The Denver
OBSERVER
JULY 2016

Messier 4 (M4), a globular cluster in the constellation Scorpius, is featured in "July Skies," below. The relatively short exposure used for this photograph results in an image more like that seen by observers through a telescope. Note the central "bar" of stars near the cluster's center; familiar to long-time observers, it's one of M4's noticeable traits. ***Image © Darrell Dodge***

JULY SKIES

by Zachary Singer

The Solar System

Technically, you can see *all* the planets this month, plus Pluto, too. Realistically, though, that's a bit of a stretch—let's start off at the innermost planet and see what's going on.

Mercury arrives at superior conjunction on the 6th—that is, it's as directly in line with the Earth-Sun line of sight as it's going to get (the "conjunction"), and when it does, it's on the far side of the Sun (the "superior" aspect of the event). Because so many charts and astronomical sources illustrate the planets' orbits as though they're all lying in the same flat plane, you might think Mercury is hidden by the solar disk—occulted or, in layman's terms, "eclipsed" by the Sun. In reality, the orbits are all off a bit, so though it's neatly hidden by the Sun's *glare,* Mercury's disk is actually about 1° away from the Sun's. As the month progresses, the planet's orbit will move it east of the Sun, from our point of view—by mid-month, the planet will be about 11° from the Sun, and about 6½°above the local horizon at sunset (not counting the Rocky Mountains from here in Denver).

In the Observer

Venus will be in the same neighborhood, since it's also moving eastward out of the solar glare. Venus, at a brilliant -4 magnitude, will be much easier to spot than Mercury, and ***on the evening of the 16th, the two planets will align about ½° from each other.*** Look for Venus in the sunset's afterglow at 8:30 PM. Note that planets will be about 1° apart one day before and one day after the main event—not quite as impressive as ½°, but still noteworthy and worth a look! If the bright horizon makes Mercury hard to find, it will be at the "3 o'clock" position, to the right of Venus, as you look west on the 15th, at about the "1 o'clock" position (and closest to Venus) on the 16th, and at the "11 o'clock" position on the 17th.

Sky Calendar

4	New Moon
11	First-Quarter Moon
19	Full Moon
26	Last-Quarter Moon

Mars is now well past opposition, so it's up at a convenient hour and makes a lovely target on a warm summer evening. At the beginning of July, it's already at the meridian by 9:30 PM—well before astronomical

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The Executive Board conducts the business of the DAS at 7:30 PM, at Chamberlin Observatory.
Please see the Schedule of Events for meeting dates. All members are welcome.
http://www.denverastro.org

PRESIDENT'S MESSAGE *by Ron Hranac*

The International System of Units

I work in telecommunications engineering, where the ironic saying, "The only constant is change," seems to be very appropriate. (Consider, for example, internet access: I remember when dial-up phone modems provided oh-so-slow connections counted in hundreds of bits per second—now, data moves at millions or even billions of bits per second.)

Still, there are *real* constants in addition to the never-ending "change" that apply directly to engineering, astronomy, physics, and other fields. One is the speed of light. According to the National Institute of Standards and Technology (NIST), the speed of light *in a vacuum* is 299,792,458 meters per second. The symbol for this specific condition, "c_0," is usually simplified for the general public, who are much more familiar with "c" as the (generic) designation for the speed of light.

Why bother with "c_0," then? Because the *precise* speed of light varies slightly in other mediums—say, air or water. To an engineer or physicist, that variation could be a critical difference, while the public is OK with rounding to "about 300,000 kilometers a second."

Note as well the use of a *lowercase* c. Uppercase C is reserved for electric charge or quantity of electricity, expressed in a unit called a "coulomb." So there's the crux of our discussion this month: The need to pay attention to subtle differences in the symbols for units. Mix them up, and you could lose some important understandings about the units you're describing. If you're not an engineer, well, getting it wrong still looks sloppy.

With all this in mind, a good reference for getting your constants and units right could be quite useful, and there is one: The International System of Units (SI), which can be found at *http://physics.nist.gov/cuu/Units/*. The table on page 5 summarizes SI base units and their symbols. As the term "base units" suggests, these are the foundational measures of time, distance, energy, mass, and so forth.

The next step for describing units is to add SI *prefixes*, which are "…used to form decimal multiples and submultiples of SI units." For example, a billion of a given unit is represented by "giga-" (G), as in *giga*bits per second. A million (10^6) is "mega-" (M), a thousand (10^3) is "kilo-," whose symbol is lowercase k. On the small side, a *thousandth* (10^{-3}) is "milli-" (m), and a *millionth* (10^{-6}) is "micro-", which is abbreviated with the Greek letter "mu" (μ).

Put the units and the prefixes together as necessary, and you've got a good working system: The familiar "cm," for example, stands for one-hundredth ("centi-" or c) of a meter (m). Less-familiar

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DAS SCHEDULE

JULY 2016

1-3	Dark Sky Weekend—EGK Dark Site & Brooks Observatory
9	DAS Summer Picnic, 4:00-6:00 PM (See "DAS News," p. 3)
9	Open House—DU's Historic Chamberlin Observatory—Starts at 8:30 PM
15	General Meeting at DU's Olin Hall, Rm. 105, 7:30 PM
22	E-Board Meeting—At DU's Historic Chamberlin Observatory, 7:30 PM
5-7	(AUGUST) Dark Sky Weekend—EGK Dark Site & Brooks Observatory

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

July 12th, 8:00 PM: Star Party and astronomy lecture for members and their children, **The Club at Pradera** golf course, **Parker, CO.**

July 15th, 8:00 PM: Moonlight Extravaganza and Science Night, Philip S. Miller Park, Castle Rock, CO.

July 25th, 8:00 PM: Troop 506 (Arvada), Boy Scout Merit Badge, **Camp at Easter Seals Facility, Empire, CO.**

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

DAS Picnic

The DAS Annual Club Picnic is coming up on **Saturday, July 9th at 4 PM**, before the July Open House.

As in past years, DAS will provide picnic meats, fixings, utensils and soft drinks. Members are invited to bring pot luck items including chips and dips, salads, casseroles, and desserts.

After the picnic, many members set up telescopes in Observatory Park and ready the observatory's 20-inch 1894 Alvan Clark- Saegmuller refractor for the July Astronomy Open House, which begins at 8:30 PM.

Space Day at DMNS

Denver Astronomical Society teamed up with the Denver Museum of Nature and Science for Space Day on Sunday, June 5th. Solar scopes were set up on the museum's fourth floor terrace, and several hundred members of the public enjoyed safe viewing of the Sun. White-light views of the Sun were limited to seeing faint granulation on the solar disk, given that Space Day took place during a four-day period of no sunspots. H-alpha views were the day's winner, with a couple of nice prominences visible.

Images © Ron Hranac.

HUBBLE'S BUBBLE LIGHTS UP THE INTERSTELLAR RUBBLE

by Ethan Siegel

NASA Space Place

When isolated stars like our Sun reach the end of their lives, they're expected to blow off their outer layers in a roughly spherical configuration: a planetary nebula. But the most spectacular bubbles don't come from gas-and-plasma getting expelled into otherwise-empty space, but from young, hot stars whose radiation pushes against the gaseous nebulae in which they were born. While most of our Sun's energy is found in the visible part of the spectrum, more massive stars burn at hotter temperatures, producing more ionizing, ultraviolet light, and also at higher luminosities. A star some 40-45 times the mass of the Sun, for example, might emit energy at a rate hundreds of thousands of times as great as our own star.

The Bubble Nebula, discovered in 1787 by William Herschel, is perhaps the classic example of this phenomenon. At a distance of 7,100 light years away in the constellation of Cassiopeia, a molecular gas cloud is actively forming stars, including the massive O-class star BD+60 2522, which itself is a magnitude +8.7 star despite its great distance and its presence in a dusty region of space. Shining with a temperature of 37,500 K and a luminosity nearly 400,000 times that of our Sun, it ionizes and evaporates off all the molecular material within a sphere 7 light years in diameter. The bubble structure itself, when viewed from a dark sky location, can be seen through an amateur telescope with an aperture as small as 8" (20 cm).

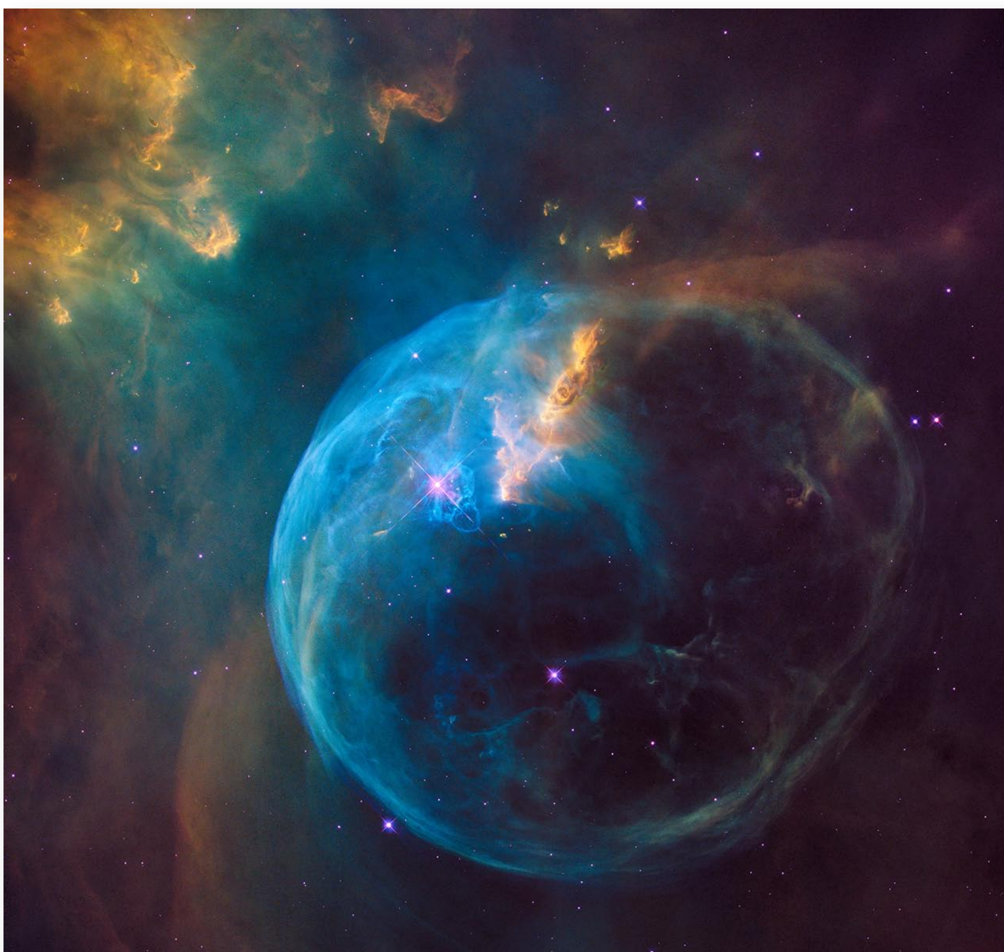

Image credit: NASA, ESA, and the Hubble Heritage Team (STScI/AURA), of the Bubble Nebula as imaged 229 years after its discovery by William Herschel.

As viewed by Hubble, the thickness of the bubble wall is both apparent and spectacular. A star as massive as the one creating this bubble emits stellar winds at approximately 1700 km/s, or 0.6% the speed of light. As those winds slam into the material in the interstellar medium, they push it outwards. The bubble itself appears off-center from the star due to the asymmetry of the surrounding interstellar medium with a greater density of cold gas on the "short" side than on the longer one. The blue color is due to the emission from partially ionized oxygen atoms, while the cooler yellow color highlights the dual presence of hydrogen (red) and nitrogen (green).

The star itself at the core of the nebula is currently fusing helium at its center. It is expected to live only another 10 million years or so before dying in a spectacular Type II supernova explosion.

This article is provided by NASA Space Place.

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President's Message

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combinations, like nanosecond, or one billionth of a second, work the same way: "n" (lowercase!) for "nano-" and "s" for second gives us "ns."

Taking this approach a step further, so-called SI *derived* units use exponents of existing units, a ratio of them, or both, to create new types of units—some examples of these include area (square meter, m^2), volume (cubic meter, m^3), speed or velocity (meter-per-second, m/s), and acceleration (meter-per-second-squared, m/s^2).

Though the names of SI units generally use all-lowercase letters, their symbols might not—some were set up as they were to avoid confusion or to maintain meaning, some because of old conventions, and some, well, just because. You may be familiar with frequency, expressed in hertz (Hz), or force, expressed in newtons (N). Notice how the h in hertz is lowercase but its symbol, Hz, has an uppercase H. The same is true of newton—lowercase n in the name, but the symbol is an uppercase N. Similarly, the base unit for thermodynamic temperature, kelvin, or K, is lowercase but its symbol isn't. (There is also no degree symbol used with kelvin or K, nor does one say "degrees kelvin," as you would with other temperature scales, like Fahrenheit.) Celsius temperature falls into the exceptions, too. Here, the name is "degrees Celsius," and its symbol is °C.

Base Quantity	Base Units	Symbol
Length	meter	m
Mass	kilogram	kg
Time	second	s
Electric Current	ampere	A
Thermodynamic Temperature	kelvin	K
Amount of Substance	mole	mol
Luminous Intensity	candela	cd

The seven base units of the SI-unit system, with their names and symbols.

Constants and units are sometimes misused, even in the professional literature. A helpful summary of the International System of Units can be found at *http://physics.nist.gov/cuu/Units/introduction.html*. I encourage you to spend a few minutes looking through the information on NIST's site.

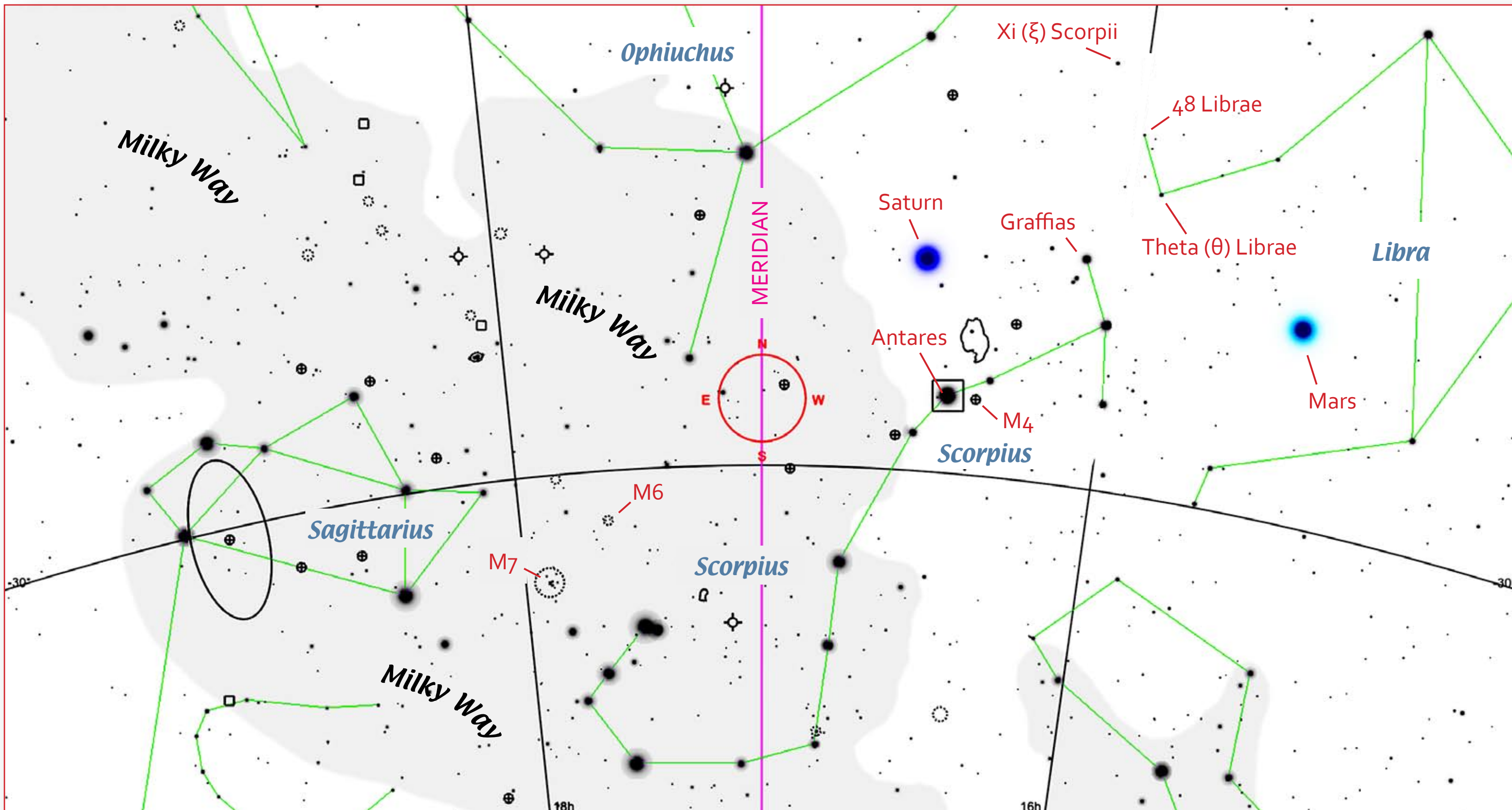
ABOUT THE DAS

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 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*.



Denver skies at 10:30 PM in mid-July; center of chart is about 23° above southern horizon. Central circle is 4°, included for scale.

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

July Skies

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twilight ends, but "close enough," especially under city lights. Mars has increased its distance from us since opposition, but though that will make the planet appear slightly smaller—16", down from 18"—it's still pretty good! Details on the Martian surface still reveal themselves as well as they did in early May, but the opportunity will dwindle noticeably by next month, as Mars' growing distance from us shrinks the planet's angular diameter even further—down to 13" by August, and just 10" in September.

Jupiter is already sinking low in the west an hour after sunset and sets by midnight in early July; it's even lower, setting by 10 PM, at the beginning of August. You can avoid the atmospheric blurring caused by low altitude by observing earlier in the evening—but then at some point, twilight will interfere. So as our line of sight to Jupiter moves closer to the Sun, there will be a trade-off between loss of contrast (viewing early, in twilight) and loss of sharpness. Personally, I'd go with the lower-contrast view—especially when observing from the city, where the skies are milky-looking anyway. Next month, Jupiter will have a *very* close conjunction with Venus, so the giant planet will at least go out with a bang before losing itself in the solar glare.

From Earth's point of view, **Saturn** is moving slightly westward (i.e., in retrograde) to a position more directly north of Antares, but the ringed planet carries on much like it did in June, shrinking just 0.2" in angular diameter. By early July, though, it transits two hours earlier, around 11 PM. In August, Saturn will cross the meridian still earlier, in twilight, and observing opportunities will diminish.

Uranus rises around 1:30 AM at the beginning of July, climbing to about 25° above the eastern horizon by 3:30, leaving relatively little time for observing before morning twilight begins. By the end of the month, though, the same benchmarks are hit 2 hours sooner, so you can either have a look at a more reasonable hour or observe when Uranus is higher. Keep in mind that with a disk less than 4" across, you won't see any surface detail, so the usual approach of waiting for best altitude isn't as important as with closer planets—but viewing early enough to avoid morning twilight washing out the planet's pale blue hue will be.

Uranus shines at magnitude +5.8 this month, which is nominally within the range of dark-adapted eyes, and should be visible to them if you know where to look—a finderscope will definitely show it. To aim your telescope at Uranus in mid-July, head to **1h 31m, +8° 52', in Pisces**—you'll find it at essentially the same right ascension throughout the month, with the declination varying by just 3' on either side.

For advanced folks, try centering the southeastern edge of your Telrad's outer, 4° circle on a line between 4th-magnitude Omicron (ο) Piscium and 5th-magnitude Mu (μ) Piscium—that will put Uranus close to the center of your finderscope, where you can easily move it into the crosshairs. (Equatorial-mount folks can also just center Omicron, and slew roughly 4° directly west, until the planet's in the finderscope.) **See the chart on page 7.**

And finally, there's **Neptune,** at **22h 53m, -7° 29'**. In the interest of space (editorial, not interplanetary), let's just say that this planet would remind you strongly of Uranus, except it's much farther away, and therefore smaller (at just over 2") and dimmer (at magnitude 8). The relative difficulty of seeing this remote planet lends it an unmistakable air of the exotic, though, and like many astronomical objects, it's perhaps not only what you see, but what you *imagine* of it from your own knowledge, that makes observing Neptune worthwhile. Neptune's disk is about the same angular dimension as the separation between the tighter of the pair of binaries in the Double-Double—about the limit of seeing on many nights in Denver. You'll need high power to perceive

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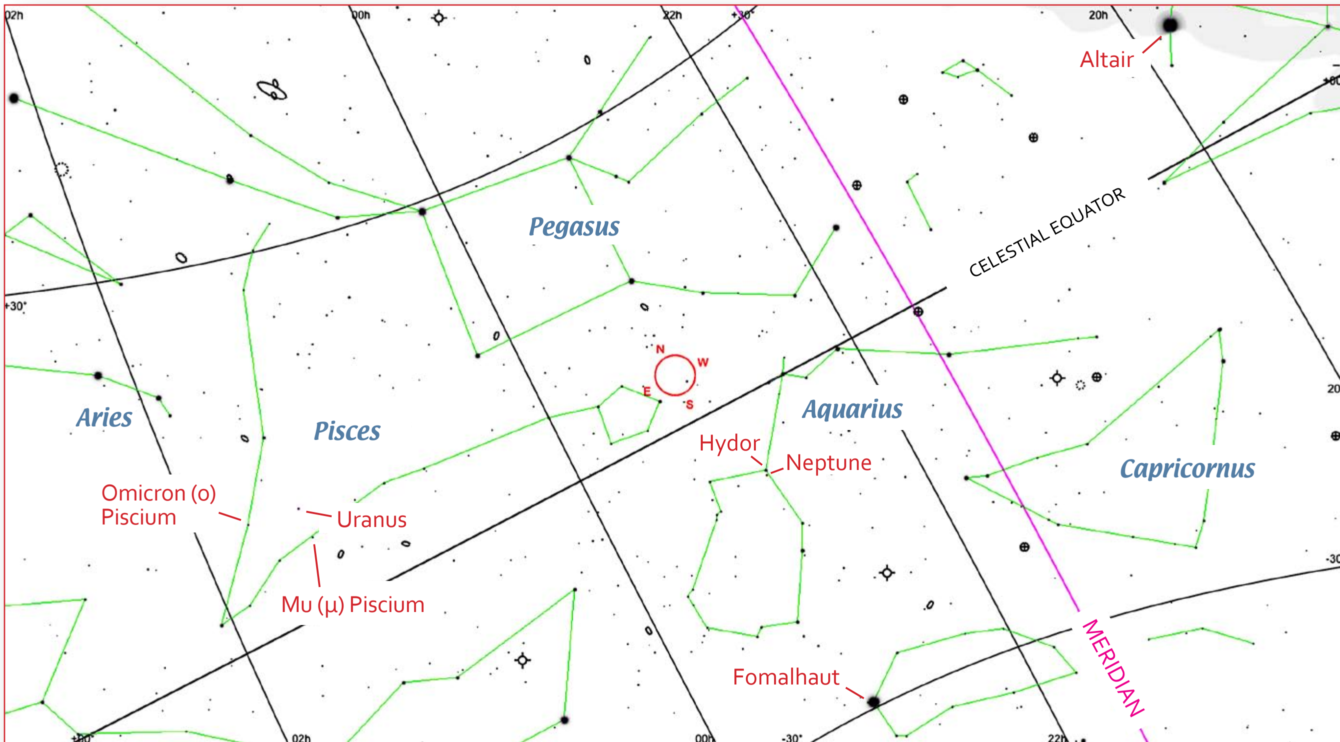

Relative positions of Uranus and Neptune, looking southeast at 3 AM in mid-July. View is 106° wide, and center is about 50° above horizon. The *Great Square of Pegasus* makes a good starting point for getting your bearings in this area. Note central 4° circle for scale.

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

July Skies

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Neptune as a disk instead of a point of light; the planet's roundness and bluish hue are about all you'll really see, *but it is Neptune*.

As luck would have it, the planet is in a great place for finding it easily, as it is currently only about ½° from a fairly bright star, Hydor, or Lambda (λ) Aquarii. At a magnitude of 3.7-3.8 (the star is variable), it's on the edge of naked-eye visibility from suburban Denver, but is quite distinct under dark skies. Similarly, Neptune itself *should* be visible in a 6x30 or larger finderscope when away from city lights, but might be washed out in the city, especially on a hazy night. **You'll find Neptune almost straight-down from Hydor at 3 AM, relative to your local horizon—a little to the left in early July, and a little to the right late in the month.** The planet's separation from Hydor widens to more than 1° by early September, and fully 2° by October.

Stars and Deep Sky

This month, finding our deep-sky targets will be fairly simple: One easy open cluster, one very easy globular, and one very cool binary that involves a little basic star-hopping, but which should be interesting to both beginning and experienced observers. All of them are in Scorpius—if you're not familiar with this constellation, check out "Getting Your Bearings," on page 4 of the July, 2015, *Observer*. (Back issues are online at *http://www.denverastro.org/das/denver-observer/*.)

First up, then, **Messier 4,** or **M4,** a beautiful and interesting globular cluster, at **16h 25m, -26° 34'.** Quite bright at mag. +5.6, and large in your telescope, M4 is loosely gathered compared to some other globulars you might have seen; visually, it also appears slightly reddish, with a notable central "bar." The reddish appearance comes from interstellar dust, which also darkens it somewhat, but that "looseness" comes partly from being "only" about 7,000 light-years away—that is, we can "see into" M4 relatively well, because it's among the closest globulars to Earth. At first glance, then, it might not be as showy as say, M5 or M13, but its spread-out nature allows you to really appreciate the cluster's individual stars (and bar); M4 is lovely in a 6-inch, and spell-binding in 10- or 12-inch 'scopes.

M4 is *very* easy to find—just put your finderscope on Antares, the bright orange star in the "body" of Scorpius, and M4 will share the finderscope. If yours is the traditional straight-through type, with an inverted image, then M4's glow will be visible just to the *left* of the star—M4 is just over 1° due west. (See chart.)

Next, an open cluster, **M6**, also known as the **Butterfly Cluster**, at **17h 41m, -32° 15'**. As seen from Earth, M6 is the "poor cousin" to nearby M7, which appears larger and brighter. That's because M7 is much closer, at about 800-1,000 light-years, compared to M6's roughly 1,600 light-years—M6 is actually intrinsically brighter (it has a higher absolute magnitude).

Regardless, M6 is a beautiful cluster, and apart from its dual-lobed streams of stars—which suggest a butterfly to some observers—there is also a quite noticeable orange supergiant, standing alone against the cluster's blue stars. The giant makes a wonderful color contrast, and shows something interesting: Not long ago, astronomically speaking, this star was also hot, bright and blue, like its cluster-mates, but it has used up enough of the original hydrogen supply in its core to upset the balance of its internal pressures. Now, it has expanded out into a giant star with a cooler orange outer envelope, and will continue evolving into something rather different from what it once was—as will its blue brethren in the cluster.

In clear dark skies, it should be possible to see M6 naked-eye and point your finderscope or telrad at it. In lesser conditions, as I experienced last week, you might be out of luck—but no worries. Just start by pointing at M7, which is easily seen, just off the scorpion's "stinger"—M6 is only about a finderscope field or Telrad diameter to the northwest, so when Scorpius is near the meridian, a quick motion of your Telrad at about a 45-degree angle

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July Skies

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up and to the right—or aiming your inverting finderscope's crosshairs downward and left—should bring M6 into the finderscope (lower-magnification finderscopes with a wider field may even show both at once).

Last up, a fascinating binary, **Xi (ξ) Scorpii**, at **16h 5m, -11° 25'**. Perhaps not as well-known as it might be because of its position (you'd think it would belong to Libra, rather than in a tall "chimney" of sky officially attached to Scorpius), Xi is definitely worth a look: It's a nested series of stars, and most of them are easily resolvable in a 6-inch 'scope.

The innermost pair, **ξ Sco A and B,** are a matched set of 5th-mag. class F stars slightly hotter than our Sun, and rather more luminous (they're evolving off the main sequence, and are brighter than normal). The pair's orbit varies from about 5½ to 33 Astronomical Units (AU)—that is, from roughly Jupiter's distance from the Sun, to Neptune's—and takes some 46 years to complete. Unfortunately, their 1" separation is too close to split here in Denver, but they're there, and should separate nicely in calmer air than we have.

Moving slowly around them, about 7" out, is **ξ Sco C**, an 8th-mag. G8 star fairly similar to our sun. (Observing this star gives you some insight as to what our Sun looks like from about 90 light-years out.) This companion orbits the inner duo at a distance of roughly 210 AU, with a period likely over 1,000 years. Imagine being on a planet around ξ Sco C, and watching the duo rise....

Ponder that awhile, and then add this: *At more than 280" of separation*, almost due south, there's *yet another* pair, **ξ Sco D and E**, that orbits the inner three! Far enough out to have its own designation, **Struve 1999**, this pair has one Sun-like G star and a cooler and dimmer, orange K-class dwarf companion. D and E, now separated from each other by 11.7", are in a slowly widening orbit that has brought the two stars more than 300 AU apart.

According to Robert Burnham, Jr., ξ Sco D and E together orbit the inner ξ Sco AB-C system at a distance of "some 7,000 AU"—but that's based on Burnham's now-dated understanding that the star system is 80 light-years away. If it's more than 90 light-years from us, as is currently estimated, the actual separation between the D-E pair and the inner three stars is close to 8,000 AU—in either case, the period for the pair to go 'round the others would be very long indeed.

If you're familiar with the northeastern part of Libra, look for the two stars in the "upsweep" at the end of its "scale," Theta (θ) and 48 Librae—they're 4th- and 5th-magnitude, respectively. (If you're not familiar with them, don't fret—they're just one Telrad-diameter northwest of Graffias, or Beta [β] Scorpii, the topmost bright star in the scorpion's claw. Start there and look "up and to the right," when Scorpius is in the south, to find Theta and 48.) Once there, follow an imaginary line running from Theta through 48 for about the same distance, and there's Xi—matching Theta in brightness, it should be easy enough to identify, and a look through the 'scope will quickly confirm it.

—See you next month.

The Denver Astronomical Society
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