The Denver
OBSERVER
APRIL 2016

M81, the large spiral galaxy at right, and M82, left, in Ursa Major. Visible in small telescopes, this pair lies about 12 million light-years from Earth, and about 150,000 light-years from each other. ***Image © Alan Erickson***

APRIL SKIES

by Zachary Singer

The Solar System

Mercury is out of the solar glare, and toward the beginning of the month, it presents a bright, -1 magnitude gibbous disk about 6" across, and low in the west at sunset. As the days progress and the planet orbits the Sun, its phase, apparent size and brightness change; maximum elongation comes on the 18th, when the planet will appear as a "lemon wedge" nearly 20° above the horizon at sunset. (On practical basis, Mercury will still be more than 10° up that evening when the sky is dark enough to make observation easier.) Towards the end of the month, before disappearing in front of the sun, Mercury will become a thin crescent some 10" across, but very low on the horizon. Those of us in Denver proper will see the Front Range as a beautiful companion to the innermost planet, but folks close to the foothills may find their view blocked; if you're in that group, try heading eastward for a better line of sight.

Mars and **Saturn** are together in Scorpio! If you're up between 4 and 5 AM, look for the constellation high in the sky in the south—the familiar scorpion outline looks surprisingly crowded—and is a wonder on its own, *naked-eye*. Saturn, Mars, and Antares make a brilliant triangle; Mars and Antares share their hue, but the planet greatly outshines the star. Mars' apparent diameter will grow to about 16" this month; that's about as good as it ever gets during less-advantageous oppositions, so these next weeks are already a good opportunity for telescopic observation—but we're not at opposition yet, and next month will be even better! (Saturn comes to opposition in early June.)

Technically speaking, **Jupiter** is slightly diminished, appearing about 7% smaller than last month as Earth speeds away from the giant planet after opposition. Realistically, it's still a stunning object, and at about 41" across, it's easy for all 'scopes. Jupiter is now a great object for kids, because they won't have to stay up late to see it—look for the planet in the southeast around 9:30 PM at the beginning of April, and higher, on the Meridian, at month's end.

The **Moon** continues its recent habit of **occulting Aldebaran,** this time on **April 10th**; for observers in southern Denver, the event will occur

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Sky Calendar

7	New Moon
13	First-Quarter Moon
21	Full Moon
29	Last-Quarter Moon

In the 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

Resources for Learning Astronomy

"How can I learn more about astronomy?"

That question is one that we often hear from our new members and from folks who attend Denver Astronomical Society Public Nights and Open Houses. The answer to the question definitely falls into the "it depends" category, and might be answered with another question: "What would you like to learn?"

A good place to start, of course, is with DAS. Our members' knowledge covers a broad range, and we love to help others learn more about astronomy. Our monthly meetings at DU's Olin Hall are a good resource—most feature an astronomy-related lecture. The subject matter can range from entry-level up to college and above. Check out our YouTube page for a sampling: *https://www.youtube.com/user/denverastro*.

Our Public Nights (*http://www.denverastro.org/das/public-nights/*), held every Tuesday and Thursday at DU's historic Chamberlin Observatory, feature an astronomy-themed lecture followed by observing through the powerful 20-inch Alvan Clark-Saegmuller telescope. (DAS members can attend our Open Houses and Public Nights for free.) We also have an area for beginners on our web site at *http://www.denverastro.org/das/for-beginners/*.

Sometimes the area of interest is nothing more than wanting help figuring out how to get the Moon or some other object to show up more easily in the eyepiece. (A common gotcha—the telescope's finder isn't aligned with the 'scope!) The first step is to look at the instruction manual, if one is available. If the manual is missing, or it isn't clear about the procedure, bring that 'scope to one of our Open Houses and ask for some hands-on assistance.

After our local telescope shop, S&S Optika, closed (Cathie and Tim Havens retired and moved to New Mexico), DAS member Digby Kirby took over the "how to choose a new telescope" and "how to use your new telescope" presentations normally done around the Christmas holiday season. He plans to do a couple more of these during the next several months at our Open Houses.

Two magazines that cater to amateur astronomy—*Astronomy,* and *Sky & Telescope*—have a wealth of helpful information for beginners on their respective web sites. On *Astronomy* magazine's site (*http://www.astronomy.com*), click on the OBSERVING and VIDEOS tabs on the main page. On *Sky & Telescope*'s site (*http://www.skyandtelescope.com*), click on RESOURCES & EDUCATION and

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DAS SCHEDULE

APRIL 2016

8-10	Dark Sky Weekend—EGK Dark Site & Brooks Observatory
16	Open House—DU's Historic Chamberlin Observatory—Starts at 7:30 PM
22	General Meeting at DU's Olin Hall, Rm. 105, 7:30 PM
29	E-Board Meeting—At DU's Historic Chamberlin Observatory, 7:30 PM

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

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

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

March 10 - September 30 at 8:30 PM

October 1 - March 9 at 7:30 PM

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

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

DAS NEWS

Volunteer Opportunities

April 10, 7:00AM (setup)-12PM. Tabling and, ideally, solar viewing for participants of the 7th Annual Frank Shorter RACE4Kids' Health 5K and Health Odyssey, at the 1st Bank Center in Broomfield. (For questions about the event, contact Maria Torres at (720) 326-1780, or email *mtorres@healthylearningpaths.org*.

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

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Retaining New Members: New DAS "Ambassador" Position

One of the biggest pieces of constructive criticism the DAS received on our 2015 Membership Survey was that we're not doing a great job welcoming new members into our club: We send a new "welcome" letter, but beyond that, we leave it up to each new member to proactively insert themselves into the club activities. We must do better, and we need your help to do so.

We've created a new position in the club leadership: "New Member Ambassador," and we need it filled! This is an exciting new position—the ambassador is going to be the face of the club for new members, and will be key to ensuring that new members get welcomed warmly, get introduced to the existing members of the club (especially those with similar interests), get their questions answered, get signed up for our listserv, learn how to set up a trip to the Dark Sky Site, and so forth…. Since this is a new position, the responsibilities and day-to-day tasks are really up to whoever fills it!

If you'd like to hear more about this position, or are interested in being our New Member Ambassador, please contact Jeff Tropeano: *jeff.tropeano@icloud.com*.

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Club Jackets

Dan Wray is taking orders for our black club jackets. The front has your first name embroidered on the right and Denver Astronomical Society printed on the left. The back of the jacket has the DAS logo printed on it. We are offering both a light weight jacket (essentially, a windbreaker or shell) and heavier one. It has been some time since we offered the light one.

Prices: light jacket $79, heavy jacket $95; add $4 for sizes greater than XL—jackets must be paid for in advance. **To order yours, send a check made out to "DAS" to Dan Wray, 3970 W. Dartmouth Ave., Denver, CO 80236; let him know the weight of the jacket, size, and the name to be embroidered.** Contact: Dan Wray, (303) 922-0905, *daniel_wray@comcast.net*. (Note that we need to order a minimum of 12 to get a price break, so Dan may hold the order until there are enough to make it a go.)

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30-Meter Telescope Talk

On Tuesday, April 12th, at 7 PM, Arapahoe Community College will host Dr. Warren Skidmore's talk about the Thirty Meter Telescope project, the scientific drivers for building a giant telescope, how the observatory is designed to support a range of scientific studies, and about the engineering solutions that have been developed to overcome the problems of constructing and operating a giant diffraction-limited observatory.

There is no charge, and the talk is targeted to astronomy students, professionals, and amateur astronomers. The event will be held in Room 3130 on the Main Campus, at 5900 S. Santa Fe Drive, Littleton.

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ABOUT THE DAS

Membership in the Denver Astronomical Society is open to anyone wishing to join. The DAS provides trained volunteers who host educational and public outreach events at the University of Denver's Historic Chamberlin Observatory, which the DAS helped place on the National Register of Historic Places. First light at Chamberlin in 1894 was a public night of viewing, a tradition the DAS has helped maintain since its founding in 1952.

The DAS's mission is to provide its members a forum for increasing and sharing their knowledge of astronomy, to promote astronomical education to the public, and to preserve Historic Chamberlin Observatory and its telescope in cooperation with the University of Denver. The DAS is a long-time member in good standing of the Astronomical League and the International Dark Sky Association.

The DAS is a 501 (c)(3) tax-exempt corporation and has established three tax-deductible funds: the Van Nattan-Hansen Scholarship Fund, the DAS General Fund, and the Edmund G. Kline Dark Site Fund.

*****JOIN US!** More information about DAS activities and membership benefits is available on the DAS website at *www.denverastro.org*.

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GRAVITATIONAL WAVE ASTRONOMY WILL BE THE NEXT GREAT SCIENTIFIC FRONTIER

by Ethan Siegel

NASA Space Place

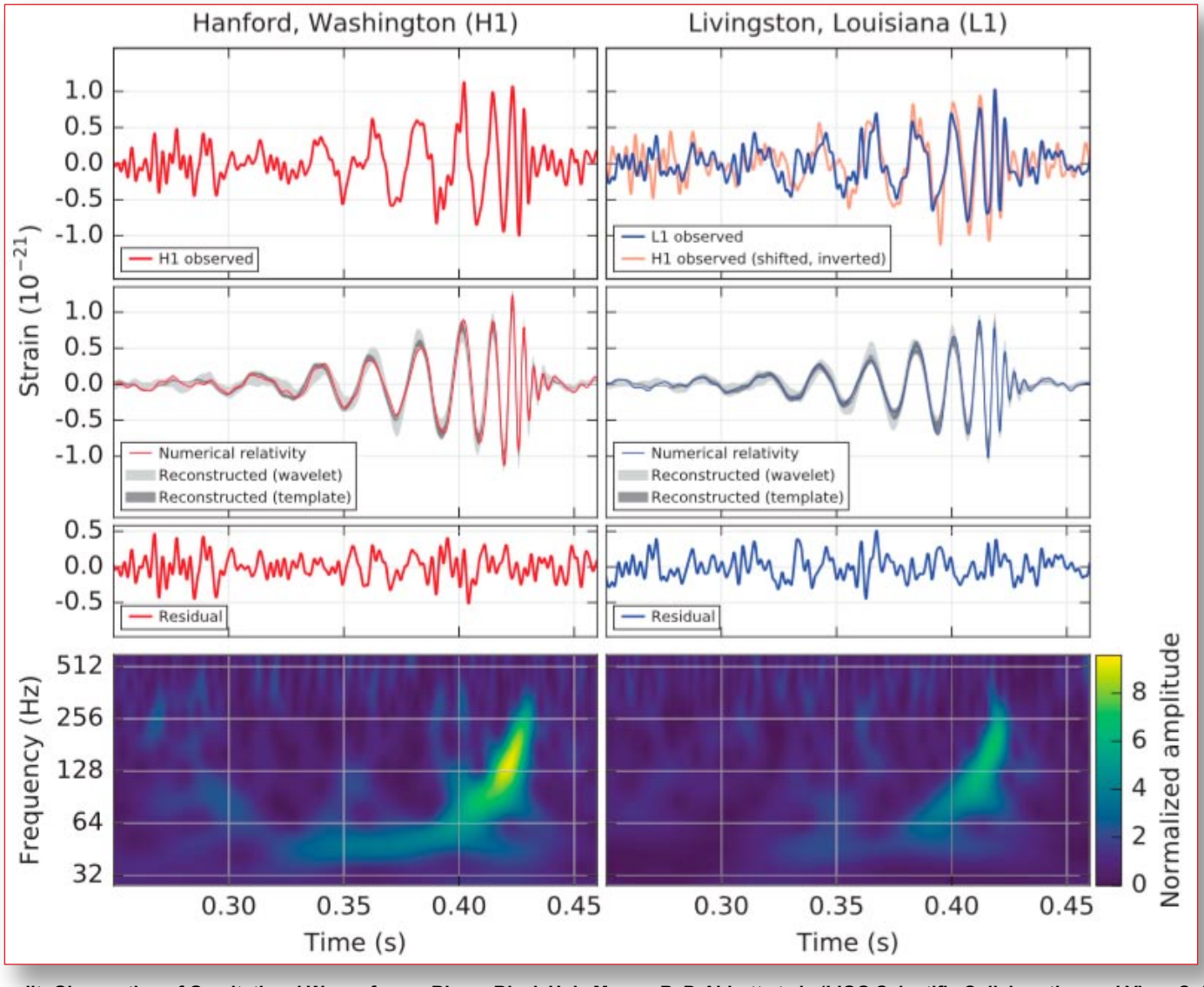

Image credit: Observation of Gravitational Waves from a Binary Black Hole Merger B. P. Abbott et al., (LIGO Scientific Collaboration and Virgo Collaboration), Physical Review Letters 116, 061102 (2016). This figure shows the data (top panels) at the Washington and Louisiana LIGO stations, the predicted signal from Einstein's theory (middle panels), and the inferred signals (bottom panels). The signals matched perfectly in both detectors.

Imagine a world very different from our own: permanently shrouded in clouds, where the sky was never seen. Never had anyone seen the Sun, the Moon, the stars or planets, until one night, a single bright object shone through. Imagine that you saw not only a bright point of light against a dark backdrop of sky, but that you could see a banded structure, a ringed system around it and perhaps even a bright satellite: a moon. That's the magnitude of what LIGO (the Laser Interferometer Gravitational-wave Observatory) saw, when it directly detected gravitational waves for the first time.

An unavoidable prediction of Einstein's General Relativity, gravitational waves emerge whenever a mass gets accelerated. For most systems—like Earth orbiting the Sun—the waves are so weak that it would take many times the age of the Universe to notice. But when very massive objects orbit at very short distances, the orbits decay noticeably and rapidly, producing potentially observable gravitational waves. Systems such as the binary pulsar PSR B1913+16 [the subtlety here is that binary pulsars may contain a single neutron star, so it's best to be specific], where two neutron stars orbit one another at very short distances, had previously shown this phenomenon of orbital decay, but gravitational waves had never been directly detected until now.

When a gravitational wave passes through an object, it simultaneously stretches and compresses space along

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President's Message

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the MULTIMEDIA tabs. The magazines are valuable resources, too. We often have free copies of back issues available at Chamberlin Observatory.

If you enjoy learning from books, there are quite a few from which to choose. Here are some of my favorites:

The Backyard Astronomer's Guide, by Terence Dickinson and Alan Dyer (Firefly Books, ISBN-13: 978-1554073443).

Turn Left at Orion: Hundreds of Night Sky Objects to See in a Home Telescope—and How to Find Them, by Guy Consolmagno and Dan M. Davis (Cambridge University Press, ISBN-13: 978-0521153973).

A Constellation Album, by P.K. Chen (Sky Publishing, ISBN-13: 978-1931559386).

For a more formal approach to learning astronomy in the greater Denver metro area, take a look at the astronomy class offerings from the likes of Arapahoe Community College, Community College of Aurora, Metropolitan State University of Denver, University of Colorado, and the University of Denver.

For those who prefer to learn in the comfort of the family room, DVD-based astronomy courses might be an option. A company called The Great Courses (*http://www.thegreatcourses.com*) sells a wide variety of video-based courses taught by well-known university professors. They have several astronomy courses available, including one that I have at home (*Understanding the Universe: An Introduction to Astronomy, 2nd Edition*, by Prof. Alex Filippenko, PhD.). Hint: Look under their sale tab for the best deals.

Ok, so how *does* one align a finder with its telescope? Here's how I do it: Attach the telescope securely to its mount and tripod, and put a low-magnification eyepiece—for example, 25 mm focal length—in the focuser (higher numbers for focal length give you *lower* power). Sight along the telescope barrel as best you can to roughly aim at a distinctive target *on the ground* at least a few hundred feet from you. (Objects in the sky are a poor choice because the Earth's rotation will cause them to move while you're trying to align the 'scope, and that can be really frustrating!) At twilight or after dark, a brightly lit business sign is a good option; during the day, look for a stop sign down the street or perhaps a chimney on a neighbor's house. (It may be necessary to adjust the focuser to bring the image into focus.) Center your target in the telescope's eyepiece—keep in mind that since the 'scope sees a narrow angle even at low power, it may take several tries to aim properly.

Next, look through the finderscope or Telrad: If the target isn't centered, adjust the finder until it is (there should be some small screws or knobs on the finderscope's mount, or on the Telrad itself). Recheck the image in the telescope eyepiece to make sure the object is still centered, and you should be good to go!

Gravitational Wave Astronomy

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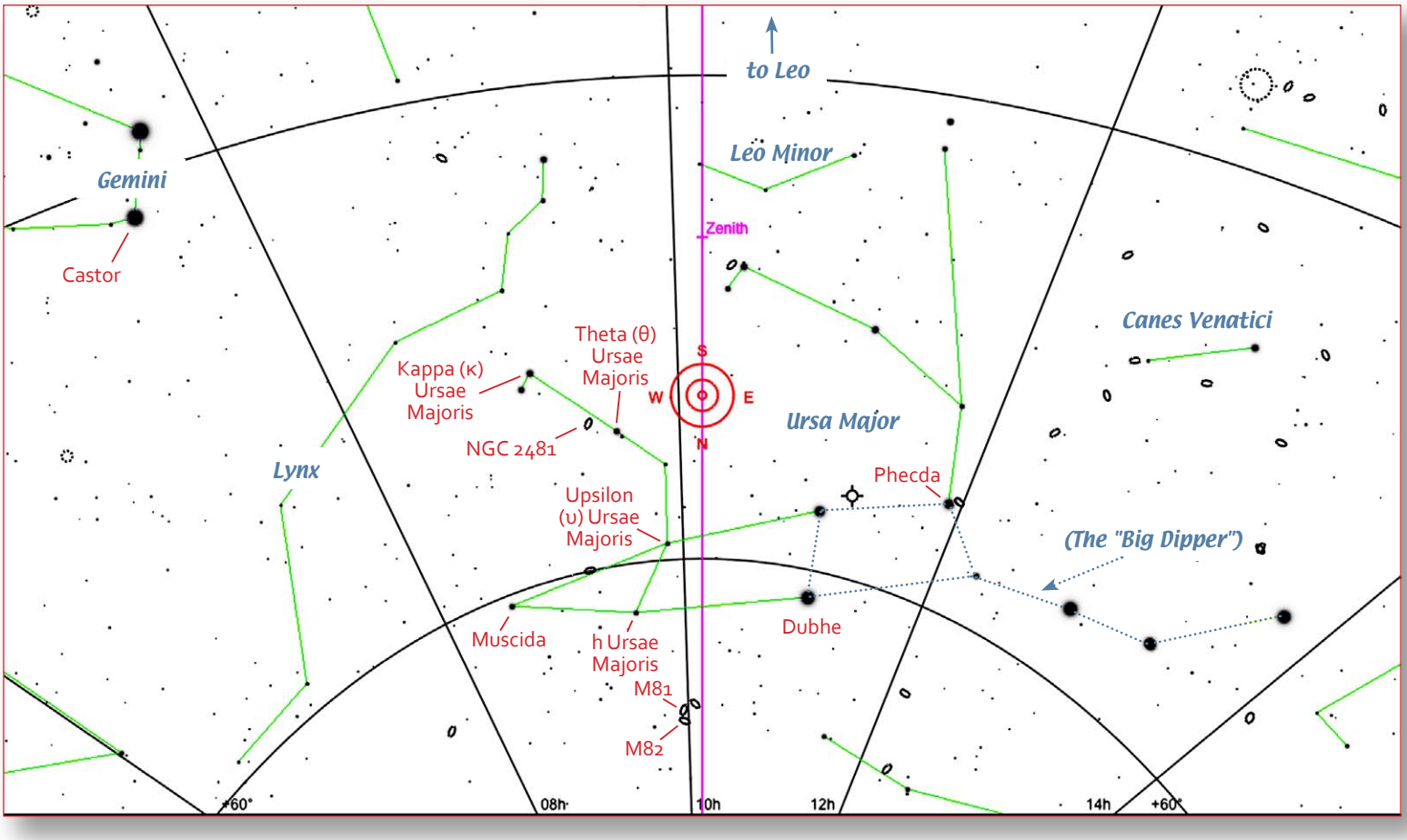
mutually perpendicular directions: first horizontally, then vertically, in an oscillating fashion. The LIGO detectors work by splitting a laser beam into perpendicular "arms," letting the beams reflect back and forth in each arm hundreds of times (for an effective path length of hundreds of km.), and then recombining them at a photodetector. The interference pattern seen there will shift, predictably, if gravitational waves pass through and change the effective path lengths of the arms. Over a span of 20 milliseconds on September 14, 2015, both LIGO detectors (in Louisiana and Washington) saw identical stretching-and-compressing patterns. From that tiny amount of data, scientists were able to conclude that two black holes, of 36 and 29 solar masses apiece, merged together, emitting 5% of their total mass into gravitational wave energy, via Einstein's $E = mc^2$.

During that event, more energy was emitted in gravitational waves than by all the stars in the observable Universe combined. The entire Earth was compressed by less than the width of a proton during this event, yet thanks to LIGO's incredible precision, we were able to detect it. At least a handful of these events are expected every year. In the future, different observatories, such as NANOGrav (which uses radiotelescopes to detect the delay caused by gravitational waves on pulsar radiation) and the space mission LISA will detect gravitational waves from supermassive black holes and many other sources. We've just seen our first event using a new type of astronomy, and can now test black holes and gravity like never before.



Looking *northward* from Denver at 9:30 PM in mid-April; deep-sky objects are plotted to mag. 10, and stars to mag. 6. Ursa Major, the Great Bear, appears upside-down when facing north at this date and time, but because the constellation appears to rotate around the north pole (near Polaris, off the chart at bottom), its orientation varies with both time of day and the season.

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

April Skies

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at just about **3:52 PM, MDT**. For observers in Fort Collins, it takes place about 30 seconds later, but to the south in Castle Rock, be ready *15 seconds earlier*. In short, as with the other occultations, don't rely on precise times, because they vary somewhat even mile by mile—in this case, because the dark limb of the Moon will approach the star in broad daylight, visual estimation of the timing will be all but impossible. Set up and be ready early.

Deep Sky

Heading out beyond the solar system this month, we have a trio of galaxies—two of which are a good bet that you've at least heard of, even if you haven't seen them. The third is rather less well-known, even by the advanced folks; it should be of interest, though, to all observers. Before that, we'll take a quick moment to catch up the new folks on the constellation, Ursa Major, or the Great Bear.

Most folks are probably more familiar with the Big Dipper, whose famous handle and scoop are easily found in the northern sky. Apart from the simplicity of the Dipper's outline (it really does look like a giant spoon!), another reason the Dipper is better known than the full constellation is that nearly all of the Dipper is *circumpolar*. That is, at our latitude and further north, the Dipper never actually sets—though it may sometimes be low at the northern horizon, it's always visible once the skies get dark (and actually, its stars are up above the horizon even during the daytime). The larger Great Bear extends further south; it therefore rises and sets, and is only visible at certain times of year (although for more of it at our latitude than a very southern constellation like Scorpius). For some perspective on this, Xi Ursae Majoris, the bear's rear foot, is actually a little farther south than Castor, the alpha star of the constellation Gemini.

To become familiar with Ursa Major, or the Great Bear, start by finding the Dipper—when you see the Dipper "right-side up" (so the would-be contents of its bowl wouldn't spill out, and the handle is to your left), its bowl can also be imagined as the bear's rear haunches, and the handle as the bear's tail. Extending the lines of the top and bottom of the bowl about another bowl's distance westward, you'll find another pair of stars, h and Upsilon (υ) Ursae Majoris, that make up the bear's shoulder; west of that, the bear's outline tapers to its "nose," marked by Muscida, or Omicron (o) Ursae Majoris.

Once you're familiar with the appearance

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April Skies

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of the bear's body, both on maps and in the sky, you'll find the bright stars in the bear's legs easy to find, since the body will give you the scale of it all—don't worry about memorizing them all; just relax and become familiar with them little by little as you look for objects of interest in their area….

Before we get going, then, one last note about Ursa Major on our map: When you look at the constellation on most sky maps, it sits "right side up," with the bear's feet below it, just north or "above" the constellation Leo, the Lion. On our map for this month, though, you'll see the bear "upside down," with its feet sticking up above it—the reason for this is that the constellation is actually north of the zenith (the straight-up point in the sky), so it will be easier to look at it if you turn around and face north to see it, instead of looking southward as we usually do. When you make your 180° "about-face" to the north, the stars there will rotate as you do, and you'll see them upside down.

The constellation also appears to rotate roughly around the North Star, Polaris, according to the time of day. Since it makes one complete revolution in about 24 hours, you'll see it shift 90° counterclockwise (when you're looking north) in 6 hours—the "upside-down" bear of 9:30 PM becomes a "vertical, nose-down/tail-up" bear in the northwest at 3:30 AM.

This mosaic image of the magnificent starburst galaxy, Messier 82 (M82) is the sharpest wide-angle view ever obtained of M82. It is a galaxy remarkable for its webs of shredded clouds and flame-like plumes of glowing hydrogen blasting out from its central regions where young stars are being born 10 times faster than they are inside in our Milky Way Galaxy.

Image: NASA, ESA and the Hubble Heritage Team STScI/AURA). Acknowledgment: J. Gallagher (University of Wisconsin), M. Mountain (STScI) and P. Puxley (NSF).

First up, then, is **M81**, at **9h 56m, +68° 59'**. This large, magnitude 6.9 spiral galaxy lies relatively close-by at an estimated distance of 12 million light-years. It's big and bright enough to be visible in all telescopes, and in binoculars, too. The inner region will be seen with careful observation in a 4-inch refractor or a 6-inch reflector, but the spiral arms might remain challenging even in large instruments. M81 forms the center of a group of galaxies including nearby M82 (mentioned below), with which it has interacted, and a number of others, like **NGC 3077** (46' to the east-northeast, at **10h 5m, +68° 39'**).

M82, at **9h 57m, +69° 36'**, floats just $^{2}/_{3}$° north of M81 from our point of view, a span that works out to about 150,000 light-years in space. This galaxy's high surface brightness makes it possible to see some structure even with a 6-inch 'scope out in the country; dust lanes are also moderately visible in my 12-inch from southern Denver on a decent night.

Previously thought to be an irregular galaxy like the Magellanic Clouds, M82 is now known to be a spiral—but whose structure and inner workings were greatly altered by interaction with M81 in the past. It has prominent dust lanes and intense starburst activity in its center, which is pretty unusual in a galaxy like this. It's also thought that a large number of supernovae are the cause of a high-speed wind blowing gas and dust outward from this area; the results show clearly in Hubble telescope images.

To find M81 and 82, follow the imaginary diagonal running roughly northwest between Phecda and Dubhe, two of the four stars making up the bowl of the Big Dipper. These two stars lie about 10½° apart; continuing in the same direction, for nearly the same distance will bring you to M81—the galaxy should appear in a finderscope. You can also "overshoot" about 1½° to d Ursae Majoris, a 4.6-magnitude star lying on the opposite side of M81 from Dubhe; placing the former star near the northwest edge of the finderscope should put M81 near its center.

Unlike M81 and M82, which are well-

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April Skies

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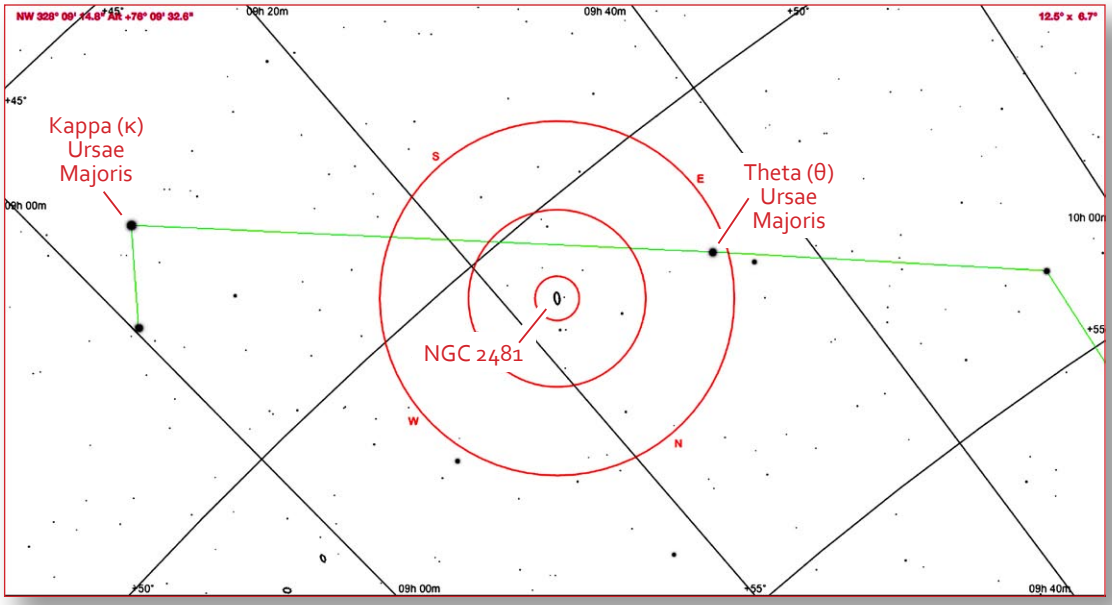
known, but far from bright "landmark" stars, **NGC 2841**, at **9h 23m, +50° 54'**, lies between 3rd-magnitude stars Theta (θ) and Kappa (ϰ) Ursae Majoris (the latter also known as Talitha Australis), near the Great Bear's front foot. A large spiral galaxy, about 150,000 light-years across, it's about half-again larger than the diameter of our own Milky Way.

Measurements of the galaxy's Cepheid variables by the Hubble Telescope suggest a distance of about 46 million light-years, or roughly double that of the more familiar Whirlpool Galaxy, M51. In spite of this large distance, NGC 2841 remains quite bright at mag. 9.2, and its inner area is easily seen in a 6-inch 'scope at about 100X; an 8-inch in good skies may begin to show detail in outlying regions.



Close-up chart for centering NGC 2481 with a Telrad. Note Theta (θ) Ursae Majoris near east-northeast edge of 4° circle, and position of imaginary line between Theta and Kappa (κ) Ursae Majoris relative to the inner and middle Telrad circles.

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

To find and center this galaxy, place Theta Ursae Majoris near the outer (4°) ring of your Telrad, towards the east-northeast. A line between Theta and Kappa should then run about halfway between the Telrad's inner (½°) and middle (2°) circles—*see the close-up chart*.

—See you next month.

The Denver Astronomical Society
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