The Denver
OBSERVER
SEPTEMBER 2016

Seen from a nearby moon, the super-Earth Gliese 667Cc may actually be a sub-Neptune, with windy cloudscapes rather than rocky vistas. The planet is so close to its orange dwarf star that it is probably tidally locked, a situation that may wreak havoc with its banded cloud formations. Yellowish clouds of sulfur tint some areas green. ***© Michael Carroll***

SEPTEMBER SKIES

by Zachary Singer

The Solar System

After a summer where you could sometimes go out and see all the planets in one long night (at least in theory), this month's planetary observing list will be noticeably shorter. Still, there's much to see.

Mercury will be a great pre-dawn target late in the month; look for it due east around 6 AM. Glowing at 1st magnitude on the 22nd, the crescent-phased planet will outshine nearby 2nd magnitude Denebola (the tail of Leo the Lion), which will lie 15° to the left when you face eastward. Six days later, at its maximum elongation from the Sun, the planet will be at its highest and brighter, at mag. -0.4; telescopic views will show a half-disk like a third-quarter Moon.

Venus is beginning to reappear from the solar glare, low on the horizon soon after sunset. Because of its current position in the solar system, it's both relatively far from us and only a small angle off the line between the Earth and Sun, so the Venusian disk is both small (about 10") and almost round (it's a "waning gibbous Venus"). Views through a 'scope won't be especially rewarding, but take heart—the situation will improve greatly in a few months.

Mars keeps getting smaller and smaller as Earth outruns it around the Sun. Though surface detail will be harder to come by, seasoned observers may note an interesting variation: As Mars recedes, the Earth-Sun-Mars angle changes, and so there is a hint of a "phase," as sunlight comes in slightly from the side.

Also, **on the evenings of the 27th through the 29th, Mars will line up about 1½° from the Lagoon Nebula (M8)—closest on the 28th.** If you can handle the brightness range (at least 6 magnitudes), this could be a good opportunity for astrophotography, especially since the moon will not interfere. (*DAS members—consider this a challenge from the Observer's editor.*)

As far as observing goes, **Jupiter** is pretty much toast for most of September—the giant planet achieves superior conjunction toward the end of the month, but it will be hidden by sunlight much sooner. We'll meet it again, in pre-dawn skies, in late October and early November.

As we discussed last month, **Saturn** is *slowly* sinking into the sunset.

Continued on Page 6

In the Observer

Sky Calendar

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

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

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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*

Catch the (Electromagnetic) Wave!

An enjoyable part of astronomy is looking at objects in the sky using a telescope, binoculars, or even our unaided eyes. Some of us take pictures of those objects using a camera or similar imaging device. But what is it that we are observing or photographing? It's light, emitted or perhaps reflected by those objects. And what's light? Light is a form of *electromagnetic radiation*, combined waves of electric and magnetic fields. (For those interested in the nitty-gritty, these waves are perpendicular to each other, as well as to their direction of travel.) There are other frequencies of electromagnetic radiation, like x-rays and radio waves, and together with light, they make up the *electromagnetic spectrum*.

To help grasp these concepts, imagine an old-fashioned car radio with a horizontal tuning dial. If you haven't used one, they employed an analog system, with a mechanical tuning knob, to move gradually from one frequency to another—as you rotated the knob, the approximate frequency you were trying to tune in was indicated with a sliding needle. Tuning an old radio like this, you can feel the continuous nature of the frequency range, instead of the specific, seemingly discrete steps we're used to with modern receivers (the latter are a product of improved electronics and not the radio waves themselves).

Let's take the idea of that old radio a step further, and think of a "super-radio" that can tune in radiation from across the entire electromagnetic spectrum. At the far left end of the dial, you'd find very low-frequency radio waves. As we move across the dial to the right—that is, going higher and higher in frequency—among the things we'll find in turn are AM and shortwave radio; TV and FM broadcasts; police, fire and other two-way radio communications; following those, microwave, satellite, and radar; *infrared, visible, and ultraviolet light;* then X-rays and gamma rays. Each of these types of electromagnetic radiation occupies its own range of frequencies within the electromagnetic spectrum.

I've been tossing the word "frequency" around a bit, but just what does it mean? To understand it, think of electromagnetic radiation as the ripples on a pond after a rock is tossed in the water. The number of waves (ripples) that pass by a given place in a second is the *frequency* (expressed in "cycles per second," or hertz), and the distance between successive peaks or troughs in those waves is the *wavelength*. Because electromagnetic waves travel at a fixed speed (the speed of light, naturally), the lower the frequency, the farther apart the waves have to be (that is, the wavelengths get longer); and the higher the frequency, the closer together the waves (shorter wavelengths).

Continued on Page 5

DAS SCHEDULE

SEPTEMBER 2016

2-4	Dark Sky Weekend—EGK Dark Site & Brooks Observatory
10	Open House—DU's Historic Chamberlin Observatory—Starts at 8:00 PM
16	General Meeting at DU's Olin Hall, Rm. 105, 7:30 PM—Dave Gianakos
23	E-Board Meeting—At DU's Historic Chamberlin Observatory, 7:30 PM
24	Okie-Tex Star Party (**Last observing night is Oct. 1)

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

New DAS Vice-President

Leo Sack has become our new DAS Vice President, after the E-Board voted unanimously to appoint him. Leo will fill the position for the remainder of the current term. We are grateful to Stuart Hutchins for serving as interim VP until a replacement was found, and we are especially grateful that Leo stepped up to take over for him.

DAS General Meeting

Friday, September 16th, 7:30 PM: Dave Gianakos will share insights on aerospace model-making. His large-scale, scratch-built models are featured in museums around the country; past projects include a flyable 1/34-scale Saturn V rocket and launch pad, and participation on the restoration team for Lunar Module-2 at the Smithsonian's National Air and Space Museum. Other models have been displayed at the Seattle Museum of Flight and the National Naval Aviation Museum.

Dave recently retired from a career as a 747-400 captain, instructor, and lead line check pilot. A relative newcomer to the Denver Astronomical Society, joining in the summer of 2015, he plans to volunteer as a telescope operator for Public Nights at Chamberlin Observatory.

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.

Volunteer Opportunities

Saturday, 9/3/16, 7:00PM: Cherry Creek State Park. Night Viewing.

Saturday, 9/10/16, 10:00AM-2:00PM: PBS Rocky Mountain Kids Fun Fest, Denver. Solar viewing and booth.

CANCELLED: Tuesday, 9/13/16: (Omni Interlocken after-party, Broomfield.)

Thursday, 9/15/16, 7:30-8:00AM: Kiwanis Club, Castle Rock. Astronomy lecture.

Tuesday, 10/11/16, 7:30PM: The Golf Club at Pradera, Parker. Star Party for members and family.

Wednesday, 10/19/16, 7:00PM: Cub Scouts, Centennial. Night Viewing and Astronomy Badge.

Friday-Sunday, 10/28/16-10/30/16: Comicon, DTC. *Booth:* 2-6PM Fri., 10AM-6PM Saturday and Sunday. *Solar Viewing:* 11:30AM-1:30PM Sat. & Sun. only.

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

A MESSAGE TO NEW AND RECENT MEMBERS

by Digby Kirby

I'm Digby, the New Member Ambassador for DAS.

If you recently joined DAS, or joined in the last year or so, first of all, welcome! We're very glad you've joined, and we want to do whatever we can to make you feel part of the group and maximize the value of your membership. (If you haven't yet seen your new-member letter sent via email, check it out—it's filled with links and information.)

This is a great time to be a member of the DAS! If you are new to astronomy, we have lots of resources available to help you get started in the hobby, including a loaner-scope program which allows you to borrow one of several loaner telescopes we have on hand. (We'll even give you some basic instruction in how to set up and use the loaner scope.) For more information, go to our website, *www.denverastro.org*, and click on "Scope Loans," at the top of our home page. (Be sure to spend some time checking out our complete website—a wealth of very useful information is contained there, including a calendar of upcoming events.)

If you are looking to buy your first telescope, we have a talk on what you need to know coming up later this fall, and we can recommend literature on this subject, if you'll give a call or send an email (my contact info is below). We also have a lending library at Chamberlin Observatory, which is open during Public Nights every Tuesday and Thursday, and once a month during Open House. If you already have a telescope and need help setting up and using it, we can help.

If you want to volunteer, opportunities abound, too—but don't worry, there's no pressure.

Both new and experienced observers will want to check out our dark site near Dear Trail, Colorado. (You'll need an orientation, and more information is available on our website, at *www.denverastro.org/das/egk-dark-site-2/*.) We have an observatory at the dark site, housing a large Celestron C14 reflector; the coming months will also bring a very large, 17.5-inch Dobsonian reflector! And of course, you can bring your own telescope to the dark site—we have a number of concrete observing pads, each complete with electrical outlets, and other amenities.

Perhaps the greatest resource we have to offer you is simply the people of the DAS. We really want to get to know you, help you feel welcome, and get you involved. A great way for us to meet you is at our monthly general meetings and at the social get-together held immediately afterward at Chamberlin Observatory. (Check out "Upcoming Events" on our website for time and location.)

When your name appears on our roster of new members, I'll do my best to contact you by phone and extend a personal welcome. In the meantime, if you have a question or need some guidance regarding our hobby—or would just like to chat, please give me a call or send a text or email. I'd love to hear from you!

Again, welcome aboard. The people of the DAS hope we can meet you personally, real soon.

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

PLANETS IN THE TWILIGHT ZONE: SUPER-EARTHS AND SUB-NEPTUNES

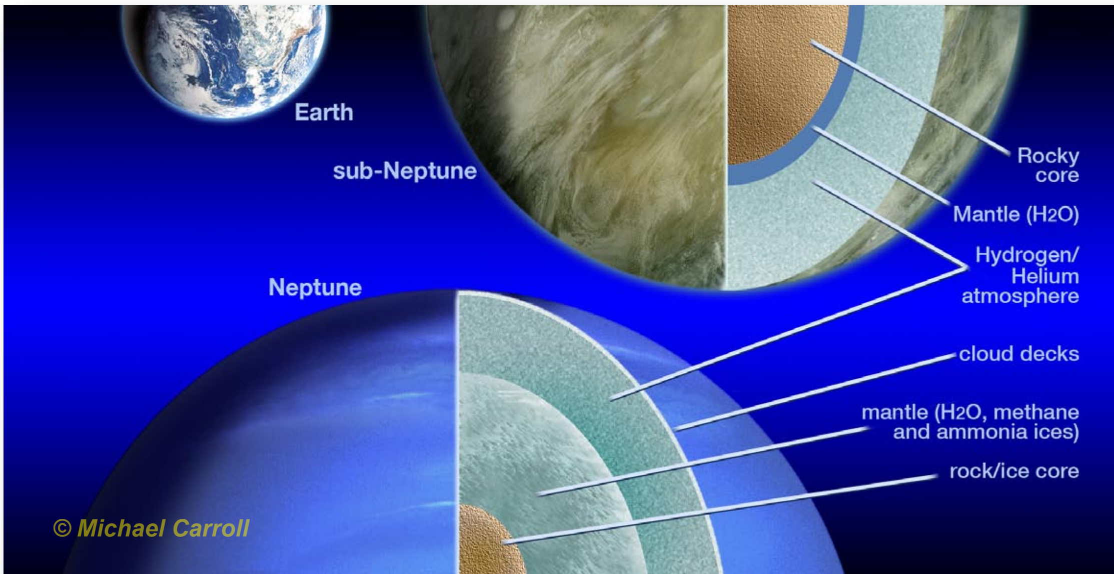
By Michael Carroll

Newly Discovered Exoplanets Challenge Long-Standing Ideas

Portions of this article appear in an upcoming Astronomy Magazine *article*

"There is a fifth dimension beyond that which is known to man…the middle ground…It is an area we call the Twilight Zone." Rod Serling's famous words, spoken at the beginning of his television series, could as easily apply to a new class of world making its way to center stage in the theater of exoplanets (planets in other star systems). This class lies somewhere between the Earthlike worlds we know, and planets not quite the size of Neptune. Geologically speaking, these super-Earths, or sub-Neptunes, lie in a sort of cosmic twilight zone.

Because of the limits in our search techniques, data on exoplanets tend to be skewed toward large, easy-to-see planets, worlds very different from our own. Many range in size from Neptune-like on up to "Jupiters on steroids." In spite of that, the Neptunian and smaller, "sub-Neptunian" or "super-Earth" planets have been found in greater numbers than any other size of exoplanet discovered so far. They're also in unexpected regions of their solar systems, and the implications are fascinating.



Earth compared to Neptune (below) and a sub-Neptune (upper right). Note differences in internal structure. ***Image © Michael Carroll***

Finding Super-Earths and Sub-Neptunes

Direct observation of a planet at interstellar distances is quite difficult—the planets' images are minute, and they're usually lost in the glow of their nearby star. But astronomers can make inferences about such planets by studying the light—and light levels—of the suns they orbit: For example, when a planet transits its star—that is, when it passes in front of the star from our point of view—the light level dims. The charting of planet-caused changes in light levels (which happen once for each orbit) is called the transit technique.

Perhaps the most dramatic advancement in the hunt for exoplanets has come at the hands of the transit technique. It's an exacting method—light levels drop by only 0.01% to 0.1%, depending on the size of the planet in comparison to its star. The duration of the transit can help reveal the planet's distance from the star and its orbital speed. The size of the planet can be determined by how much light it blocks out.

In contrast, the radial-velocity technique measures a star's movement as its planets tug upon it. Astronomers used this technique to discover the very first known exoplanets. As a planet orbits its parent star, the changing direction of the planet's gravity causes the star to wobble; part of this oscillation moves directly at—and away from—the viewer.

This cyclical movement can be measured by a shift in the star's light: As the star is pulled away from us by a planet, the star's light becomes redder, and as the planet pulls the star toward us, the light becomes more blue. This "Doppler shift" of light can be measured far more finely than visual side-to-side movements seen through a telescope; even though we cannot see a star's wobble directly, we can still detect the resulting changes in the star's light, and obtain the star's speed toward and away from us. The larger these changes in the star's velocity, the stronger its unseen planet's gravity and the greater its mass.

Astronomers use their determinations of a planet's radius and estimates of its mass to derive the planet's density—a critical measure of a planet's nature. If, for example, a planet weighs twice as much as the Earth, but is the same size, it must be very dense, and so it is rocky. On the other hand, if a planet is ten times the size of Earth but has the same mass, it must be a low-density, fluffy world more like a gas or ice giant. Among the worlds orbiting in habitable zones (those regions at a distance from the star to allow for liquid water), a wide range of planets have been charted so far, from small terrestrials akin to Mercury, to rocky or gaseous worlds slightly smaller than Neptune.

Sub-Neptunes and Super-Earths

In our solar system, we have rocky planets, like Earth, that are relatively small, and large gas giants like Neptune and even bigger Jupiter. The rocky, or terrestrial, planets are found in our inner solar system, while the gas giants all lie farther out. The new category of super-Earths and sub-Neptunians blurs these lines, both in terms of their structure and their location.

Though a planet can be larger than our own and still remain mostly Earthlike, super-Earths larger than 1.6 Earth radii are in the "twilight zone"—they appear to contain substantial amounts of hydrogen and helium, transitioning from terrestrial to

Continued on Page 5

Super-Earths and Sub-Neptunes

Continued from Page 4

gaseous—is it still a super-Earth, or is it a sub-Neptune? Larger examples, the ubiquitous mini- or sub-Neptunes, expand this class's mass range to up to 10 times that of Earth. (In comparison, Uranus contains 14.5 Earth masses, while Neptune comprises 17.)

Also in true "twilight zone" fashion, sub-Neptunes may represent a variety of planetary natures, rather than constituting a smooth transition from Earths to Neptunes. Research scientist Mark Marley models the atmospheres of exoplanets at NASA's Ames Research Center, and spends much of his time pondering sub-Neptunes. Marley believes that planets of the sub-Neptune class may turn out to be the most varied of any size worlds.

As he relates, "You get bigger than a Saturn or so, and [planets] all tend to be about the same size because they are dominated by their hydrogen/helium atmospheres. Then, when you get down closer to one Earth-mass, they're probably all rocky worlds with a little bit of atmosphere. But this range of Neptune-plus-or-minus—in between—there's probably a huge range of what these planets could be like. It's a range where every one is going to be unique."

While sub-Neptunes measure in at a transitional size between small rocky terrestrials and gaseous Neptune or Jupiter classes, their natures may vary wildly, depending on a host of factors including mass, amount of water, and size of core. "Somewhere in the galaxy, is there a three-Earth-mass Earth that really is just a big Earth?" Marley wonders. At the same time, "Is there a two-Earth-mass Earth that's just a sub-Neptune? The lines are probably fuzzy, depending on the individual history of each world, what it's like in this in-between range."

Vagabond Planets

How did these strange sub-Neptune worlds arrive where they are, close enough to their suns to host earth-like conditions? (If we judge by our own solar system, that's certainly not where we'd expect them!) Apparently, they did not form in place. Planets, it seems, are slippery things, forming in one location and shuffling off to another. Our solar system's arrangement of gas and ice giants lying in more distant orbits than the smaller terrestrial planets may not have been the norm throughout its history.

A dynamic model called the Grand Tack projects that in the past, Jupiter and Saturn marched in toward the center of the solar system, at which time Saturn pulled Jupiter back from sudden death at the Sun. According to the Grand Tack, Jupiter robbed Mars and its surroundings of icy, planet-building material—asteroids that formed outside the habitable zone—sending it toward the inner system. Thanks to Jupiter's migration in the early Solar System, about one out of every one hundred C-type (water-bearing) asteroids scattered into the outer fringes of the asteroid belt. But for each one of those, at least ten spiraled sunward, delivering water to the terrestrials where they ultimately became Earth's oceans.

The Grand Tack version of planetary history has the advantage of explaining the diminutive size of Mars, the structure of the asteroid belt, and the birth of terrestrial seas at the hands of incoming, ice-laden space rocks. It also may explain why astronomers are discovering so many giant exoplanets so near to their parent stars.

Migrating mega-worlds seem to pave the way for smaller planets in inner systems where habitable zones lie. But in many systems, gas giant worlds end up within the habitable zone as well. And while conditions on gas giants may be hostile to life as we know it, giant planets hold giant moons. Earthlike conditions may well exist on a plethora of moons orbiting gas giants in habitable zones.

We have discovered many giant planets in habitable zones, and a wide range of terrestrials as well. The field seems ripe for the discovery of worlds with thriving biomes beyond our own. The search for life forms on the Earths of distant suns is a difficult one: Physical distance complicates our efforts at remote sensing, as does our limited understanding of the very nature of life. Finding biological signatures among the faraway Earths would constitute a paradigm-shifting discovery, changing our views of biology, planetary development, and the frequency of life in the universe.

For more on the subject, see Michael Carroll's upcoming book, *Earths of Distant Suns* (Springer, winter of 2016).

President's Message

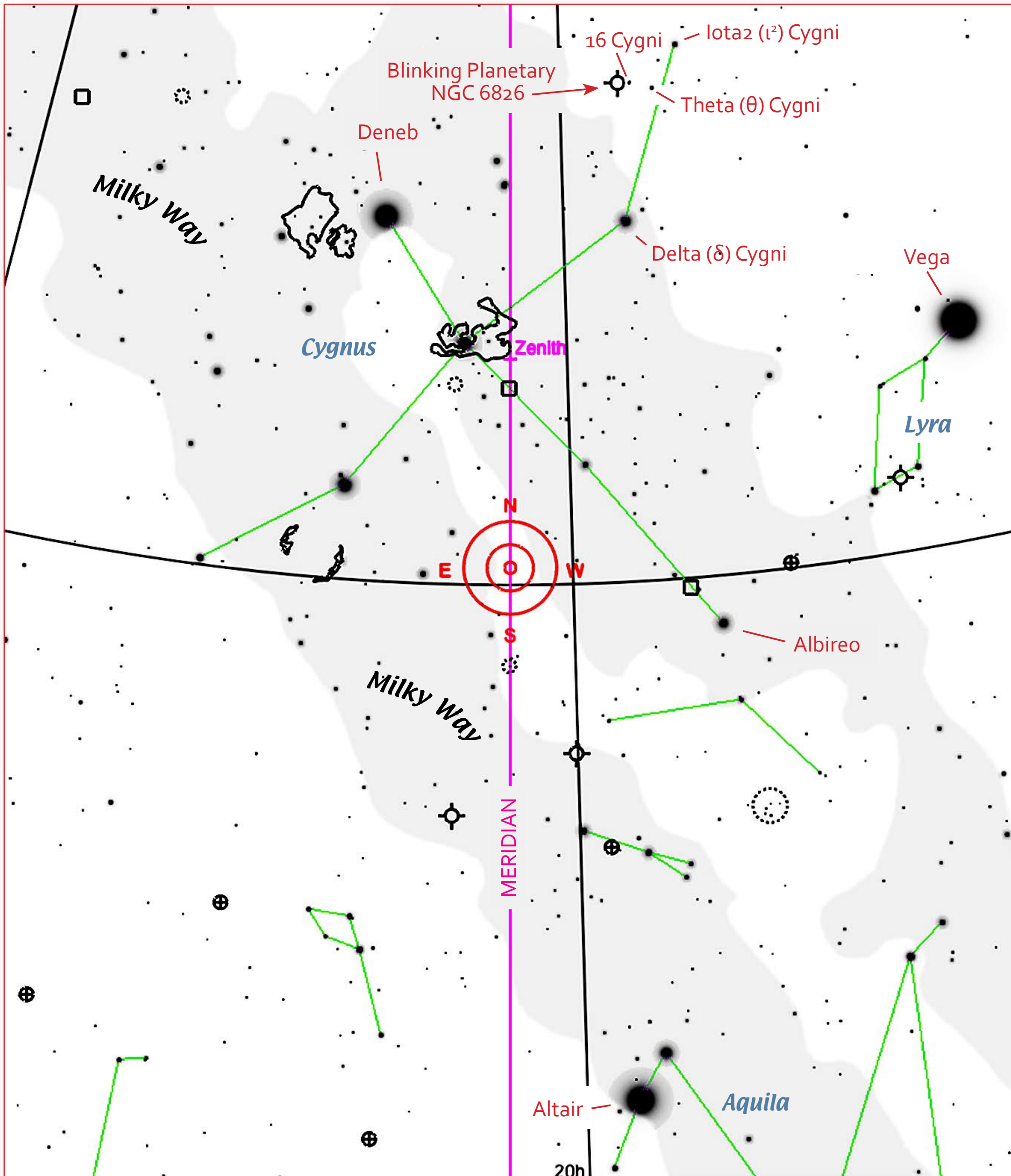
Continued from Page 2

Finally, knowing the speed of the wave and its frequency, you can easily figure out the wavelength, and vice versa. For electromagnetic radiation, the speed is about 300,000,000 meters per second; dividing that speed by the frequency (in hertz) gives you the wavelength in meters. Similarly, to get the frequency, divide the speed by the wavelength. (For the math fans out there, this equation says it all: $f_{Hz} \bullet \lambda_{meters} = c$, where f=frequency, λ=wavelength, and c=the speed of light.)

Going back to our imaginary "super-radio," the frequency of the real-world Denver-area AM radio station KOA is 850 kilohertz, an elegant way of saying 850,000 hertz. Dividing that into the speed of light, the wavelength of that station's signal must be at least 350 meters—roughly the length of four football fields.

In contrast, tuning our imaginary radio midway across the dial into the visible light spectrum, the wavelength light that astronomers call H-alpha (a certain shade of red) is 656 nanometers—that is, 656 *billionths* of a meter! That's small indeed, and even more so, compared to the length of KOA's wave. As you'd expect then, it has a very high frequency compared to radio, 457 terahertz, or 457 *trillion* hertz. Tuning our super-radio toward the right of the dial, X-rays and gamma rays have frequencies tens of thousands of times higher than light—and naturally, dramatically shorter wavelengths, too; these waves get down to the scale of atoms or even the atomic nuclei.

In the end, light can be thought of as really, really high-frequency radio waves, or radio waves can be thought of as really, really low-frequency light. As we turn our eyes to our favorite astronomical objects then, we're in effect "tuning in" to a tiny slice of the electromagnetic spectrum.



Viewing south and nearly straight up in Denver at 9:30 PM in mid-September. The three brightest stars here, Deneb (in Cygnus), Vega (in Lyra), and Altair (in Aquila, *partially shown*) make up the Summer Triangle.

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

September Skies

Continued from Page 1

By observing at twilight, earlier each night with the onset of fall, we can still see Saturn throughout September and October. But the planet's altitude above the horizon will continue to decline—to 20° at the end of this month, and just 12° by Halloween. Telescopic views won't suddenly disappear, but they certainly will get blurrier.

Because they orbit the Sun so slowly, **Uranus** and **Neptune** are about where we left them in July. Although they're both coming to opposition (Neptune on the 4th, Uranus next month), they're so far away that they won't appear noticeably larger—but they *are* up at a more convenient hour! Since they've moved only slightly these past two months, you can still use the directions from pp. 6-7 of the July Observer to put them in your finderscope (*www.denverastro.org/newsletters/july2016_denverobserver.pdf*). When you do, look for Uranus roughly 1° west of its July position; Neptune now lies about 1½° *southwest* of Hydor, aka Lambda (λ) Aquarii, instead of (½°) south.

Stars and Deep Sky

Last month, one of our targets was so unabashedly for the newbies, that I put it in at the end to give the more experienced observers a break. This month, though, an even-better-known object goes first—along with being a good start for beginners (especially if they're learning to star-hop), I'll bet most experienced observers don't know all its secrets.

All three of our objects are in the constellation Cygnus, the Swan, which is part of the Summer Triangle—if you're unfamiliar with this part of the sky, check out the article "Getting Your Bearings—Constellations of the Summer Triangle," on page 4 of last year's September Observer. It has a complete description of the Triangle, as well as a map covering a larger area: *www.denverastro.org/newsletters/september2015_denverobserver.pdf*.

Our first stop, then, is the bright double star, **Albireo, or Beta (β) Cygni**, at **19h 31m, 28° 00'**; it marks the "head" in Cygnus's traditional outline. This star is so well known because it's bright, easily found, and easily split—as well as drop-dead gorgeous, even in the smallest of telescopes. Its contrasting, orange and blue components are 35" apart, so even low magnification works well, and Denver's famously lousy "seeing" won't mess it up. (In larger scopes, it's really a treat!)

As for the science behind this star, it's often missed, because the object is so beautiful to gaze at. That's a shame, because Albireo can be a source of wonder, too—first, unlike many doubles we observe (including our next target) the exact relationship of the main pair remains unknown. Even now, astronomers are unsure if Albireo is truly binary, with the two stars actually in orbit around their common center of mass. (If they *are*, they're so far apart that it would take more than 75,000 years to complete an orbit, according to Prof. James Kaler, of the University of Illinois; Robert Burnham, Jr. calculated their physical separation at about 4400 Astronomical Units (AU), or more than 100 times Pluto's average distance from the Sun.)

We *do* know, though, that the bright orange star has an unseen companion, that truly is in orbit around it. That "close" companion is half-again as far from the orange giant as Pluto is from the Sun (that's still quite a distance), and ironically, it's very close in its characteristics to the blue star in the main pair.

Continued on Page 7

September Skies

Continued from Page 6

Both "blue" stars are 3 times the mass of the Sun, and the orange giant is even larger, at about 5 solar masses. Because heftier stars use up their fuel more quickly, the orange giant has already given up fusing hydrogen in its core. It's now burning helium there instead, and as part of this evolution, the star has swelled to a diameter 50 times larger than our Sun's. Albireo turns out to be as interesting to *think* about as it is to look at.

To get to Albireo, start with the Summer Triangle—at this time of year, you'll find it high in the south at 9:30 PM; the "topmost" two of its three bright stars, as you face southward, will be near the zenith (almost straight up)—**see the chart**. You'll find Albireo about halfway between Vega and Altair, with a small jump to the northeast—that is, towards Deneb. Just as easily, you can start at Deneb, and look southwest, "downward" along the cross-shape of Cygnus, until you get to Albireo at the bottom.

Note that Albireo can sometimes be difficult to see naked-eye in the city, because its brightness is just at the level at which city lights can obscure it. Using averted vision around its estimated location often helps sniff it out, and once you've found it a few times, it's pretty hard to miss.

Next up, **16 Cygni**, at **19h 42m, +50° 34'**; it's a true binary pair (and important for star-hopping to our third target, a nearby planetary nebula). Interestingly, these stars are both class G (that is, very much like our Sun in brightness and color). The dimmer star, 16 Cygni B, is almost exactly the same brightness as the Sun, giving you an idea of how our home star looks through a telescope from about 70 light years out. Like Albireo, this pair is an easy split; its separation of 39" works out to a physical distance of least 840 AU between them.

But there's more—a planet has been detected around the B star—pretty unusual, at least so far, for binary systems. According to Prof. James Kaler, University of Illinois, the planet is about 70% more massive than Jupiter, with an eccentric orbit that takes it from as close as ½ AU from 16 Cygni B, out to almost 3 AU, about every 2 Earth-years. Think of two Suns orbiting each other, with at least one planet in orbit around one of them, and you've got the picture—while this system isn't as visually striking as Albireo, there sure is a lot to chew on!

16 Cygni is out on the western "wingtip" of Cygnus (that is, the side toward Vega). Look first for 3rd-magnitude Delta (δ) Cygni—it's the "bend" in that wing, about half of the wing's width outward from Cygnus's center. From there, as the chart shows, the wing bends "upward," like a flying bird's, toward Iota2 (ι^2) Cygni, the 4th-magnitude star at the tip—though a magnitude dimmer than Delta, it's still the next-brighter star outward. (Iota2 is dim enough to be often washed out under city lights, but it's easily found in the country.)

Put the center of your Telrad on the line from Delta to Iota2, and slide it toward back toward Delta until Iota2 *almost* touches the opposite edge of the outer (4°) Telrad circle. When you look in your finderscope, Iota2 will be the brightest star in the field, though close to the edge. Near the middle, though, the next brightest star, Theta (θ) Cygni, should be obvious. Center it, and look for the *next* brightest star, about a degree away—it makes a distinct right-angle when you look from Delta to Theta, and then to this one—and *it's the star we're looking for,* 16 Cygni. Modest magnification in your telescope will quickly confirm whether you have the right star.

If you found the star-hopping to 16 Cygni challenging, take heart—our next object is just an eyepiece-field away: **The Blinking Planetary, NGC 6826**, is just 29" due east of 16 Cygni, at **19h 45m, +50° 34'**. This is a beautiful object, created in a manner similar to that of the Ring Nebula (M57), which we toured last month. Unlike the Ring, though, which shows off its shape even in moderate instruments, you'll need a large telescope to see structure clearly in NGC 6826.

Still, as the name of this nebula implies, it's famous for another reason: In smaller telescopes, say, up to about 8 or 10 inches, it "blinks"! When you look straight at the nebula, its central star—the one that threw off its outer atmosphere to form the glowing cloud—is easily visible. Look away, though, and the nebula appears, shining softly in the area around the star.

The phenomenon is really just an illusion—it comes from alternately using two different kinds of eye-receptors to see two different kinds of targets. On one hand, the star's light is very highly concentrated—perfect for the sharper-seeing but less light-sensitive receptors at the center of your visual field. On the other hand, since the *nebula's* light is spread out over a wide area, it's relatively dim *at any one given point*, and therefore a poor target for those central receptors.

Looking directly at the star only makes things worse because your eye adjusts for the star's glare (think of approaching headlights on a highway at night), so the nebula disappears. When you look to the side, though, a more-sensitive set of receptor nerves works on the nebula, and because these nerves collect light over a wider area ("playing to the nebula's strength"), the nebula pops up brightly, albeit less sharply. It's a fascinating and entertaining effect.

As it happens, the Blinking Nebula's central star is particularly bright for a planetary—roughly 100 times brighter than the Ring Nebula's, even though both objects are of about the same visual magnitude—and this deepens the effect even more.

In smaller 'scopes, the supposed approach for making the nebula blink is to *dial up* the power. In my 12-inch reflector, though, the nebula blinks reliably at *lower* magnifications, and less and less as the power increases, until the blinking stops completely—the nebula then remains visible, along with the star. (Reports indicate that the nebula doesn't blink at all in telescopes of larger aperture than mine.) Since human eyes vary in sensitivity, adding yet another factor, it's best to try out different magnifications and see what works best for you. In any case, NGC 6826 is bright for a planetary nebula and displays a noticeable blue tint, making for quite a view, "blinking" or not.

Remembering that the Blinking Nebula is just ½° from 16 Cygni, finding the nebula is easy—if you have a very low-power eyepiece, with a telescopic field wider than 1°, just center 16 Cygni, and look for a bluish, star-like but "blurry" object near the edge of the view. For everyone else, center 16 Cygni in your *finderscope*, imagine a line from Theta to 16 Cygni, and then extend it about half-again the distance. When you put your finderscope's crosshairs there, the nebula should appear in your telescope's eyepiece—even in a narrower, say half-degree, field.

And finally, *for equatorial users*—you've got it made! Just center 16 Cygni, and slew your 'scope ½° directly east (that is, use the right-ascension control only), and the nebula should be very close to the center of the field.

—See you next month.

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.

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