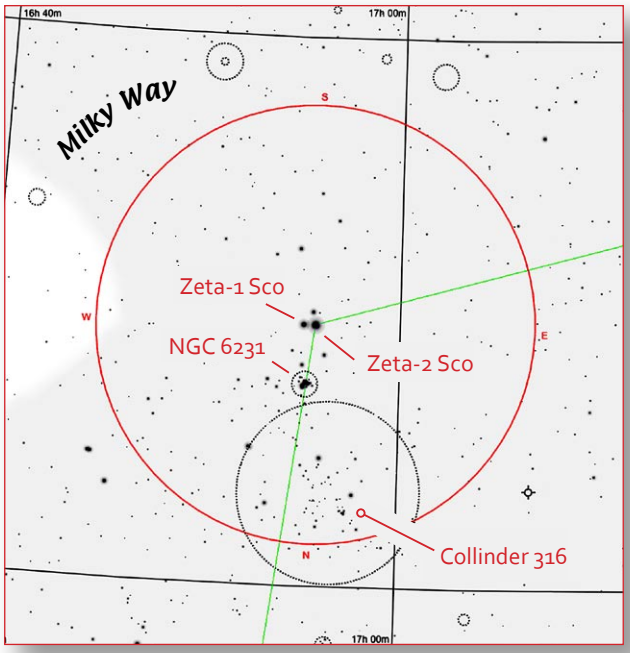
Some observers have noted color differences between the pair, but on a recent, and typical, observing run with other DAS observers on a 12-inch 'scope, we all saw the stars as "bright-white and white" or "white and light gray." Similar descriptions have been the norm over the years for my 6-inch, too. In either instrument, though, the star draws attention even from experienced observers.

Frankly, that's already plenty to take in, but there's *more*, if you're into it—advanced folks and curious beginners, I'm looking at *you*. (If your *head* will go supernova, though, skip down to the directions for finding Beta, just below.)

It turns out that the brighter star of the wide pair has a 10th-magnitude companion lying about 0.5" away (about 80 AU in actual distance)—the companion would be visible in a telescope, but the tremendous glare and proximity of the brighter star obscures it. Even large amateur 'scopes won't show it, but you know it's there, orbiting invisibly (to us). The brighter star has yet *another* star in orbit around it, and it's even closer in—that companion is a spectroscopic binary—that is, its presence wasn't so much seen as *detected*.

So far, the star-count for this system is four—two you can see with your telescope, and two that you can't. But the *dimmer* star in the visible pair is a spectroscopic binary, too, so the total count (that we know of) for Beta Scorpii stands at five. Interestingly, two of these unseen companions are themselves large enough to explode as supernovae—so much for a quiet neighborhood.

One last note, before we get out for a look: In a telescope, Graffias/Beta Sco appears to have still *another* companion, referred to in some sources as "Beta Sco D." This magnitude +7.5 star is seen almost 9 arcminutes from the bright pair, at a 30° bearing. It shows readily at higher magnifications, but data suggest it's only a line-of-sight interloper, rather than an actual member of the system. (Too bad—it would have been grand!)



Inverted view **(south is up) around Zeta (ζ) Sco, showing area as seen in a finderscope field. Large circle covers 4°, for reference.**

To find Graffias, follow the curve of the scorpion's body to the northwest—there, a bent line of stars runs almost perpendicular to the body—these represent the arachnid's claws. Graffias is the topmost, and brightest of them, and should be obvious once you compare the sky to your chart. Use an eyepiece of moderate power to confirm the split in your telescope, and you're in.

Our next targets, two open clusters, share membership in what's known as the Scorpius OB-1 Association. Such associations are groups of hot, blue stars (they're Class O or B, and thus the name), which are seen either individually (after being violently ejected from their parent cluster) or in open clusters (where they vastly outshine their clustermates and get all the attention). Because of the lines-of-sight between Earth and the flung-out stars, members of such an association can appear near each other in the sky, or sometimes a considerable number of degrees away.

Our jumping-off point is Zeta (ζ) Scorpii, aka ζ Sco, which looks like a single star to the unaided eye, but two stars in a finderscope or binoculars. Zeta is easily found, right at the "bend" in the scorpion, where the north-south-aligned bright stars of the body start running east-west in the tail. (See charts.)

With OB associations in mind, it's not a huge coincidence that one of the stars making up Zeta is an extremely hot Class O star, named **Zeta-1 Scorpii**—it's part of Scorpius OB-1, too. (Zeta-1 is sometimes shown as "ζ¹ Sco" for short.) Ironically, Zeta-1's neighbor, Zeta-2, is an unrelated star that looks brighter because it's so much closer to us—"only" 130-150 light-years, compared to Zeta-1's roughly *6,000* light-year distance. There's much more to Zeta-1 than we have space for here, but a good starting point is Prof. James Kaler's write-up, at http://stars.astro.illinois.edu/sow/zeta1sco.html.

Our first cluster, **NGC 6231,** also known as **Caldwell 76** (**C76**), or more obscurely as Collinder 315 (Cr315), is just ½° north of Zeta Scorpii, at **16h 55m, -41° 51'**. Under dark skies, this cluster looks like the head of a comet—it's bright enough to be seen naked-eye, but its stars are too close together to be resolved, and appear "fuzzy." Like Zeta-1 Sco, it lies some 6,000 light-years from us—and Zeta-1 is thought by many sources to be a cluster member.

In a telescope, NGC 6231 is a beautiful object, reminiscent of the Pleiades—but unlike the Pleiades, it fits easily into a moderate eyepiece field. The five brightest stars in the cluster are of 5th or 6th magnitude, and most of the 20 brightest only get down to magnitude 8 (the last two are just over the line for 9th-mag.).

A wider view at lower power brings in some of the dimmer cluster members, which together span about ¼°. Remembering that Zeta-1 is also a potential member, a field just over ½° will include the whole crazy collection, and a field of ¾° or more will give you some breathing room.

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Advanced observers with an interest in Wolf-Rayet stars should note that two of the cluster's 20 brightest stars boast this rare "Class W" designation. If you'd like to find them, *Burnham's Celestial Handbook, Volume 3*, has a detailed chart of all 20 bright central stars in its article on NGC 6231.

To get to NGC 6231, just center Zeta Scorpii in your finderscope! 6231 is right next to it—though it may appear almost star-like at first glance. Look again, and you'll recognize this tight cluster for what it is. For those of you with normal, "straight-through" finderscopes, remember that your image will appear upside-down, so the cluster will appear *below* Zeta. *See detailed chart.* (At 10:30 PM mid-month, Zeta and 6231 will indeed be one-above-the-other; at other times of night, or earlier or later in the year, the finderscope field will seem to rotate, so adjust your angle accordingly.)

Last up is **Collinder 316** (**Cr 316**), just north of NGC 6231/Collinder 315, and centered at **16h 57m, -40° 51'**. As mentioned, this cluster is also a Scorpius OB-1 member. Unlike NGC 6231, though, this cluster covers a wide section of sky—some 100', or a touch over 1½°. Owners of rich-field telescopes will be in luck here, as will binocular users. In practice, you'll love the view if you can manage a field of about 1°—it drew *ooohs* and *aahhhs* in my 'scope. A bit tighter might do in a pinch, but a ½° field was just too narrow.

(DAS members, don't give up the ship if you have a big 'scope and want a wide field—my 12-inch will give me nearly 2° when set up appropriately. If you're not sure how, ask more-experienced folks—we love to help—or just start teaming up with someone with the right gear; it's a good way to meet new friends.)

Before we head off to find Cr316, here's one important note: At Denver's latitude, the area between Cr316 and Zeta Sco only reaches 8°-10° above the horizon *at best*. While objects in Scorpius generally are low, Cr316 and Zeta are even lower than most, so *take extra care to ensure an unobstructed southern horizon*.

Advanced folks: There's actually another cluster, Trumpler 24 (Tr 24), overlying Cr316 in the northeast corner—I've left it off our charts for clarity, but you may run across it on deep maps. It's part of the Scorpius OB-1 association, too.

Collinder 316 is surprisingly easy to find, for a relatively obscure object! If you already toured NGC 6231 and it's still centered, then look back into your finderscope, and you'll see 316's stars sprinkled liberally across the field, almost directly opposite from Zeta Scorpii.

If you want to go to Collinder 316 *first* (or you've moved your 'scope since 6231), then just center on Zeta Sco—as the inverted detail chart shows, Cr316 shares the field, towards the lower edge. You can also hit 316 by aiming your Telrad halfway between Zeta Sco and Mu (μ) Sco—if you're comfortable with that "artsy" approach, it may be quicker.

—See you next month.

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