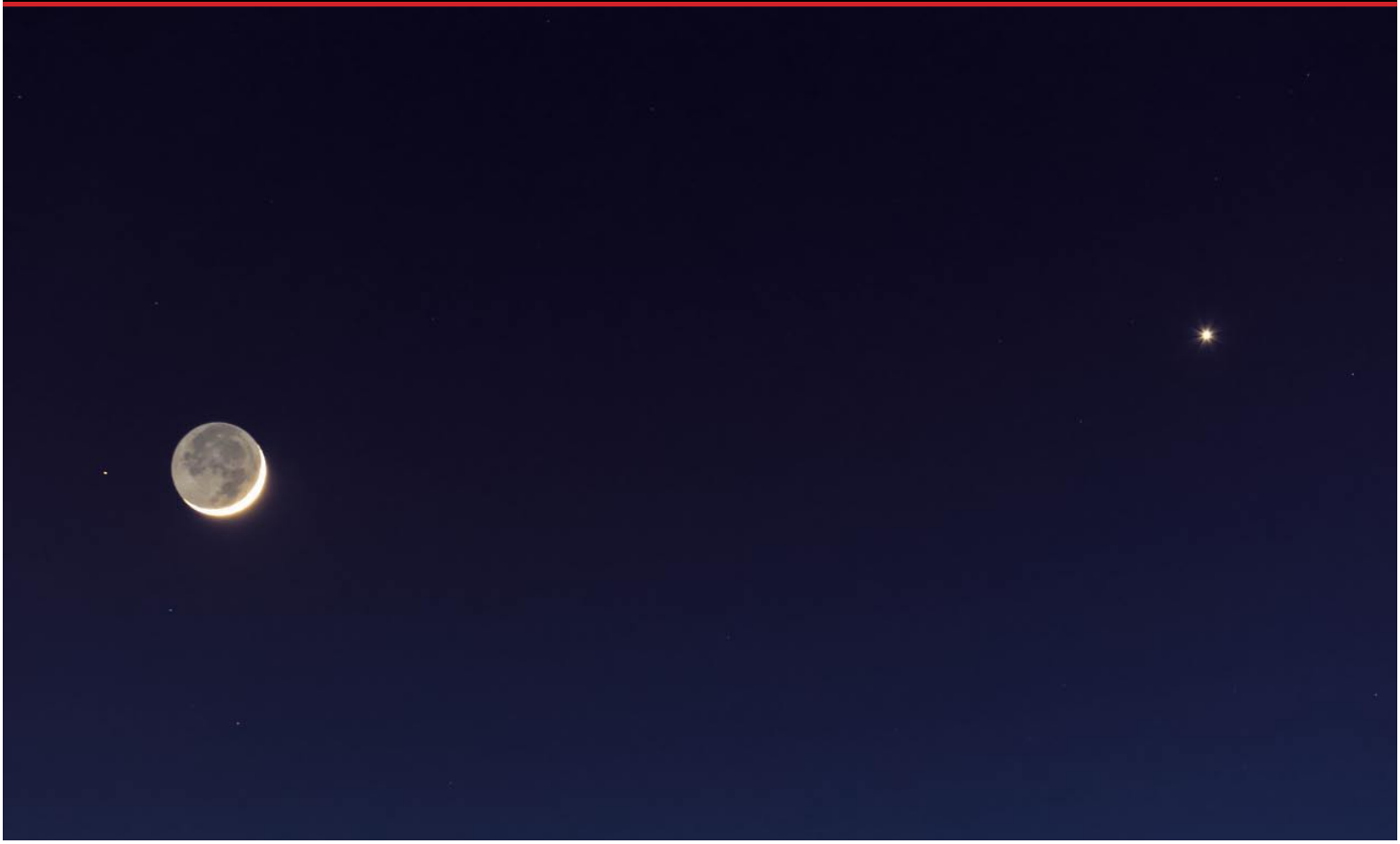
The Denver
OBSERVER
MAY 2018



The Moon and Venus, captured in Denver's City Park on the evening of April 17th, when the Moon was about 10% illuminated and the pair were about 6° apart. (The Moon's shaded area is lit by Earthshine.) There will be a similar Moon-Venus pairing May 17th.

Image: © Sorin 2018 SoggyAstronomer.com

MAY SKIES

by Zachary Singer

The Solar System

We will have quite a season for planets, and it's just getting started, with Venus, Mars, Jupiter, Saturn, and even the minor planet Vesta…

First though, a quick mention of **Mercury**—technically, it's a few degrees above the horizon half an hour before sunrise during the first days of May; but realistically, Mercury will spend the month lost in glare.

Venus, on the other hand, makes a stirring sight in the west, soon after sunset. In early May, it's bright at magnitude -3.9, and shows a gibbous disk almost 12" across—by the end of the month, it sits a touch higher and brighter, and grows to just over 13". (At that point, Venus will still be gibbous, but clearly on its way to becoming a "half-disk" or "lemon wedge," which is how the planet will appear at the beginning of August.)

Look for a beautiful **conjunction with the Moon on May 17th**. It will resemble the one we had in mid-April, in both position and lunar phase, and the two bodies will lie a little over 6° apart. Half an hour after sunset, the pair will be roughly 20° above the horizon—for the photographers planning ahead (to get an interesting foreground to go with the sky), Venus will lie at a heading of 286° and the Moon will be just to the left at 279°. (Note that the bearings are "true," rather than "magnetic," so set your compass accordingly.)

Mars is getting quite good! As May begins, the red planet already spans 11" in an eyepiece and sits about 26° up in the south around 5 AM. By the 31st, the planet will be

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Sky Calendar

7	Last-Quarter Moon
15	New Moon
21	First-Quarter Moon
29	Full 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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PRESIDENT'S MESSAGE

by Ron Hranac

A Matter of Size

Size matters!

Astronomy is a science that deals with the very small and the very large. At one end of the size scale are the tiny wavelengths of the light we see in our eyepieces, and at the other end are the incredible distances across space. You may not realize it, but the two extremes are related to each other.

Let's start with some of the small sizes in astronomy: The wavelengths of light that we can see with our eyes are in the roughly 400 nanometer (nm) to 700 nm range. (Think of light waves like ripples on a pond of water; wavelength is the distance between successive peaks or dips in those ripples.) A nanometer is tiny, just *one billionth* of a meter. To put that in perspective, the *Giardia lamblia* micro-organism that might live in our imaginary rippled pond (and which can cause a rather nasty digestive ailment if consumed) has a diameter that is about 20 times larger than the wavelength of green light. Want *really* small? The wavelength of gamma rays is *thousands* of times smaller than that of light—less than the diameter of an atom!

On the other extreme, distances in space can be, well, enormous. The nearest star to Earth other than the Sun, Proxima Centauri, is approximately 24,980,000,000,000 miles from us—that is, roughly 25 trillion miles. Rather than deal with unwieldy numbers like that, astronomers use the term *light-year*, which is the distance light travels in one year (it's just less than six trillion miles). Proxima Centauri is thus about 4.2 light-years away, meaning its light—zipping along at a bit more than 186,000 miles per second—takes about 4.2 years to reach Earth. Even 4.2 light-years is a big number, or at least, a big distance, that defies comprehension for many. Look at it this way: If the Voyager 1 spacecraft were heading for Proxima Centauri at its current speed, *it would take more than 70,000 years to get there.* (Where is the Millennium Falcon when we need it?)

Even the distance between Earth and the Sun is a big number, averaging slightly less than 93 million miles (astronomers call that distance an astronomical unit, or AU). Indeed, the Sun is far enough away that its light takes a little more than eight minutes to reach us, so we can say that the Sun is just over eight light-

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DAS SCHEDULE

May 2018

4	E-Board Meeting—At DU's Historic Chamberlin Observatory, 7:30 PM. All members welcome.
5	DAS Member In-Reach—At DU's Chamberlin Observatory, 7:00 PM
12	Dark Sky Weekend—EGK Dark Site & Brooks Observatory
19	Open House—DU's Historic Chamberlin Observatory—Starts at 8:00 PM
25	DAS General Meeting—DU's Olin Hall, Rm. 105—Starts at 7:30 PM

(June 2018)

1	E-Board Meeting—At DU's Historic Chamberlin Observatory, 7:30 PM. All members welcome.
13	Rocky Mountain Star Stare
16	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.

President's Message

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minutes away.

When you look at the full disk of the Sun through a properly filtered 'scope, you might be surprised to know that the Sun's equatorial diameter is equal to about 109 Earths stacked side-by-side. Jupiter? About 11 Earths wide. And so on.

You may not realize it, but one of amateur astronomers' favorite devices—the telescope—depends heavily on the small end of our scale in order to show you the large one: The main mirror or lens requires *precision* polishing—its shape, or "figure" as astronomers call it, must be accurate to a mere fraction of a wavelength of light! A poorly polished mirror will deliver blurry images, especially under high magnification—though you can't see the error in the polishing with your eyes, you'd notice it when using your 'scope to peer across those vast interstellar or intergalactic distances…

The stars themselves depend on these "small" distances too—though we often talk about all the energy produced inside stars (the scale of that is huge), the action within them actually occurs at the *sub-atomic level*, in the *nuclei* of the atoms undergoing fusion. Even some of the clues astronomers use to detect the expansion of the Universe itself—talk about *immense scale!*—come from shifts in the wavelengths of light.

When it comes to the world of astronomy, size does matter.

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May Skies

Continued from Page 1

nearly a magnitude brighter, at -1.2, and will grow to more than 15"—roughly as big as it was at our last opportunity two years ago! (At that time, Mars spanned 18" *at its best*.)

By the end of the month, the coming sunrise will begin to wash out the sky by 5 AM, so you'll probably want to observe between 4:00 and 4:30 AM. Many of you may not be thrilled with the hour, admittedly, but it represents a good opportunity, because the planet will be high enough for reasonably sharp views—*and* our notoriously turbulent Denver skies are often steadier then, improving image quality still further. In short, May will bring the beginning of detailed views of the Martian surface, with further improvement through late July—Mars will span a full 24" by then, and rise much earlier.

Jupiter is just a month from opposition, so it's well positioned for observation—it transits just after 1:30 AM at the beginning of the month, and is already 30° up in the southeast by midnight. At magnitude -2.3, it's unmistakable—Jupiter easily outshines Zubenelgenubi in Libra, which it approaches this month (the star and planet will have a tight conjunction in mid-August). By month's end, Jupiter transits around 11:15 PM, making observations even easier.

Saturn shares a 2° field with M22 in Sagittarius all month, as the planet cruises near the top of the constellation's "teapot." At magnitude 0, Saturn will stand out clearly from its background. Though it's visible earlier, Saturn is a great target when observed an hour or so before dawn—it's at its highest, right on the Meridian, at 5 AM in early May, and thus fits nicely with views of Mars, which

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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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ASTRO UPDATE

Selected Summaries of Space News

by Don Lynn

Dark Matter

Last month, I reported that a small radio telescope in Australia had for the first time detected gas clouds ionized by the earliest stars in the history of the Universe (see "First Stars," on page 4). The temperature of those clouds, though, was only half what theory predicted. More research has now been published regarding whether that gas could have been cooled by interactions with dark matter. At present, nearly all of the possible ways dark matter could explain the gas clouds' temperature have been ruled out.

Star Formation

Gas that is in the process of collapsing to become stars is not spherical in shape, but instead forms long filaments. It is only recently that telescopes have had the resolution to observe structure inside these filaments. New observations by ALMA (a radio telescope array in Chile) have been made of a star-forming region in Orion known as the Integral-Shaped Filament. Though filaments forming lower-mass stars have been previously resolved in Taurus, this is the first time that structure inside a filament that is forming high-mass stars has been seen.

Both the Taurus and Orion observations found the filaments to be made up of smaller "fibers" of gas. The Taurus fibers were 1½ light-years long, while the Orion fibers were typically only ½ light-year long but more numerous. More observations are needed to help astronomers understand exactly how gas collapses to form stars.

Black Hole Jets

Data from a black hole that is devouring a star show that the radio signal nearly duplicates the X-ray signal, but *13 days later*. The best explanation for this is that the black hole is producing a jet that takes 13 days for material in it to reach an area conducive to emitting radio waves.

It is believed that the X-rays are produced by heated material falling from the accretion disk into the black hole. Jets, sometimes seen with black holes, appear to originate near the accretion disk. Such jets likely produce radio emissions throughout their length, but radio waves produced close to the black hole are probably absorbed by material there. Thus, in radio waves we see only the outside ends of jets, where they have emerged from the absorbing material, and in this case, it apparently takes 13 days for the jet to emerge.

It had been theorized that the strengths of radio waves emitted by jets should be controlled by the amounts of material falling into the black hole, but this is the first observation that demonstrates that. (If it were not so, then the shape of the radio observations would not mimic the shape of the X-ray observations.)

Central Milky Way Black Holes Found

Black holes that orbit another star (binary black holes) give off a bright burst of X-rays once in a great while, but also continuously give off a *dribble* of them. Theory suggests that there should be thousands of black holes, many binary, near the center of our Milky Way galaxy. But previous searches looking for their bright X-ray bursts have come up empty. A new search looked instead for the dribble of X-rays and found a dozen black holes near the Milky Way's center (within three light-years), and therefore near the supermassive black hole that lives there. Knowing how much space they searched, and the percentage of black holes that are binary, they extrapolated that there are *over 10,000 black holes* in the central part of our galaxy.

Dawn (Ceres Spacecraft)

Water ice was found exposed at the surface of Ceres that was not there months ago. The ice may have been uncovered by a landslide or condensed on shaded areas from vapor emitted nearby, but in either case, it shows the asteroid is more geologically active than thought. The floor of the crater where the ice was found also shows evidence of past glacier-like flows of ice and rock. In other areas, new observations found a dozen deposits of hydrated carbonates. Under the conditions on Ceres, these chemicals will dehydrate (that is, lose the water in their chemical structure) over millions of years. Thus, their exposure on the surface must have occurred in recent geological times. Their exposure could have been caused by impacts, landslides, or cryo-volcanism.

Free-Floating Moons

Systems of planets (including our own solar system) show evidence that planets' orbits moved around in the distant past. Planets are often found in orbits where they could not have formed with the composition they now show. A new study, using computer simulations that included moons, shows that such movements of planets' orbits likely threw a lot of moons out of their planetary systems. Also occurring were moons swapping to other planets, moon collisions, and moons moving into their own planetary orbits. Free-floating moons (that is, ones not orbiting a star) should be common. It may be possible to detect free-floating moons by gravitational microlensing—that is, gravitational deflection or magnification of light from more distant sources when a moon passes in front of the light.

Galaxy Lacking Dark Matter

Astronomers using the Hubble Space Telescope and other observatories have found that a relatively nearby galaxy has almost no dark matter. Typically, galaxies have halos of dark matter far more massive than the ordinary matter content. This galaxy, dubbed NGC 1052-DF2, had its total mass (including dark matter) measured by tracking globular clusters in orbit about it. The result was about the same as the mass estimates for just the stars, leaving no room for dark matter.

The galaxy is larger in size than our Milky Way, but contains 1/250th the number of stars. The team of astronomers intends to study other galaxies with sparse stars to see if any of them are also lacking in dark matter. If you are a fan of MOND (the alternate theory of gravity that proposes to explain observed celestial motions without resorting to dark matter), you are going to hate this galaxy: If MOND explains most of the galaxies of similar visible mass to this one (which apparently have huge dark matter halos), it has to utterly fail to explain the orbits of the globulars around this

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DAS NEWS

May Member In-Reach

This month's In-Reach, for DAS members and their guests, will be held at **7:00 PM** on **Saturday, May 5th**. We'll demonstrate the technique of starhopping to find objects, as well as learning how to actually see them (or not) live rather than in photographs. It's meant for those who have simple, non-computerized scopes or just binoculars, and are in the process of learning the sky. Star-hopping introduces the feeling of satisfaction at being able to hunt down objects by yourself, and if the weather permits, maybe we'll finally have some hands-on opportunities on the lawn to put it to use.

As usual, feel free to bring snack food. We'll have binocular sign-out at the south entrance for the evening, loaner scopes will be available for checkout later in the month, and there's a fresh new stack of handouts for sky targets.

May General Meeting

Join us on **Friday, May 25th, 2018, at 7:30 PM,** for our General Meeting and a presentation by the DAS's own **Connor Bray**.

Connor is an active DAS member and currently an undergrad at the Colorado School of Mines, where he will complete his BS in Engineering Physics this December before starting an MS in Applied Physics.

Over the past year, Connor has worked with the Electroweak Interactions Group on his senior design project: it's a design study of a large scale HPGe array for the FRIB Decay Station. Before he graduates, Connor will have completed two internships at NASA.

The first was last summer, where he was the Flight Vehicle Performance Analysis Lead for the Preliminary Research Aerodynamic Design to Land on Mars (PRANDTL-M) project at NASA's Armstrong Flight Research Center. Additionally, this summer Connor has an internship at NASA's Goddard Space Flight Center to work with the All-Sky Medium-Energy Gamma-ray Observatory (AMEGO) project. Connor has had a passion for space exploration for as long as he can remember, and he hopes to someday work at NASA.

A reception following the meeting will be held at DU's Historic Chamberlin Observatory. Coffee and light refreshments will be served.

DAS Seeks a Treasurer

Mike Nowak has announced that he will be stepping down from his role as DAS Treasurer effective May 31st. He is planning to pursue certified public accountant (CPA) designation (on top of an upcoming move), and unfortunately won't have the time to devote to continue serving as Treasurer. We're grateful for Mike's support of the Society and his time as an officer. That means we're looking for a replacement. If this is something that interests you, please drop a note to president@denverastro.org.

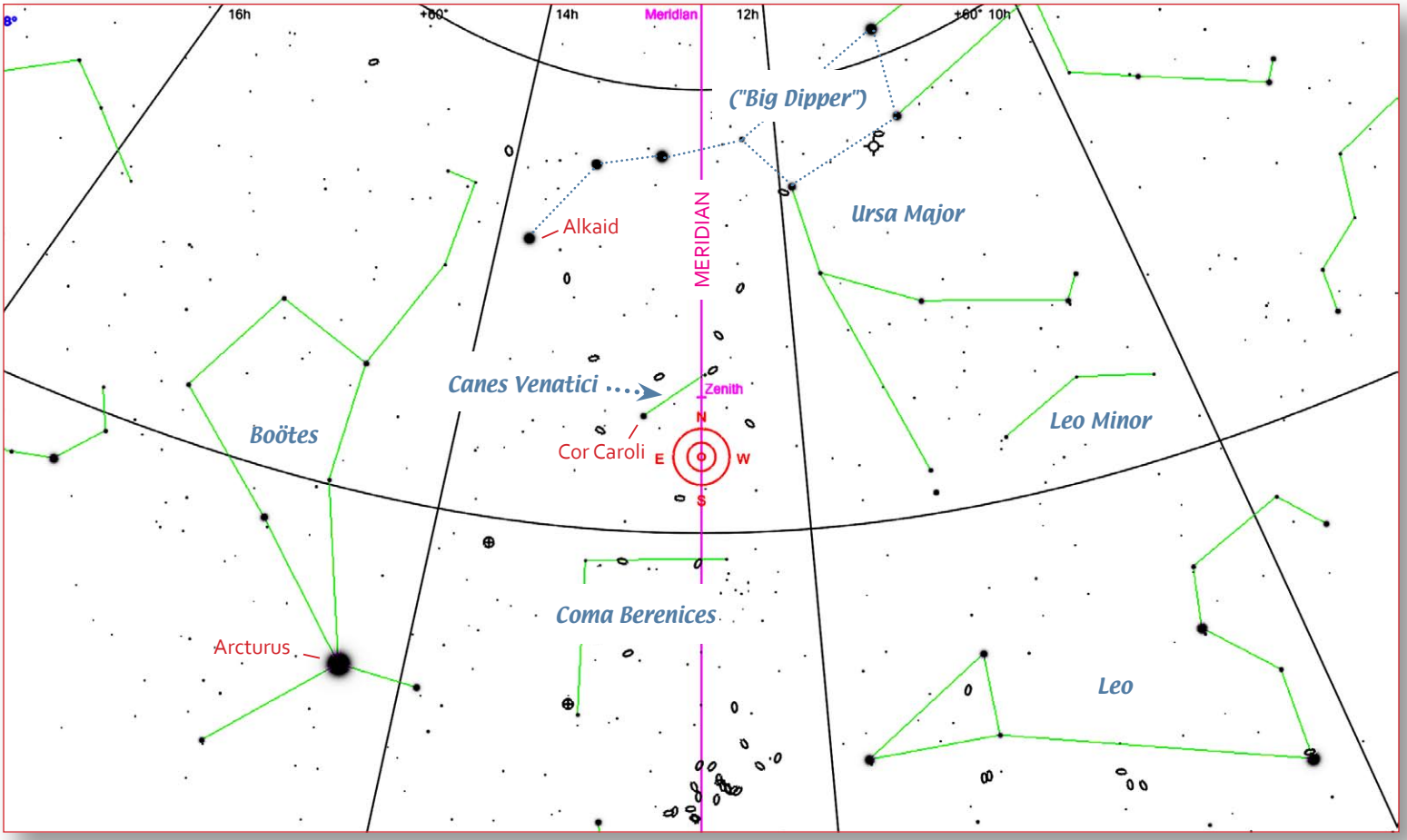
DAS at the March for Science

On Saturday, April 14th, DASers Chris Ubing and Dena McClung manned the DAS table in Civic Center Park at Denver's March for Science.

They had talks with their visitors about solar observing, and showed them solar prominences in hydrogen-alpha (Hα) light through a Coronado PST. They handed out some of the Open House schedules and invited people to come see us at the Chamberlin Observatory for Public Nights and/or Open Houses.

Chris Ubing shows solar prominences to March for Science participants.

Image © Dena McClung



The view for an observer facing southward and looking *straight up* in Denver at 10:00 PM in mid-May. Our deep-sky targets this month are in the constellation Canes Venatici (see chart center, and close-up chart at the bottom of page 7). Users of Dobsonian telescopes will have a difficult time pointing their 'scopes to this part of the sky (i.e., near the zenith), and will want to wait until an hour or so later to let the Earth's rotation move these targets sufficiently westward. (Telrad circles included for scale.)

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

May Skies

Continued from Page 3

lies about 15° eastward. As with the other planets, Saturn will be in an increasingly advantageous position through the spring and into the summer—by June 1st, you can get a good view of Saturn, 25° up in the south, at 2 AM.

Uranus was at superior conjunction (roughly in a line with the Sun, with the Sun between us and the planet) on April 18th, and is still lost in sunlight.

Neptune rises about two hours before dawn in early May, but remains too low for decent observing before the oncoming glow sets in. By the end of the month, though, the gas planet is high enough for a look—at around 4:00 in the morning. (You'll find it about a degree west of 4th-magnitude Phi [ϕ] Aquarii.)

And finally (for the solar system part of our tour), the asteroid **Vesta,** third-largest in the asteroid belt, is fairly bright at 6th magnitude in Sagittarius this month, on its way to opposition in June. If you don't mind observing in the wee hours, this is a good opportunity to check one of the big players out, as it cruises past celestial landmarks that will help with finding this object.

Look for Vesta after 2:00 AM, when it will be at least 25° up, high over the Sagittarius "teapot," and note that through mid-month, the asteroid lies very near M24 and M18. From there, it loops westward toward M23, which it appears close to next month. By then, Vesta will attain 5th magnitude and will be in good viewing position some two hours earlier. (See detailed chart on page 7.)

Stars and Deep Sky

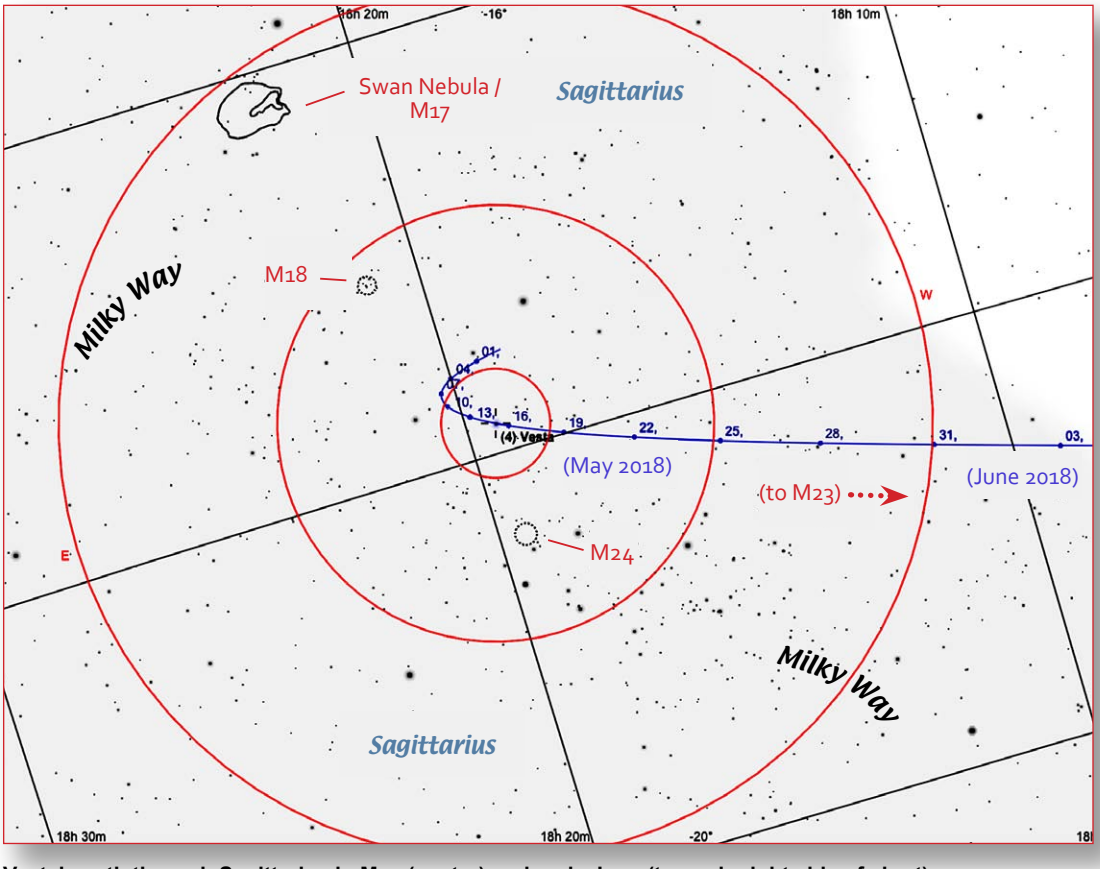
This month, we have two unusual galaxies in the constellation of Canes Venatici. The first is **M94,** at **12h 52m, +41° 01'**. M94 is bright enough to be seen in a 5- or 6-inch 'scope (at least the central area). Though it's a spiral galaxy, like our own Milky Way, M94 is built differently. First off, it's much smaller, with a diameter of about 33,000 light-years (the Milky Way's is about 100,000, or three times larger). You can get a good feel for this galaxy's proportions by comparing it with M81, part of the famous pair of galaxies in Ursa Major (see "April Skies," page 7, in the April 2016 *Observer*, at http://www.denverastro.org/xobserver/april2016_denverobserver.pdf.) M81 lies at roughly the same distance as M94, but is more than double its size (and so more similar to our own galaxy).

M94's inner spiral is also very tightly wound, with intense rings of blue "starburst" action (where new stars are being formed). The color comes from the newly formed stars, of which the brightest are very hot and therefore blue. (You won't see the color in the eyepiece, but it shows clearly in deep photographs.) This inner structure is surrounded by a larger, dimmer, and less-defined halo, which is visible in larger telescopes. Very deep photos reveal an outer ring, separated from the halo by a distinct gap, as though

Continued on Page 7

May Skies

Continued from Page 6



Vesta's path through Sagittarius in May (center) and early June (towards right side of chart).

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

something caused a much earlier "wave" of star-formation—astronomers continue to debate its origin.

When observing M94, at least initially, avoid the natural inclination to use very high powers with your 'scope to make up for this galaxy's petite dimensions. Even if you crank your power up to 300x, the galaxy won't fill the eyepiece, but the reasonably bright view you'd have had at more moderate powers (perhaps 10x per inch of aperture) will be squandered. Just enjoy this object for what it is, and let your *mind* wander through its structure.

To find M94, first find Cor Caroli, which is also known as Alpha (α) CVn for short. If you face south and look straight up, you'll see the Big Dipper high overhead. Now look for the star where the Dipper's "bowl" joins with its "handle." Imagine a line from there to the bright star at the end of the handle (Alkaid), and make a loose right-angle from there southward (towards Leo's tail). You'll quickly notice Cor Caroli, at about the same distance "below" Alkaid as Alkaid is from the Dipper's bowl. (See chart on page 6.)

Now that you have Cor Caroli, look about 5° northwest (roughly towards the area "below" the Dipper's bowl, when the bowl appears right side up), to find the 4th-magnitude star Chara, or Beta (β) CVn. Center your Telrad between Cor Caroli and Beta CVn. (There's a chance you *might* spy M94 in a 9x50 finderscope, towards the edge of the field, but don't worry if you don't—you're pretty close anyway.)

There's one last step: Imagine the Cor Caroli-Beta CVn line, and slide the Telrad toward Alkaid until that line lies about a third of the way in from your Telrad's outer, 4° circle to its mid-sized circle. That should get M94 inside a ½° eyepiece field, or at least, close enough to spiral gently around the area to find your target. (See the close-up chart of Canes Venatici, below.)

Our other target, **NGC 4490, also known as the Cocoon Galaxy**, lies just a few degrees away, at **12h 31m, +41° 33'**. (Don't confuse this object with the similarly named Cocoon *Nebula* in the constellation Cygnus.) Officially, this galaxy is classified as a barred spiral, but its shape is distorted by its smaller, 12th-magnitude companion, NGC 4485. As a result, 4490 looks more like a cosmic "comma" in photographs, with the "pointy" end extending toward 4485, but you'll likely need at least a 12-inch 'scope to perceive this visually. (DASers, note that we have a 14-inch 'scope at our dark-sky site). The inner part of NGC 4485 is bright enough to see in a 6-inch 'scope, so you won't go away empty-handed.

NGC 4490 has nearly twice the diameter of M94, but appears

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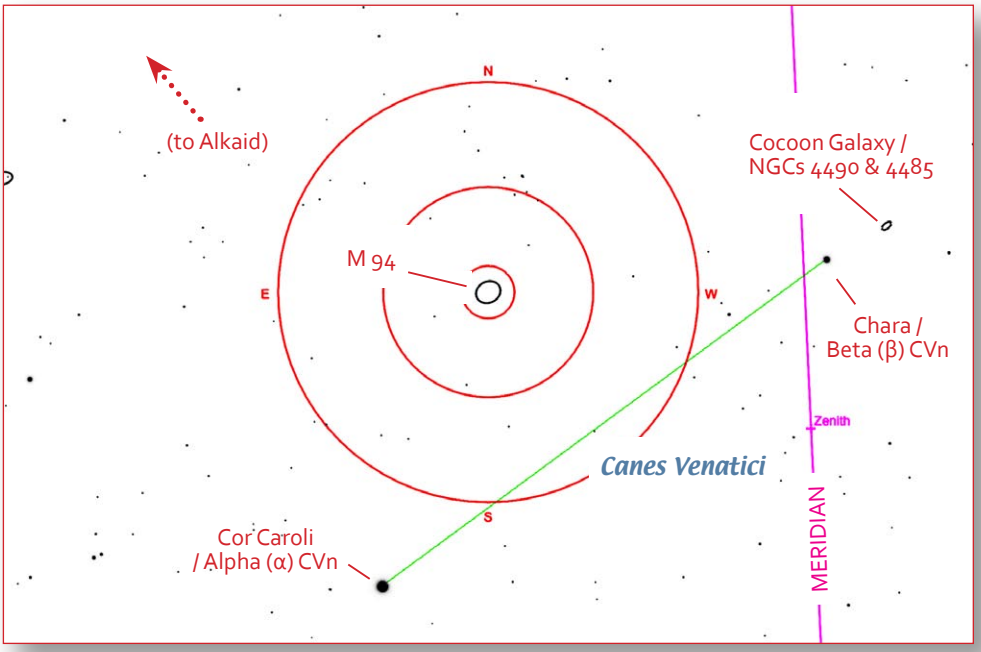

Close-up view of Canes Venatici, showing Telrad centered on M94. Note position of the imaginary line running between Cor Caroli and Beta (β) CVn when M94 is centered.

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

Astro Update

Continued from Page 4

one.

Unchanging Galaxy

Astronomers identified a galaxy that appears unchanged for the last 10 billion years. It's fairly common for galaxies to stop forming new stars and have no further galaxy collisions (and therefore remain essentially unchanged), but not as early in the history of the Universe as this one. The galaxy is NGC 1277, which is relatively nearby at 240 million light-years away, and fairly easy to study. Such study may tell astronomers what stops star formation and what conditions were like 10 billion years ago. (The galaxy has twice as many stars as the Milky Way, but is only ¼ its size.) NGC 1277 is in the midst of a huge cluster of galaxies, and so might be expected to interact with other galaxies and intergalactic gas, but apparently has not, probably due to its high speed.

Magellanic Clouds

The Large and Small Magellanic Clouds, our neighboring galaxies, have long been interacting gravitationally with each other. There are two long streams of gas ripped out of them, one called the Magellanic Stream, located on the trailing side (relative to the Clouds' motion), and the other on the leading side, called (you guessed it) the Leading Arm. In 2013, a spectroscopic analysis showed that the Magellanic Stream contained gas ripped out of both Clouds. A new study of the Leading Arm, using the Hubble Space Telescope, showed its gas was ripped out of just the Small Cloud. (Apparently, the Large Cloud is winning the gravitational war, once again proving that mass wins.)

The new observations were done with Hubble's ultraviolet spectrograph, finding the spectral lines imprinted by the Arm's gas on light from more distant sources (quasars). The Leading Arm has collided with the Milky Way and is causing star formation in our galaxy. ∞

May Skies

Continued from Page 7

slightly smaller in a 'scope, because it lies nearly 60 million light-years away. NGC 4485, on the other hand, really *is* smaller—roughly half the diameter of M94. Interestingly, 4485 and 4490 are nearly a million light-years apart, but their *visual* separation appears to be far less—most of the distance between the pair lies along our line of sight (the smaller galaxy, NGC 4485, is closer to us).

Finding NGC 4490 shouldn't be difficult, and as noted, if you've just observed M94, then you're already in the neighborhood. Just center your Telrad on Chara (Beta CVn), and slide it on our imaginary Beta CVn-Cor Caroli line, *away* from Cor Caroli—stop when Chara appears about halfway between the smallest (½°) Telrad circle and the mid-sized (2°) one.

—See you next month.

∞

The Denver Astronomical Society
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