The Denver
OBSERVER
DECEMBER 2017

Messier 76, the Little Dumbbell Nebula, one of the deep-sky objects featured in this month's "Skies." *Image © Joe Gafford.*

DECEMBER SKIES

by Zachary Singer

The Solar System

December will be a decent month for planetary events; though some planets are slipping from view, others will take their place. We also have an **occultation of Aldebaran;** as seen from Denver, **the Moon will pass in front of the star at approximately 4:06 PM, on the 30th.** At that point, with sunset still more than half an hour away, the star won't be visible to the naked eye, but it should be in a telescope if you know where to look: Imagine a square drawn just large enough to touch the edges of the Moon, and with the square's bottom parallel to our local horizon. At about 4:00 PM, a few minutes before the actual event, you'll find Aldebaran at the lower-left ("easternmost," *relative to our sky*), corner of that box—a half-degree field of view in your 'scope will include the Moon's eastern section and the star, with plenty of room.

I recommend you observe early—it should be a beautiful view, with the star a bright spark near the Moon's edge, and over the following minutes (they'll go fast, just like the recent solar eclipse did), you can see the Moon move in its orbit around us, using the star for a benchmark. (Before 4:00 PM, look for Aldebaran outside the square, but along the diagonal from the Moon's center to that lower-left edge.)

Aldebaran will reappear at about 5:00:27, give or take several seconds, for observers close to the DTC area. Look for it along the Moon's western edge, at about the "2 o' clock position" on the Moon's disk—or imagining

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Sky Calendar

3	Full Moon
10	Last-Quarter Moon
17	New Moon
26	First-Quarter Moon

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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*

Astronomy Lingo

Amateur astronomy has its own, somewhat unique vocabulary. That's fine if you've been in the hobby for a while, but if you're new to amateur astronomy or are simply curious about it, astronomy's everyday lingo may as well be Latin. Here's a look at some of the essentials.

What better place to start than with than the phrase **amateur astronomy**? According to my copy of *Webster's New World Dictionary*, "amateur" means "one who does something for pleasure, not for pay; nonprofessional." In particular, amateur is derived from the Latin *amare*, which means "to love." That same dictionary defines "astronomy" as the science of the stars and other heavenly bodies, their motion, position, size, etc. The word astronomy is from the Greek ἀστρονομία, for "law of the stars."

Naked-eye observing of the sky is an easy way to simply enjoy what's up there. It's also a good way to learn some of the modern **constellations** (88 recognizable star-patterns, with boundaries defined by the International Astronomical Union; examples include Orion and Ursa Major) and **asterisms** (groups of stars that form patterns, but are not officially constellations, such as the Teapot in Sagittarius or the Big Dipper in Ursa Major).

Most amateur astronomers use a **telescope**, which is an instrument with lenses or mirrors, or a combination of lenses and mirrors to make distant objects appear as if they are closer, bigger, and brighter. There are three general types of telescopes: refractor, reflector, and catadioptric (or compound optic).

The name **refractor** comes from the telescope's basic design, which includes an **objective** (main) **lens** at the front end of the tube that refracts (bends) the incoming light toward the focus point at the back of the tube where the eyepiece is located. The Alvan Clark-Saegmuller 20-inch telescope in DU's historic Chamberlin Observatory is a refractor.

As you'd expect, a **reflector** uses mirrors, instead of a lens, to form an image. (What is commonly called a Dobsonian or Dob telescope is actually a reflector 'scope on a Dobsonian mount.) Light enters the front of the telescope's tube and travels to rear. There, the light is reflected by what is called the

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DAS SCHEDULE

December 2017

3	DAS Holiday Party—Embassy Suites Tech Center—Starts at 6:00 PM. The speaker will be Karly M. Pitman, Ph.D., Executive Director of the Space Science Institute.
8	E-Board Meeting—At DU's Historic Chamberlin Observatory, 7:30 PM. All members welcome.
16	Dark Sky Weekend—EGK Dark Site & Brooks Observatory
30	Open House—DU's Historic Chamberlin Observatory—Starts at 4:30 PM
	(January 2018)
5	DAS General Meeting—DU's Olin Hall, Rm. 105—Starts at 7:30 PM
12	E-Board Meeting—At DU's Historic Chamberlin Observatory, 7:30 PM. All members welcome.

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

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

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

March 10 - September 30 at 8:30 PM

October 1 - March 9 at 7:30 PM

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

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

President's Message

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primary mirror back toward the front of the tube where a smaller **secondary mirror** reflects the light out the side of the tube to the focus point and eyepiece. In some reflectors, the secondary sends the light back towards the main mirror, in a similar manner to the third type of 'scope.

A **catadioptric** telescope uses a combination of lenses and mirrors. Light enters the front of the tube and passes through a lens (called a corrector or meniscus) to the primary mirror at the rear of the tube. The primary reflects the light back to the secondary, which is mounted on the rear of the corrector. The secondary mirror reflects the light back once more toward the primary, where a hole in the primary's center lets the light pass through to the eyepiece. It may sound complex, but this back-and-forth light-path results in a much more compact design. The popular **Schmidt-Cassegrain** ("Schmidt-Cass") and **Maksutov-Cassegrain** ("Mak") 'scopes from various manufacturers are catadioptric designs.

For more information about the three types of telescopes just discussed, along with diagrams and animations showing the light paths through those 'scopes, see http://www.skyandtelescope.com/astronomy-equipment/types-of-telescopes/.

The diameter of the objective lens or primary mirror is the telescope's **aperture**. For instance, the Alvan Clark-Saegmuller refractor at Chamberlin has a 20-inch-wide objective lens. Aperture is all-important, because it's related to how much light a telescope gathers—think of a telescope as a "light bucket." The bigger the aperture, the dimmer or fainter the object that can be observed (weather and sky conditions permitting, of course).

In simple terms, the distance the light travels through a telescope from the objective lens (or the primary mirror) to the focus point, where the eyepiece is located, is called the **focal length**. The longer the focal length, the greater the **magnification** when using a given eyepiece. (Magnification is calculated by dividing the telescope's focal length by the eyepiece's focal length.)

How much magnification is enough? It depends; too much, and the image becomes dim and fuzzy. A good rule of thumb is to use *no more* than 25x per inch of telescope aperture: For a 6-inch, 25 times 6 equals 150 power; for a 10-inch, 25 x 10 equals 250 power. Dim deep-sky objects often benefit from using *lower* power than this and tight double stars may need more.

A telescope's focal length divided by its aperture is the **focal ratio**, or **f-number**. For example, one of my small refractors has a focal length of 600mm and an 85mm aperture, which means the focal ratio is 600/85 = 7, written as f/7. In photography, a larger focal ratio means longer exposures are necessary—borrowing this idea, a telescope with a larger focal ratio is said to be "slow" and one with a smaller focal ratio is said to be "fast." In general, fast 'scopes are good for seeing a larger **field of view** (a bigger chunk of the sky) and lower magnification, and slow 'scopes provide the opposite.

I've barely touched on some of the vernacular of amateur astronomy. If this has piqued your interest, check out the glossary at https://starizona.com/acb/basics/glossary.aspx.

December Skies

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the previous square, look roughly where the square's diagonal from center to the *top-right* corner intersects the lunar limb. As with the entry, start observing ahead of time, and watch as the departing Moon increases its angular separation from the star afterward.

Look for **Mercury** late in the month, after it emerges from the solar glare as a pre-dawn object. After about the 20th, it should be visible in the east around 6:45 AM, when the planet's then-thin crescent begins to separate from the dawn's glow. On the 20th, Mercury will shine at magnitude 1.0 and stand about 7½° above the horizon; by the 25th, the planet's fuller disk brightens nearly a magnitude and climbs to 10½°—and by month's end, the planet glows at magnitude -0.2 and almost 11° up at the same time of day. (Since sunrise will by then come several minutes later, the extra time will allow a height of 11.6° a half-hour before sunrise.) Maximum elongation, when Mercury's angle from the Sun is greatest, occurs on the morning of January 1st (a Happy New Year's present,

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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.

ASTRO UPDATE

Selected Summaries of Space News

by Don Lynn

Interstellar Visitor

The Pan-STARRS telescope in Hawaii has discovered an object whose trajectory clearly shows that it came from outside the solar system. (Objects have been found previously which *may* have been interstellar, but this is the first unequivocal example.) Its spectrum does not match typical Kuiper Belt objects, another reason to believe it is interstellar. It was at first classified as a comet, based on its orbit, but further observations failed to find any hint of tail or coma, so it was reclassified as an asteroid. Then the IAU invented a new class for it: Interstellar Object.

The discoverers named it 'Oumuamua, Hawaiian for "To reach out first." It is now known as 1I/2017 U1 ('Oumuamua) or various contractions of that. It appears to be highly elongated and rotates every three to five hours. ' 'Oumuamua's direction of approach and velocity do not match any nearby star systems, so we don't know where it came from.

Exo-comets

An amateur astronomer searching through Kepler (planet-finding space telescope) data found three dips in light level that did not fit the shape expected for planets transiting (passing in front of) stars, but did fit objects with tails, meaning comets. These were brought to the attention of professional astronomers, and eventually six of these were found. These are the first comets ever discovered outside the solar system. It is believed that all of the comets passed quite close to their stars and vaporized.

Exoplanet Too Large

A gas-giant planet, dubbed NGTS-1b, has been found orbiting a very small star (half the diameter of our Sun), making it the largest known planet compared to the size of its star. Current theory holds that when such a small star forms, it does not have enough material orbiting it to form a gas-giant planet, so the new discovery sends theorists back to the drawing board. The planet was found by the transit method (it slightly dimmed its star as it passed in front), and confirmed by the radial velocity method (it causes its star to wobble as it orbits).

Close Exoplanet

An Earth-sized exoplanet that is in or near the habitable zone (where temperatures should allow liquid water to exist) has been discovered orbiting Ross 128, a red dwarf star just 11 light-years away. (Only Proxima Centauri has a habitable-zone planet nearer to us.) Young red dwarfs flare a great deal, splattering their planets with high levels of ultraviolet and X-rays. But Ross 128 has aged beyond this and is relatively calm, making the star-system a good place to search for life. The planet was found using the radial-velocity method; it orbits its star every 9.9 Earth-days. In about 79,000 years, stellar motion will sweep the Ross 128 system toward us, so that it will be even closer than Proxima's.

Star Too Small

It takes a long time to make a white dwarf star: A star, initially Sun-like, has to use up its hydrogen fuel, become a red giant, and then collapse to a white dwarf. The smaller the star's initial mass, the longer it takes to use up the fuel, because such stars consume hydrogen at a far slower rate. In fact, any star with an initial mass substantially smaller than the Sun has not had enough time since the Big Bang to become a white dwarf. Yet there are a few dozen known low-mass white dwarfs. Another has just been discovered in Perseus, and it is the lowest mass known for a white dwarf (in the range of 20-30% the Sun's mass).

As with all other low-mass white dwarfs, this star has a closely orbiting companion that must have stolen mass from the star. (This happens when the star reaches the end of its hydrogen fuel and swells up into a red giant. During the swollen phase, the companion can gravitationally pull material off the star.)

An unusual feature of the new discovery is that the companion is a brown dwarf, not an ordinary star (brown dwarfs are too small to shine like other stars). So even though the brown dwarf must have stolen substantial material, it didn't retain enough to graduate from a brown dwarf to a normal star.

Old Exoplanet Evidence

100 years ago, the Mount Wilson 60-inch telescope photographed the spectrum of Van Maanen's Star, a nearby white dwarf. The spectrum unexpectedly showed some heavier elements, which shouldn't be near the surface of a white dwarf (heavy elements ordinarily sink into a white dwarf's interior, and so wouldn't appear in spectra). The best explanation at the time was that interstellar dust was raining down on the star.

That same spectrum was recently studied again, with new perspective gained over the last century. The best theory now is that planetary or asteroidal material was swallowed by the star relatively recently (in terms of astronomical time). So a century ago, astronomers were presetned with evidence that exoplanets exist, before they understood the significance of that evidence. This new interpretation also means that Van Maanen's Star likely has an asteroid belt and planets, though none has yet been discovered.

Curiosity Drill Work-Around

The sampling drill on Mars rover Curiosity has not been used for about a year, ever since it developed mechanical trouble. The problem has been isolated to sensors mounted on posts on each side of the drill.

A work-around using sensors in the arm holding the drill, instead of the sensors on the posts, has been tested on Earth and will be tried on Mars in the near future. Curiosity may soon be able to resume drilling, and analyzing the samples. During the past year, Curiosity has been relying on its laser zapper and infrared spectrometer to analyze rocks, instead of the drill method.

Jupiter's Auroras

X-ray space telescope observations of Jupiter have found that its southern auroras pulse regularly, every 11 minutes, but the northern ones are erratic. Interestingly, Saturn's auroras do not produce X-rays, while Jupiter's do.

DAS NEWS

Upcoming DAS Elections

A reminder that our annual elections get underway at the **January 5^{th}** General Membership meeting, when **nominations open for E-Board officer and trustee candidates**. The election itself takes place at the February General Membership meeting; the new board will be installed in March. This year's Chairman of the Election Subcommittee is Ivan Geisler.

Volunteer Opportunities

Friday, Dec. 8^{th}, 2017, start 1:45 PM: *Godsman Elementary School, 2120 W. Arkansas Ave., Denver, 80223.* Solar viewing and kids' activities for grades 1-5.

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

After New Year's: January General Meeting

Mike Carroll

On Friday, January 5^{th}, at 7:30 PM, Mike Carroll will present "Distant Earths," and will have books available for signing.

Writer, lecturer and artist Michael Carroll has nearly thirty books in print. He is a science journalist and children's author, having written for such magazines as *Astronomy Now* (UK*), Popular Science, Astronomy, Asimov's, Analog, Sky & Telescope, Clubhouse, Odyssey, Sea Frontiers,* and *Artists* magazines. His books include *SPACE ART* (Random House/Watcon Guptil), *Alien Volcanoes* (Johns Hopkins University Press 2008, with Rosaly Lopes), *Living Among Giants: Exploring and Settling the Outer Solar System* (Springer), *Drifting on Alien Winds,* and others.

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.

Are you skilled at editing videos?

If you're familiar with iMovie (or more advanced software like Final Cut Pro or Adobe Premiere Pro), the DAS would like you to consider contributing your skills to editing videos of our General Meetings for posting on YouTube.

We need someone who can use an existing on-screen format for creating a title frame, combine videos of the speakers with PowerPoint presentations, and post them on the DAS YouTube channel. A "how-to" guide has been created by Jeff Tropeano.

If you're interested, **please contact Darrell Dodge at dmdodge@aol.com.**

Happy Holidays from the DAS!

December Skies

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if you can get up for it!).

Venus remains bright at -3.9 magnitude, but is rapidly sinking into the Sun's glow, passing "behind" the Sun, from our Earthly point of view, in early January. The planet will return as an evening object. (Looking ahead, there will of course be conjunctions; among them, a tight one with Mercury in March.)

Mars, still a 2^{nd}-magnitude pre-dawn object, sees its disk grow by about 14% by the end of December, to just under 5". By next summer, at Mars' opposition, the planet will shine at magnitude -2.8, more than 4½ magnitudes brighter, and its disk will span a magnificent 24". In the meantime, get ready for a tight conjunction with Jupiter on the mornings of January 6^{th} and 7^{th}, when the two planets will be less than ⅓° apart.

Jupiter is becoming a decent target—though only 20° up a half-hour before dawn at the beginning of December, it will be nearly 30° up—in darker skies, a full hour before dawn—by New Year's. At opposition in May, Jupiter will appear about 1/3 larger, and almost a magnitude brighter.

Saturn is toast this month, as expected. Superior conjunction is on December 21^{st}; we'll see the ringed planet again, early next year, as a pre-dawn object.

Uranus still makes an interesting target. It's about 55° up in the southwest at 9:00 PM mid-month. Place your Telrad about midway between 4^{th}-magnitude Omicron (ο) and 5^{th}-magnitude Zeta (ζ) Piscium, and Uranus should appear as a 6^{th}-mag., pale-blue "dot" in your finderscope. (Note that the planet will be about halfway toward the finder's eastern edge.)

Neptune hasn't moved far from Hydor, aka Lambda (λ) Aquarii—the planet still lies just over a half-degree southward of the star as the month begins. By New Year's, Neptune maintains its distance from the star, but the planet's "6 o'clock" position from Hydor has shifted clockwise to a roughly "7 o'clock" position. In either case, it shouldn't be hard to find—just center Hydor in your finderscope and look for the dim blue planet. If you haven't observed the planet lately, keep in mind that this convenient opportunity will slip away soon—though it's still high up in the evening in early December, the planet will be low on the horizon at 9PM at New Year's—and it will slide completely into western twilight before the end of February.

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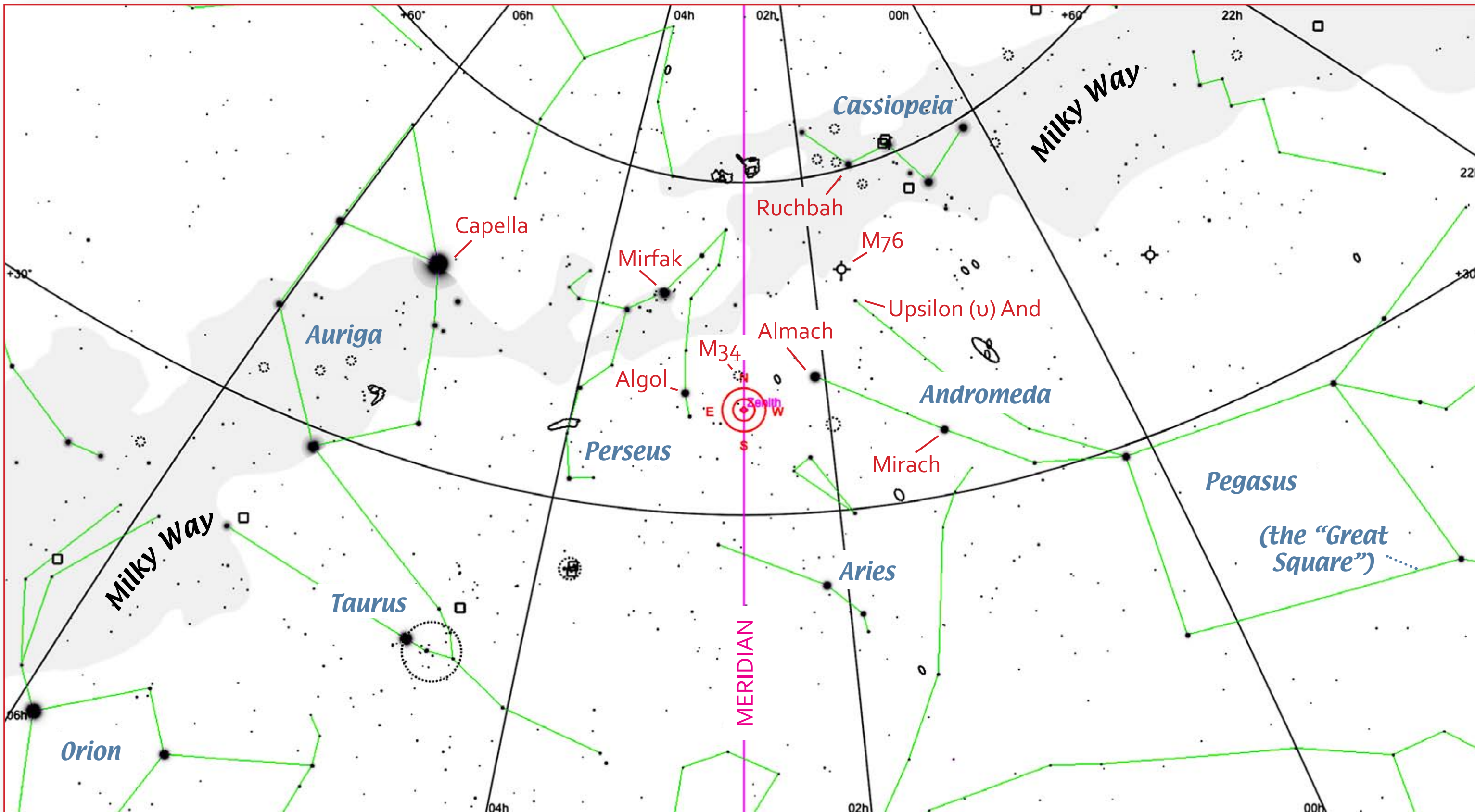

The Denver sky at 9:00 PM in mid-December. Telrad circles included for scale; their center is *straight up*. (See also the close-up of chart center on p. 7.)

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

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Stars and Deep Sky

This month, we tour the area between Andromeda and Perseus—you'll find this swath of sky *straight up* at 9 PM mid-month. (Because the sky moves westward as the days go by, the same area will be overhead at 10 PM in the beginning of the month, and 8 PM at the end.) Since we had some challenging targets last time, we'll switch things up a bit and have two fairly easy ones and one that's a little more challenging: an eclipsing binary, a lovely open cluster, and a fascinating planetary nebula.

If you know your way around this region, skip down to "Starting the Tour," below.

Getting Started with Navigation

Since our main "guide stars" are generally bright enough to be seen in the city, it's a good strategy for those who are unfamiliar with these constellations to go outside a few times and have a look, eyes-only, before trying to find the deep-sky targets. Our main chart this month shows a wide view of the surrounding constellations for your reference.

One way to get oriented is to find the Great Square of Pegasus, which is about 50° up in the west, at the times mentioned above. (Note that as it approaches the horizon, Pegasus is viewed at an angle, so its "square" will look more like a diamond when you face it directly.)

Look at the "lower-right" star of the square (it's the "bottom" of the diamond in this orientation), and imagine a line to the square's "top-left" star (now the "top" of the diamond); this line extends onward into Andromeda. Follow the lower, brighter chain of stars as it curves around, looking first for Mirach (Beta [β] Andromedae), and then our jumping-off point, Almach (Gamma [γ] Andromedae). Two things are worth noting: (1) Mirach is about the same distance from the "top-left" star in Pegasus as we hopped across the square in the first place, and (2) in the city, the dimmer, upper chain may not be visible. (We visited the area around Mirach and Almach in the November 2015 Observer—there's a lot to see there: http://www.denverastro.org/newsletters/november2015_denverobserver3.pdf.)

Starting the Tour

Algol, or **Beta (β) Persei**, at **03h 09m, +41° 01'**, usually bright at 2nd magnitude, makes a great landmark for finding other objects in and around Perseus (we'll use it that way for our next target). But the star has a big trick up its sleeve—at regular intervals, it dims by over a magnitude! Algol, is in fact the first-known of a whole class of variable stars, known as eclipsing binaries: What looks like one star, is in fact two in orbit around each other—the unseen companion's orbit sweeps it in front of the bright primary, blocking its light. When this happens, the total brightness of the system dims—and because that dimming is tied to the clockwork-like orbit of the companion, it's a very predictable cycle.

In Algol's case, it occurs every 2.9 days. During an eclipse, there's gradual dimming over a period of hours, in much the same way that we experienced this past summer, when the Moon began to pass in front of our Sun. The deepest part of Algol's eclipse, though, takes about *two hours* to complete, unlike the two minutes of the 2017 solar eclipse.

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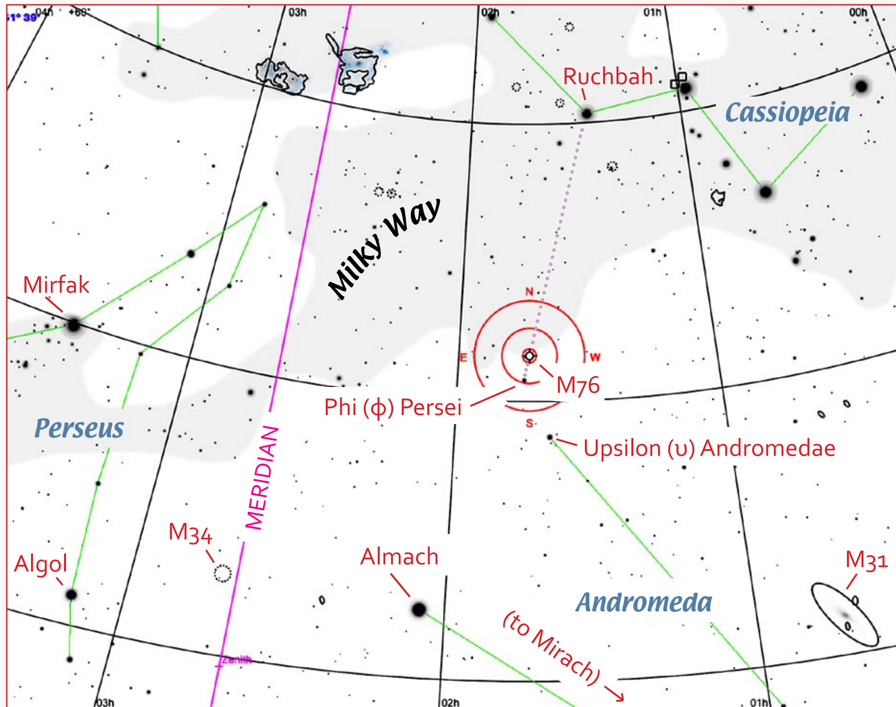
Unlike most objects in amateur astronomy, Algol is best appreciated with the naked eye—a repeated glance at the star over time will give you a feel for how it usually looks, and how its brightness compares to that of the surrounding stars. Most of the time, it's nearly as bright as nearby Mirfak (Alpha [α] Persei), for example. If you get in the habit of checking out the bright triangle of stars formed by Algol, Mirfak, and Almach (see charts), then Algol's dimming—*a partial eclipse of that sun*—will be quite striking!

In another way, Algol is very much like other astronomical objects—what you see with your eyes (or a telescope) is only a part of the experience. The real depth of what we observe comes from actively engaging our imagination with the facts that scientists have gleaned over the years.

Algol's true nature was *deduced, over a century ago,* by brilliant scientists, who could not see the dim companion directly. Today, most astronomy resources still refer to the "unseen companion" star, as I have here.



Close-up of area surrounding Algol, M34, and M76 (latter centered in Telrad circles). Note position of Telrad relative to Phi () Persei, and alignment with Ruchbah (dotted line).

Astonishingly, researchers using the advanced interferometers of CHARA (the Center for High Angular Resolution Astronomy) on Mt. Wilson have recently *imaged Algol's eclipsing pair*, confirming what had been expected by theory alone. Imagine the awe I experienced when I saw CHARA's choppy but *real* movie of the two stars in orbit—you'll find it near the bottom of their eclipsing-binary page at: http://www.chara.gsu.edu/astronomers/science-highlights/55-eclipsing-binaries.

Naturally, you need to know *when* to look, so here are some dates and local (Denver) times for Algol's upcoming minima, as calculated by *Sky and Telescope*. You can also go to their Algol page yourself, at http://www.skyandtelescope.com/observing/the-minima-of-algol/. (They'll want you to register to access the page, but it's free.) A google search will also bring up various Algol minima calculators.

Times below are for the midpoint of each eclipse.

12/15/17	3:33 AM	1/4/18	5:17 AM
12/18/17	12:22 AM	1/7/18	2:06 AM
12/20/17	9:11 PM	1/9/18	10:56 PM
12/23/17	6:00 PM	1/12/18	7:45 PM

There's much more to Algol than I can share with you in this limited space, so for a really great overview—and deep details, too!—go to the Algol page for the Royal Astronomical Society of Canada, at http://calgary.rasc.ca/algol_minima.htm.

Finding Algol is simple, once you're familiar with the neighborhood. Use Mirach and Almach as pointers, following the arc of Andromeda away from Pegasus. You'll quickly notice another bright star, Mirfak, or Alpha (α) Persei, a similar distance beyond Almach. If you imagine a line from Mirfak down to the southern horizon, you'll see Algol, the next star of similar brightness. Algol also sits at the 90° angle of a triangle made with Mirfak and Almach; it's just a little farther across the sky from Algol to Almach than from Algol to Mirfak.

If Algol is an object for your mind, then **M34**, an open cluster in Perseus at **02h 43m, +42° 49'**, is its opposite—something for your eyes. While some clusters impress with vast quantities of dimmer stars, M34's light comes primarily from a smaller sample of bright ones—in the city, it might remind advanced observers of M41 in Canis Major. (Interestingly, M34 is thought to be related to the Pleiades and a number of other clusters; they share similar motion through space.)

This bright cluster shines at 5th magnitude and easily found between Almach and Algol—it's even subtly visible in 9 x 50 finder under moderate skies in suburban Denver. In clear dark skies, including the DAS dark sky site on a good night, the cluster can be seen naked-eye. A 1° telescopic field works well, and slightly less is OK, too—but a ½° field is too narrow. In the country, try using lower magnification, to get an even wider view—the background contains a rich star field, and the gorgeous view is filled with stars!

To find M34 in dark skies, just look for its glow just less than halfway from Algol to Almach. (See the close-up chart, above.) Under less-perfect conditions, as in the city, aiming your Telrad at the halfway point should include the cluster within the magnified field of your finderscope. Under heavier light pollution, or whenever your finderscope fails to show the cluster, make a precise approach by aiming carefully at the midpoint of the line between the two stars mentioned earlier, then pull back 1° towards Algol. Once there, make a perpendicular 1° shift northward (towards Polaris), so that the mid-sized, or 2°, Telrad circle's edge falls on the Algol-Almach line. Your telescope should have at least *some* of M34 in it; if not, spiraling around that point should bring it right in.

Our last stop for the month is the planetary nebula, **M76**, or the **Little Dumbbell Nebula,** at **01h 43m, +51° 39'**. In a 'scope of sufficient aperture, *on a good night*, M76 displays complex and interesting structure, with a bright central bar and twin, roughly symmetrical rounded "halos" extending outward like a double-handled coffee mug.

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December Skies

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On poor nights, even my 12-inch shows only the central bar, especially when attempted without a UHC filter. On good nights, the lobes stand out well, but are much easier with the UHC. Either way, using about 10x per inch of aperture (60x in a 6-inch, 120x in a 12-inch) provides a decent view, but about 15-16x per inch is better. (In the 12-inch, details on the lobes, including swirls, stood out nicely at 188x with the UHC.) Since M76 has a reasonably large angular diameter as we see it, 100x or so in a 5- or 6-inch instrument should still show detail, if conditions allow it—but much of the time, expect to settle for the central bar.

As typical for planetaries I've seen, distance estimates for M76 are "iffy"—and various sources report distances from 2,000 to 5,000 light-years and farther. Given the uncertainties of both the nebula's angular diameter and its distance from us, M76's exact size is difficult to determine, but it's safe to say that it's at least 1½ light years across the length of the central bar, if the nebula is 2,000 light-years from us, and proportionately larger if it actually lies farther away.

In a November 1974 paper in the *Astronomical Journal*, A. G. Millikan, of the Eastman Kodak Company, discusses photographs he made on the 4-meter telescope at Kitt Peak—he reports extension out to nearly 5 arcminutes, far larger than the more common value of 3 arcminutes for the lobes. His report, with a black-and-white image showing subtle wisps beyond the more familiar structure, is at the link following. (Note that the image, Plate II on the second page of the PDF file, is labelled "NGC 650-651," another name for the nebula.)

http://articles.adsabs.harvard.edu/cgi-bin/nph-iarticle_query?1974AJ.....79.1259M&data_type=PDF_HIGH&whole_paper=YES&type=PRINTER&filetype=.pdf

To find M76, look first for Upsilon (υ) Andromedae, the mag. +3.6 counterpart to Almach, at the end of Andromeda's dimmer arc. You'll notice slightly dimmer Phi (φ) Persei about 2° away, slightly off the curve from Andromeda—center Phi in your Telrad. Now imagine a line from Phi to Ruchbah, the star at the lower-left vertex of Cassiopeia's "W" (or top-right of the "M," if that's easier). Slide the Telrad along this line a little less than a degree toward Ruchbah, so that Phi is nearly on the 2° (mid-sized) Telrad ring, and M76 should be in your telescope eyepiece. (This is illustrated, including the Telrad circles, on p.7.) Note that M76 will *not* appear in smaller finderscopes, like 6x30s, but it won't matter.

One last comment, for Dobsonian 'scope folks—we'll be looking straight up at our specified observing time, making your instrument a bear to handle. Try observing an hour before or an hour after, when you'll have better leverage.

—See you next year… Wishing you a blissful 2018.

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