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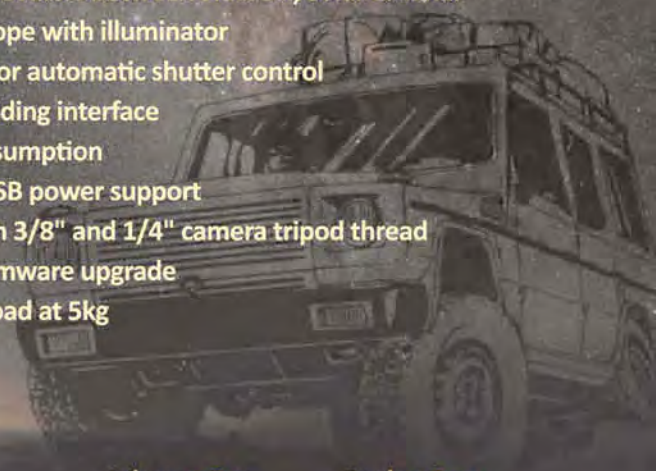
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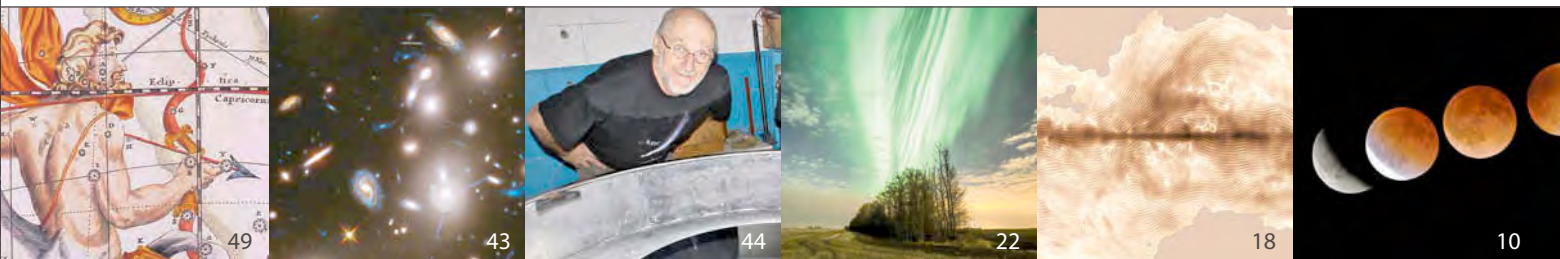
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COVER: Invisible visually in telescopes, the Elephant's Trunk Nebula (IC 1396), in Cepheus, is a favourite target for today's astro-imagers. The nebula is about 3,000 light-years distant. COURTESY NOAO/AURA

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Summer Stargazing: Embracing the Best Nights

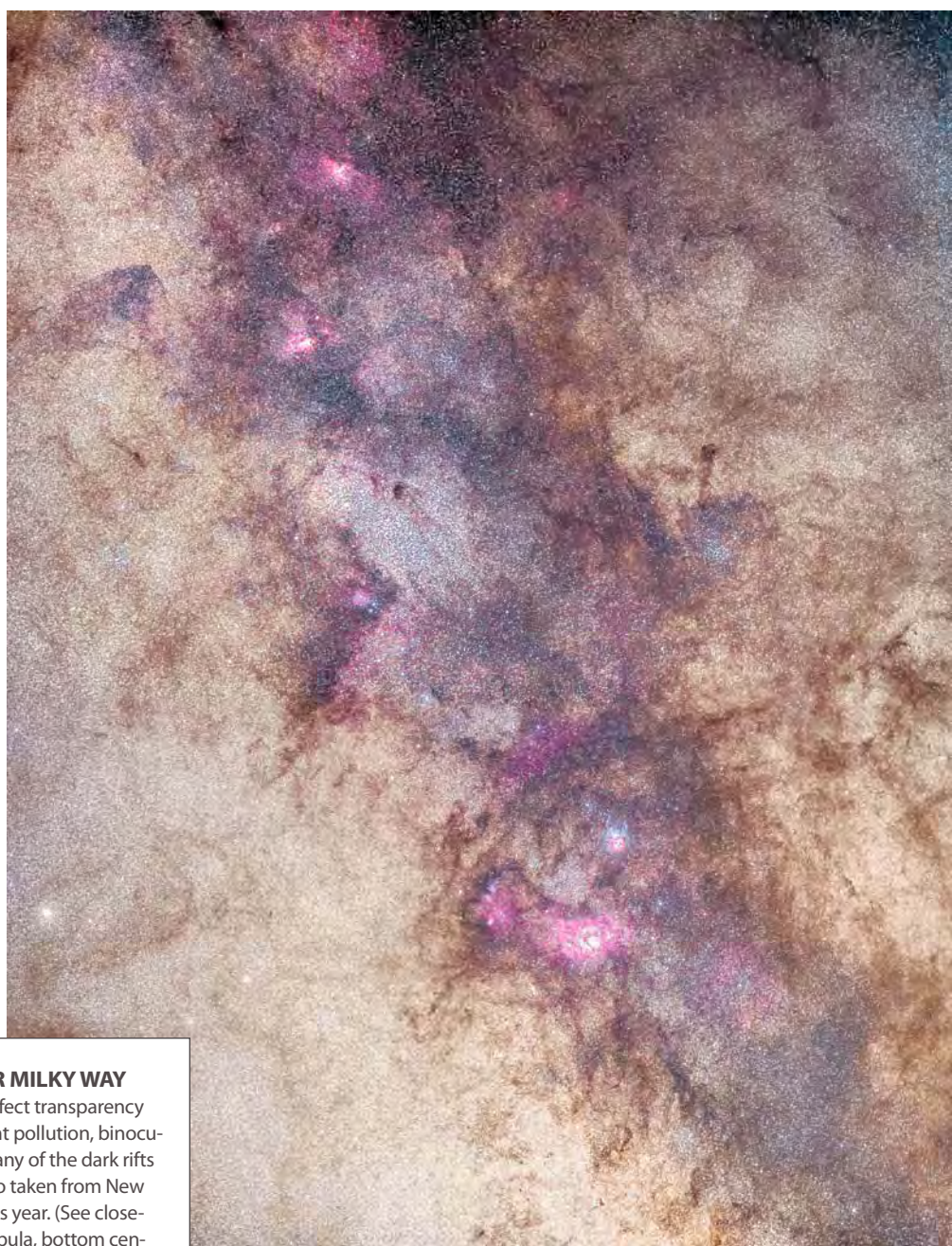
Drifting among the Milky Way's star clouds with binoculars can be addictive on the right night

ONE of the many surprises awaiting the unsuspecting novice stargazer is the discovery that all nights are not equal, even though the sky may appear to be clear of clouds. Experienced skywatchers soon become aware of two variables that backyard astronomers refer to as transparency and seeing.

Transparency is the clarity of the air above you, the observer. There's more to it than clouds or no clouds. A fine summer day with low relative humidity is signalled by a deep blue sky that, in turn, is often followed by a cool, clear night. Away from sources of light pollution, the Milky Way should be distinctly visible on such nights. Under the best conditions of excellent transparency, the Milky Way has a textured appearance to the naked eye, with obvious dark rifts. Sixth-magnitude stars should be visible less than five degrees from the horizon, and binoculars will reveal stars right down to the true horizon.

That's the ideal, of course, but no matter where your observing site is, watch for low-humidity and cooler-than-average summer nights. Under average- or high-humidity conditions, the daytime sky takes on a milky appearance, particularly immediately around the Sun (which you can gauge most easily by using a building or another obstacle to block the Sun). So by late afternoon, you have a fairly good idea what to expect at night.

The other night-sky factor—seeing—is quite different, but beginners often confuse the two. Seeing refers to the condition of the Earth's atmosphere above the observer as seen through a telescope. Steady air that



RICH SUMMER MILKY WAY

On a night of perfect transparency with minimal light pollution, binoculars will reveal many of the dark rifts seen in this photo taken from New Mexico earlier this year. (See close-up of Lagoon Nebula, bottom centre, on page 21.) PHOTO BY ALAN DYER

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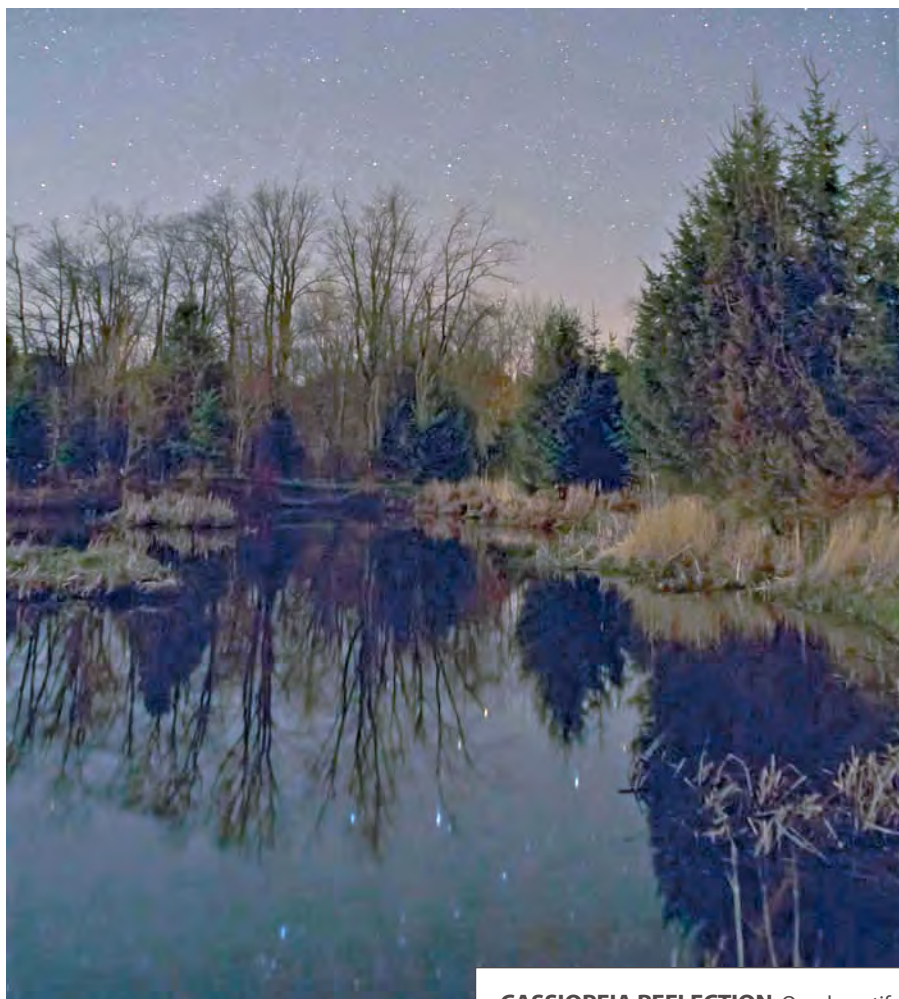
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CASSIOPEIA REFLECTION On a beautiful late-spring evening, the W-shaped constellation was looking more distinctive in this tranquil pond than in the real sky. Lynn Hilborn of Grafton, Ontario, used a Canon 6D with a 24mm f/2.8 lens for this 25 second exposure that sets the mood for summer stargazing.

allows fine telescopic definition of planetary and stellar detail is prized by experienced observers. A hazy night with poor transparency can have excellent seeing—or not. More about this in a future column in this space.

JUPITER'S SHRINKING RED SPOT

There is now no doubt about it: Jupiter's long-lived Great Red Spot is shrinking—and the shrinking is accelerating. The downsizing, which is slowly changing the shape of the spot from oval to round, has been observed since the 1930s but has become obvious only in the past few decades.

Recent Hubble Space Telescope images clearly reveal size changes during less than a decade as the spot has reached the smallest size ever observed. The full-disc image of Jupiter shown on the facing page was taken on April 21 with Hubble's Wide Field Camera 3. It reveals more detail than can be achieved by any telescope operating on the Earth's surface.

The Great Red Spot is a churning anticyclonic storm that rotates in a counter-

clockwise direction in Jupiter's southern hemisphere. Winds inside the Jovian storm rage at immense speeds of up to several hundred kilometres per hour. The spot has appeared in images of the giant planet almost since the invention of photography and in astronomers' sketches of the planet before that. At times, the spot has been the most conspicuous feature on the planet.

That was the case in the early 1980s when I remember setting up a 75mm refractor for my astronomy students and having every one of them see it—an obvious deep rusty "eye" embedded between two sandy brown cloud belts. It was easy to imagine why the spot was once thought to be a permanent feature of the giant planet. But that idea was abandoned by the early 1960s, when astronomers began to pay more attention to the features of our plan-

etary neighbours as they became potential targets for robotic spacecraft.

Historical observations from the late 1800s gauged Jupiter's turbulent spot to be about 41,000 kilometres at its widest point—wide enough to accommodate three Earths comfortably within it side by side. In 1979 and 1980, NASA's Voyager spacecraft measured the spot at a shrunken 23,200 kilometres across. Now Hubble is watching the Great Red Spot shrink to its smallest dimensions yet.

"Recent Hubble Space Telescope observations confirm that the spot is now just under 16,500 kilometres across, the smallest diameter we've ever measured," says researcher Amy Simon of NASA's Goddard Space Flight Center in Maryland.

Amateur astronomers, who are able to make Jupiter observations more frequently than Hubble's busy schedule allows, have

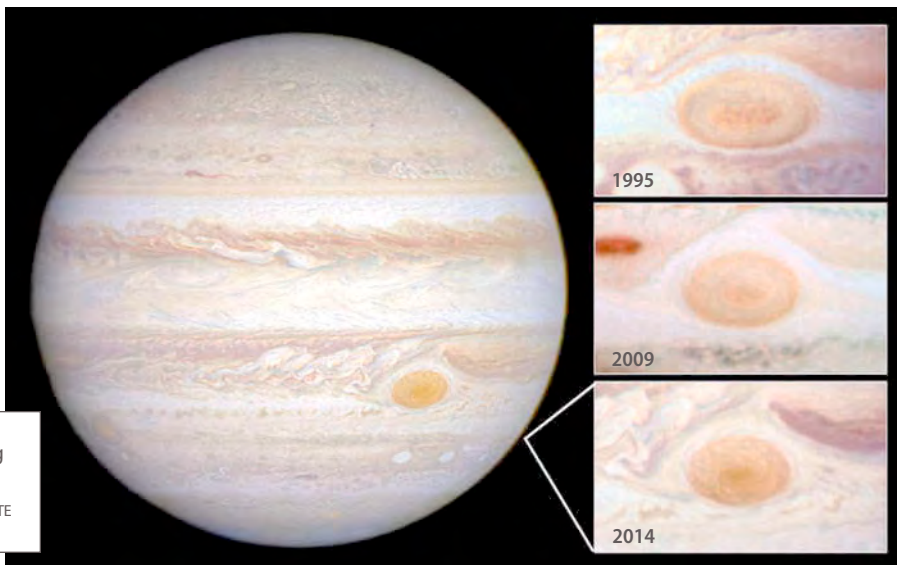
noticed a definite acceleration in the Great Red Spot's shrinkage rate. The spot's "waist-line" is getting smaller by slightly under 1,000 kilometres per year. The cause of this shrinkage is not yet known.

"In our new Hubble observations, it is apparent that very small eddies are feeding into the storm," says Simon. "We hypothe-

size that these eddies may be responsible for the accelerated change by altering the internal dynamics of the Great Red Spot."

Simon's team is planning to study the motions of these eddies as well as the internal dynamics of the spot to determine how the stormy vortex is fed with or sapped of momentum. ♦

JOVIAN BELTS AND RED SPOT The amazing shrinking Great Red Spot has visibly contracted over the past decade. SPACE TELESCOPE SCIENCE INSTITUTE



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AURORA & SCOPE

I was pleasantly surprised by this nice aurora one evening last autumn. The scene was shot on October 8 from about six kilometres south of Sydenham, Ontario (north of Kingston). Camera settings: Canon T3i at ISO 1600, 20-second exposure, using an 18mm lens.

*Gregory Himmelman
Sydenham, Ontario*



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OCCULTATION OF REGULUS

Was the exceptionally rare occultation of Regulus by the asteroid Erigone on March 20 observed anywhere at all? It was completely cloudy for me and apparently everyone else in Canada and the United States in the occultation visibility path that ran from New York City all the way past Cochrane, Ontario (*SkyNews*, March/April, page 34). The path also went over the west end of Bermuda and up into Nunavut and the High Arctic. Seems a real shame that an event of this rarity would go unobserved everywhere. And I was so ready.

And therein lies the problem. Experience has shown me that the likelihood of clouds increases directly in proportion to the amount of planning one puts into observing a rare celestial event. Therefore,

I have decided not to plan anything special at all for the total eclipse of the Sun on April 8, 2024, because my observatory is inside the path of totality. But I am keeping quiet about it!

Mark Kaye
Sydenham, Ontario

SUBMITTING LETTERS AND PHOTOS TO THE EDITOR

SkyNews editor Terence Dickinson welcomes your letters about your astronomical observing activities and your comments about anything you read in the magazine. Submission of photos as attachments is encouraged (please include details of location and equipment used). Photos should be in jpeg format up to 2MB file size; limit two pictures per submission. Send to: editor@skynews.ca

OBSERVING IN OZ

During recent travels in Australia, I connected with local groups of astronomers to learn about observing sites and astronomy events. In northern Queensland, the Townsville Astronomy Group (TAG) invited me to a monthly dark sky observing session west of Townsville on May 3. The sky conditions were perfect that night, and although the lights of the campground are evident in this photo, the sky is quite dark and the Large Magellanic Cloud, a satellite galaxy of the Milky Way, is easily visible just above the group at right. Pictured here are some members of TAG holding a copy of *SkyNews* that I presented to them as a Canadian astronomy gift. It is nice to know that no matter where we go in the world, there are astronomy enthusiasts with similar interests.

Rick Stankiewicz
Peterborough, Ontario



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APRIL'S LUNAR ECLIPSE

On the night of April 14/15, the full Moon plunged through the Earth's shadow, producing a total lunar eclipse. Most of Canada was cloudy that night, but Toronto astrophotographer Michael Watson was determined to capture the event—and he did.

WORTH THE CHASE It was a long drive from Toronto to Ottawa—Ottawa, Illinois, in this case—to get out from under a massive cloud deck covering northeastern North America on eclipse night. But once out, Michael Watson knew from long experience that the cool, dry midwestern night air would reveal crisp detail during the best total eclipse of the Moon for Canada or the United States since 2007. The entire event—over three hours long—is displayed in the upper sequence. From right to left, the full Moon moves into the Earth's shadow, becomes fully immersed, then emerges from the shadow.





FULLY ECLIPSED MOON

Using a 6-inch f/8 Explore Scientific apochromatic refractor, Michael Watson was able to record the delicate coppery shading caused by the Earth's shadow at the midpoint of the total eclipse. When in full shadow, the full Moon is reduced to less than one ten-thousandth its normal brightness. The coppery colour is caused by the red component of sunlight being refracted by the Earth's atmosphere—in effect, it's the combined light from all the sunsets around the circumference of our planet.

DSLR

Planetary Imaging:

A TUTORIAL

With equipment you already own, you can create planetary images that were only dreamed of two decades ago *Article and photography by Art Cole*

THE ADVENT OF DSLR TECHNOLOGY has revolutionized amateur astrophotography to the extent that anyone with even modest equipment can take astronomical images that easily surpass those taken by professional astronomers in large observatories as little as 15 years ago. Nowhere is this revolution more apparent than in the field of planetary astrophotography, where digital camera technology combined with computer processing is used to create exquisite planetary images.

But how is this possible? How does digital technology make such a difference? Before we discuss this, it's necessary to look at the underlying problem that plagues planetary astrophotographers: using high-magnification imaging to capture tiny plan-

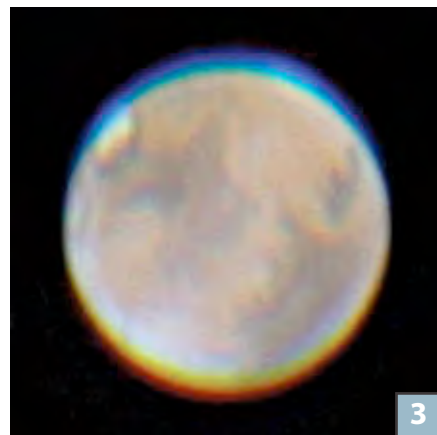
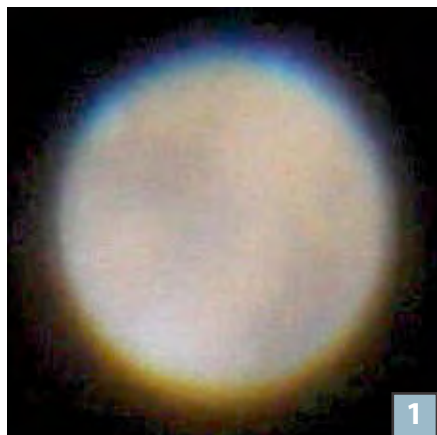
etary details through the Earth's ever turbulent atmosphere. The degree to which the atmosphere degrades our view of space objects is called "seeing" by astronomers (the scientific term is scintillation). On an exceptional night of excellent seeing, planetary views can be astonishingly crisp and clear. But when the seeing is average or poor, planetary discs change shape, look fuzzy and dance around in both the eyepiece and the camera. This makes it difficult or impossible to see fine detail. Even on a good night, seeing varies from instant to instant, causing views of planets to quickly transition back and forth between moments of sharpness and blurriness.

Digital imaging allows us to compensate for this effect by capturing thousands of individual video frames over a long time period, discarding the frames that are blurred due to seeing effects and combining the remaining good frames through averaging. This process, called "lucky imaging," not only greatly reduces the effects of turbulence but increases the signal-to-noise ratio of the final

image, resulting in sharp details and high contrast. In the past, when film was used for planetary photography, this technique was impractical. Although it was tried as early as the 1950s, the process of manually sorting through hundreds of film frames and optically combining the best ones was tedious and time-consuming.

Fortunately, for those of us who have access to a decent telescope, a DSLR camera and a computer, the tools and techniques for pro-

MARS: THE MAGIC BEGINS At the time this image was acquired, Mars was near its recent opposition in mid-April and 15 arc seconds in apparent diameter. 1: A single frame from a video of Mars. 2: The result of stacking 25 percent of the highest-quality frames from the video. 3: The stacked image after initial sharpening. 4: The sharpened image after alignment of the red, green and blue colour channels. 5: The image after final sharpening, colour adjustment and histogram adjustment. 6: Size reduction provides a subtle enhancement of detail.



cessing in the digital domain are available, low-cost and mature. By following the steps discussed here, you can create your own high-quality planetary images that will astound your friends and colleagues—and maybe even you.

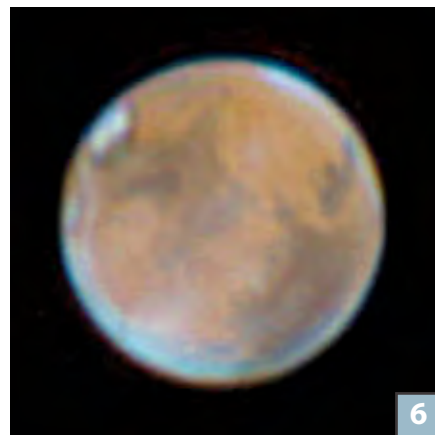
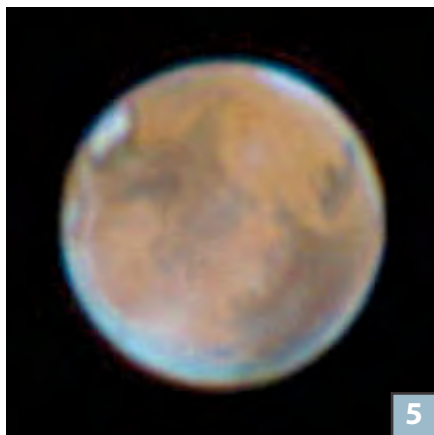
OUTDOORS

There are a few prerequisites to use your DSLR camera for planetary imaging. First, you need a telescope on a tracking mount so that you can capture several minutes of video at a time, and you need a DSLR camera with video capability and a way to connect the camera to your telescope. I also suggest using a remote shutter release to allow you to start and stop your video capture without touching the scope. There are two basic methods to attach the DSLR to the scope. With a standard nosepiece adapter, you can place the camera image sensor at the telescope's prime focus, while an eyepiece projection adapter allows you to use an eyepiece to enlarge the planetary disc and project it onto the camera sensor. As my telescope provides a long focal length, I use the former method, along with a 3x Barlow lens to increase my focal length to 6000mm. If you have a shorter focal length, I would advise using the eyepiece-projection method. Any telescope dealer in Canada should have the necessary components in stock.

Some things have not changed over time, however. If you want crisp, clear detail, then you must wait for a night of good seeing.

But seeing aside, there are a few other important things that must be addressed. First, you have to let the telescope equalize to the ambient temperature, which can take up to an hour or more. This minimizes air convection currents inside the telescope (often called “tube currents” by amateur astronomers), which can be as detrimental to your imaging as is the poor seeing caused by the Earth's atmosphere. In addition, temperature equalization helps to prevent the telescope tube from thermal expansion and contraction, which will affect the focus by altering the focal length. You must also ensure that the telescope is well collimated (meaning that the optics are aligned), and lastly, before doing any imaging, the focus must be set as precisely as possible. Focusing should be done using a star, not the planet itself, and with the camera already installed. To achieve perfect focus without any guesswork, I recommend using a focusing mask (I use a Bahtinov mask; Google this for more information).

PLANETARY IMAGING SETUP Author's equipment: an 8-inch Schmidt-Cassegrain with a 3x Barlow lens and a Canon T3i DSLR.





DETAIL-ORIENTED Above: From left to right, Jupiter and its moons Io and Ganymede. Below: From left to right, Ganymede, Io and Jupiter. These examples display cloud-structure detail that eludes visual detection except on rare nights of exceptionally good seeing, which is precisely the power of the imaging techniques described in this article.



YOUR DSLR

Assuming that all your optics are in order, you will have to enable some crucial settings in your DSLR to provide the best possible video. First, this caveat. Although numerous DSLRs made since 2009 have video capabilities, the ones that work well for planetary imaging are the following Canon camera models: T3i, T2i, 60D and 70D. These are among Canon's most popular DSLRs.

Choose a video mode that gives a 1:1 relationship between the pixels on the camera sensor and the pixels in the recorded video, or as close to 1:1 as possible (a lot of DSLRs won't do an exact 1:1 but have settings that come close). There are two reasons for doing this. The first is to prevent the camera from mathematically combining the data from the sensor pixels to create the pixel information in the video, which will cause a significant loss of image information in the video recording. The second reason is to make the planetary disc larger in the video and to get rid of all the useless black space that would otherwise take up most of the frames.

Consider the hypothetical situation in which a DSLR camera has an image-sensor size of 5760 x 3240 pixels (I've made up

this value, but it's representative of reality) and the video mode has been set to high-definition video, which is 1920 x 1080 pixels. The camera creates each pixel in the video by combining the data from the image sensor's corresponding 3 x 3 pixel grid. So even before you make it indoors, you have already reduced your planet information by eight-ninths, and you cannot recover this lost information through processing.

On my camera, I use the HD video mode along with the 3x digital zoom. Although it may sound counterintuitive, the digital zoom in video mode actually preserves data by preventing the camera from combining the sensor pixel information. Depending on the DSLR model, there are various ways to reduce or eliminate pixel combining, including using the digital zoom, zooming the LCD display view and recording it as a video on a laptop or, perhaps the best way of all, using the "video crop" mode, if the camera has it, which creates a video directly from the raw pixels at the centre of the camera sensor. There is software for this, in particular BackyardEOS (backyardeos.binaryrivers.com/default.aspx).

Once your video mode is set properly, you'll need to set the

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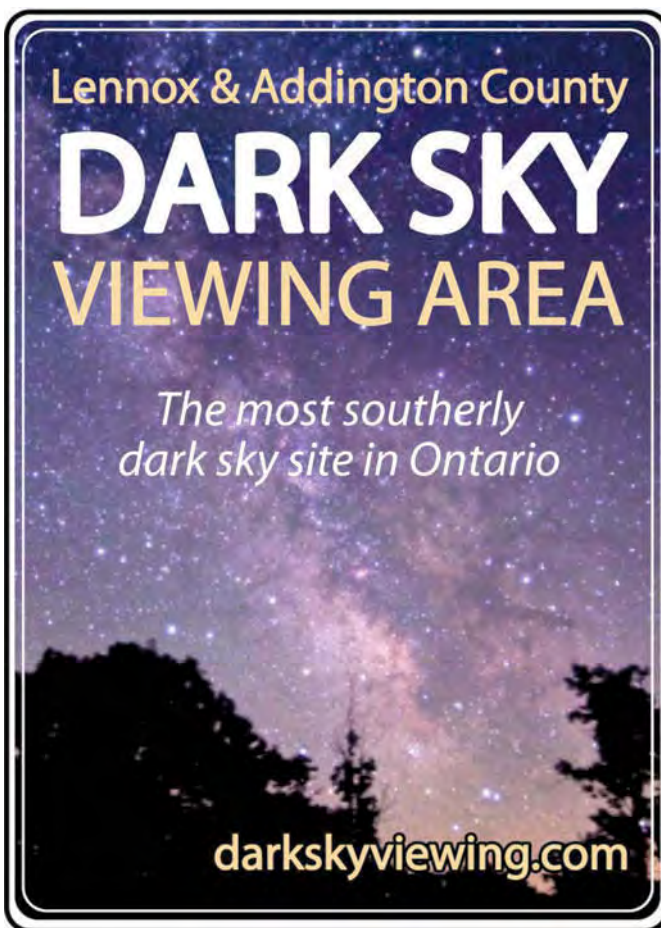
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GIVE ME A RING This Saturn image displays subtle cloud belts on the planet itself as well as the A, B and C rings and Cassini's division in the famous ring structure.

frame rate, exposure time and ISO setting. Because we are trying to capture fleeting glimpses of planets during moments of good seeing, we want to keep the exposure times low and the frame rates high. I run my DSLR at 30 frames per second with a 1/30-second exposure time (usually the default setting) and vary the ISO to give me a reasonably bright image. I typically use ISO 800 to ISO 3200. Do not overexpose the planet while capturing video, as the brighter areas will get clipped to the maximum brightness value and that lost information will be unrecoverable.

INDOORS

Indoors is where the real magic happens. This is where you take a grainy, blurry-looking video and turn it into something memorable. Planetary digital processing has a lot of individual steps, but they can be sorted into three main categories:

1. Selecting the best frames based on quality
2. Aligning, stacking and combining the best frames
3. Postprocessing the resulting combined image

Once you have copied the video onto your computer, you will need to convert it into a format that is compatible with your favourite processing software. The converted video can then be processed with software that examines each frame and determines its quality based on the image sharpness. At this point, you can specify what percentage of the best frames you want to keep for subsequent processing. This is the stage where you are reducing the effects of momentary poor seeing by discarding frames captured when the atmosphere was at its most turbulent. The percentage of frames you keep will depend on the seeing at the time. I generally retain the best 25 percent of the frames, but if the seeing was exceptional, I sometimes retain up to 50 percent.

Now that you have a nice set of good frames, you can move on to stacking. Again, software is used to process the video, but this time, each frame is examined to determine where the planetary disc is located so that the frames can be stacked and aligned, much like stacking pancakes evenly on a plate. After stacking the frames, the software combines them, usually by averaging, which drastically boosts the signal-to-noise ratio and produces a single-image file instead of a video.

At this point, your single image has been processed to reduce the effects of poor seeing and has been noise-reduced by combin-

ing hundreds, if not thousands, of video frames. This image is loaded with information, but we're not done yet—there is still some digital trickery that will get more out of your data. On to postprocessing.

The last major step in this fine-tuning process is to sharpen the image, and it is the result of this step that usually evokes the most oohs and aahs. Sharpening transforms a nice, smooth-looking planetary photo into an image like the ones you see in books and magazines. Various algorithms are available to sharpen the image, but perhaps the most common is wavelet sharpening. Sharpening brings out the fine details in the image, and sharpening tools commonly provide a multiresolution capability, so you can specify the amount of sharpening to apply to features of different sizes.

After sharpening, a number of cosmetic—but very important—effects should be applied. In rough order of application, they are: RGB alignment, to get rid of the red and blue fringes on the image; histogram adjustment, to brighten the overall image and/or redistribute the histogram curve; fine sharpening, to bring out additional detail; saturation adjustment, to boost the colour in the image and make it more vibrant; and size reduction (this one is optional). While you may be reluctant to reduce the size of your beautiful planetary image, reducing it to 50 percent of its original size will further reduce noise and make it appear much sharper. And remember, there is a limited amount of useful information available in your image, so if you are too aggressive in your sharpening or colour adjustment, you will wind up with an unnatural-looking result. Moderation is the key.

A wide variety of free and paid software is available to accomplish all these tasks. Some of the more popular free packages include VirtualDub (video file conversion), RegiStax (quality estimation, stacking, sharpening, some postprocessing), AutoStakkert! (quality estimation, stacking), PIPP (file conversion, quality estimation, initial frame alignment) and GIMP (postprocessing). These can be used together to create high-quality planetary images from video. There are also a number of highly capable commercial software packages that can be used to carry out this process from beginning to end. I use a combination of free and paid software, as it gives me very fine control over each processing stage, along with a rich feature set.

I hope this quick tutorial has given you a better understanding of the planetary imaging process and will help you to create fantastic images that you can be proud of using equipment you already own. The process can be a bit daunting at first, but with a little practise, it becomes much easier and your results will keep getting better and better. It's worth the effort—the Earth's neighbour planets are amazing and dynamic and are out there just waiting to be in your video. ♦

To pursue this subject further, see A Guide to DSLR Planetary Imaging by Jerry Lodriguss, an e-book available at www.astropix.com.

Art Cole is an amateur astronomer, an RASC member and an electrical engineer from Hammonds Plains, Nova Scotia, with a background in spacecraft systems, signal processing and digital communications.

A Cosmic Secret Revealed

Peering closer to the instant of the Big Bang—a major advance in cosmology

IN APRIL 2013, when a team of cosmologists met in Cambridge, Massachusetts, to discuss an exciting new research finding, the city was in chaos. It was the week of the Boston Marathon bombing, and on the streets and alleys surrounding the hotel where the scientific gathering was under way, a dramatic manhunt was unfolding.

“Day one of the meeting was ordinary. On day two, people were not allowed to leave their hotel rooms,” recalls Mark Halpern, an experimental cosmologist at the University of British Columbia (UBC). “We were right in the thick of it.”

While sirens blared and the city went into lockdown, the researchers occupied themselves with a different matter: how to keep a spectacular scientific find from becoming public prematurely. The team was sitting on what looked to be a Nobel Prize-worthy discovery that no one wanted to reveal without being absolutely sure it was right.

The discovery came from the second run of the Background Imaging of Cosmic Extragalactic Polarization experiment, better known as BICEP2. If correct, it showed clear evidence of primordial gravitational waves—powerful ripples propagating through space-time that were unleashed less than one trillionth-trillionth-trillionth of a second after the universe began.

The finding effectively put cosmologists on the very threshold of the Big Bang. But when the BICEP2 team first became aware of it, no one was celebrating, says Halpern. “Our reaction was that we must be doing something wrong to get such a big signal.”

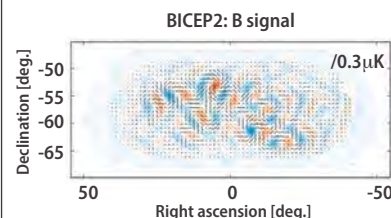
BICEP2 was built to probe the cosmic microwave background, a distant glow emitted when the universe was only 380,000 years old and light was first able to travel freely across space. It is the earliest moment in cosmic history that we can

observe directly. But like a frost-covered window, it conceals whatever lies beyond at still earlier times.

The observations took place near the South Pole, where the cold, dry air is best for microwave astronomy. BICEP2 imaged a portion of the cosmic background through the microwave equivalent of polarized sunglasses. That yielded a telltale pattern, like frozen swirls on the frost-covered window.

According to the BICEP2 team, the best

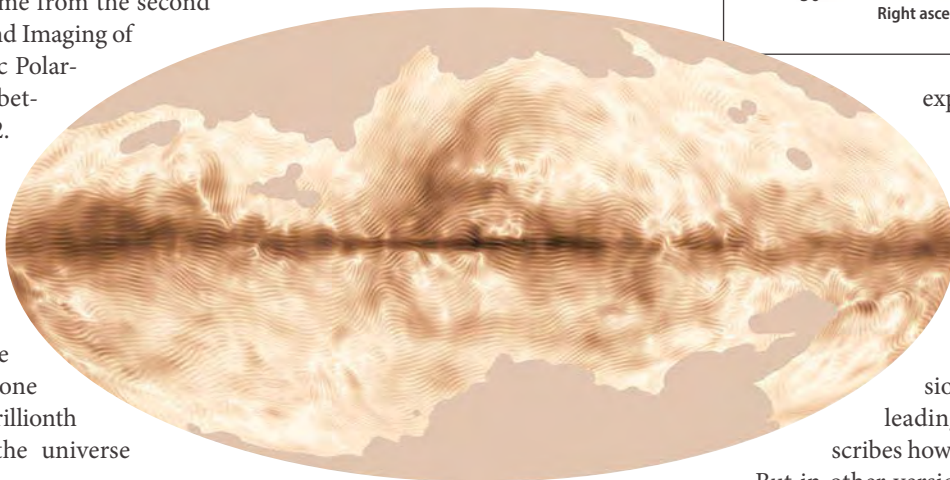
SMOKY AND SWIRLY A Planck satellite image of polarized microwaves from the Milky Way (below left) illustrates the influence of the galaxy’s magnetic field on interstellar dust. After subtracting this signal, Planck will look for a more distant background pattern of polarized microwaves from the early universe that could be due to gravitational waves, as reported in March by the BICEP2 experiment (below).



explanation for this result is that gravitational waves from the very early universe left their mark on the cosmic background. This is predicted by the simplest versions of inflation, the leading theory that describes how the universe began.

But in other versions of inflation, the gravitational waves are too weak to leave a discernible trace.

In planning the experiment, the BICEP2 team had to take a calculated risk. It was not clear how strong the gravitational wave signal might be or whether it would be there at all. An experiment capable of exploring a wider range of possibilities would take longer to develop. By aiming for the most obvious kind of signal (though not necessarily the most likely), BICEP2 was first out of the gate among its competitors.



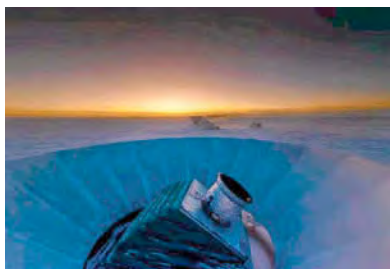
Along the way, the experiment was aided by two leaps in technology. The first allowed sensitive detector elements that were formerly built by hand one at a time to be produced in an array. The second was a breakthrough in signal amplification involving superconductors. Halpern and his group at UBC developed BICEP2's readout electronics—the part of the hardware that moves and organizes data from the detector array so that they can be analyzed.

Once the data were in, Halpern was part of the inner circle that had to assess whether the experiment had behaved correctly during its two-year run. The diligence paid off. When the BICEP2 find was published and announced on March 17, the team could demonstrate that it had been able to rule out alternative explanations for its result.

That day, Halpern's students turned to him in amazement and asked, "What other secrets are you keeping?"

At face value, the measurement suggests that about 20 percent of the energy liberated during inflation was used to generate gravitational waves. This imposes a significant constraint on cosmological theory. Incredibly, it is consistent with a scenario in which our universe crystallized out of a larger, chaotically expanding space that is forever spawning other universes.

But there is a possible wrinkle. In its



CLEAR VIEW FROM ANTARCTICA

The BICEP2 experiment, which included electronics built at the University of British Columbia, observed for two years from a scientific base near the South Pole, where the cold, dry air favours viewing in the microwave part of the spectrum—an essential component in seeking to understand the earliest moments of the Big Bang.

PHOTO BY STEFFEN RICHTER, HARVARD UNIVERSITY

analysis, the BICEP2 team had to make assumptions about other sources of polarized microwave energy that could be affecting the measurement. Chief among those sources is our own galaxy, which is riddled with interstellar dust that emits polarized microwaves because of the way the dust grains line up along the Milky Way's complex magnetic field.

In May, scientists with the European Space Agency issued a stunning Van Gogh-like Planck satellite image of this dust

contribution (large illustration, facing page). It showcases the foreground "noise" that will need to be painstakingly stripped away before Planck can confirm or refute the BICEP2 findings.

The image is incomplete and does not include the part of the sky where BICEP2 looked. "We can't say anything right now," says Peter Martin, interim director of the Dunlap Institute for Astronomy & Astrophysics in Toronto and a member of the Planck team. Martin and his colleagues "have to dig all the way through" a rich dataset before revealing whether Planck, too, sees gravitational waves from the Big Bang. An answer is expected in October.

Meanwhile, astrophysicists are reacting to the new result. Halpern is working on BICEP3, which is heading to the Antarctic later this year. Other experiments, such as the South Pole Telescope and a balloon-borne detector called SPIDER, both with Canadian team members, are hoping to add to the result one way or another. And the new data have spurred an avalanche of theoretical papers about our cosmic beginnings. The secret is out. Now the race is on to understand what it means. ♦

Ivan Semeniuk is a science reporter for The Globe and Mail newspaper and website. His columns appear regularly in SkyNews.

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CELESTIAL WONDERS

Our readers have once again supplied us with a striking array of cosmic images, ranging from April's total eclipse of the Moon to a remote spiral galaxy. Got an image you would like to share? Send a jpeg along with camera and location details to editor@skynews.ca.



▲ ECLIPSE-IMAGE PARADE

David McColm photographed the lunar eclipse in April from Whistler, British Columbia. His images show the progress of the eclipse from near midtotality, at left, as the Moon gradually moves out of the Earth's shadow. Although the Moon's orbital motion carries it from right to left through the shadow, the daily rotation of our planet is a faster apparent motion that makes the Moon track from left to right, as seen in this sequence.

ECLIPSE AT MIDTOTALITY

Above right: While much of Canada was clouded out during the April 14/15 total lunar eclipse, Roy Bishop of Avonport, Nova Scotia, was one of the lucky skywatchers who managed to view and image the event. He captured this picture at midtotality with a 4-inch f/6.6 Astro-Physics apo refractor and a Canon 70D at ISO 200.



► A COMET AND A GALAXY

While on vacation at Arizona Sky Village, two hours east of Tucson, Barry Mark of Ottawa caught Comet PanSTARRS 2012 K1, lower left, near galaxy M51, upper right, on the morning of May 1. This 4-minute shot at ISO 1600 was taken with a modified Canon T3i on a Sky-Watcher Esprit 80 at f/5.





▲ **LAGOON NEBULA REGION** Using a 5-inch apochromatic refractor at his Flagstaff, Arizona, observatory, Canadian astro-imager Klaus Brasch selected a perfect night to assemble this mosaic of several dozen exposures at ISO 6400 to frame the Lagoon Nebula (M8), right, with neighbouring nebula NGC6559, at left. This image provides an interesting comparison with the more detailed 103-inch-telescope portrait of the Lagoon featured in the May/June *SkyNews* on pages 44-45.



▲ **ARTISTIC ASTROPHOTOGRAPHY** Warren Finlay of Edmonton, Alberta, submitted this creative image showing an aurora with crocuses in the foreground. How did he manage to focus the camera on both the flowers and the aurora? By combining two images. Details: 13-second exposures at ISO 3200 using a Canon 6D and a 14mm f/2.8 lens.



▲ **MARS UP CLOSE** Daniel Leclerc recorded this image of Mars on April 16, two days after the red planet's closest approach to Earth in seven years. Taken with a Sky-Watcher 8-inch Newtonian from his backyard in Pointe-aux-Trembles, Quebec, Leclerc's image clearly shows the Martian north polar cap and, below the cap, the dark desert region Acidalius. He used a DBK 21AU618.AS CCD camera at 60 frames per second and AutoStakkert!2 image-processing software on 1,500 frames, followed by wavelet filtering with Iris.

GALLERY

► HUGE SPIRAL GALAXY M106

At a distance of 24 million light-years, M106 is a relatively nearby spiral galaxy. This detailed celestial portrait by Ron Brecher of Guelph, Ontario, shows two pinkish intensities that astronomers attribute to gas being heated by powerful blasts of energy from the 30-million-solar-mass black hole at the galaxy's core. Photo data: 18-hour exposure with 10-inch f/3.8 ASA reflector and SBIG 11000 CCD.

▼ AWESOME AURORA

Professional photographer Zoltan Kenwell of Edmonton, Alberta, captured this prairie scene, 30 kilometres northeast of the city, on the night of May 7/8 using a Canon 5D Mark II with a 16-35mm f/2.8 lens set at ISO 1250 for a 6-second exposure. See more of Kenwell's work at his website (www.InFocusImagery.com).



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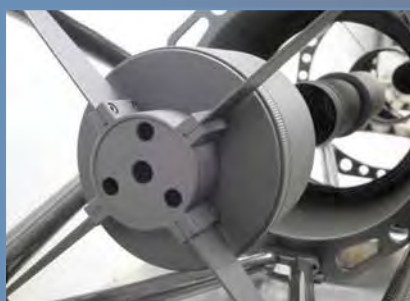
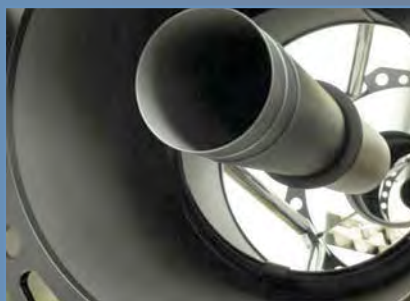
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SMALL BUT POWERFUL

Scutum the shield has no bright stars and is smaller than all but four of the 88 constellations. Even so, little Scutum lays claim to something truly impressive: the Scutum Star Cloud.

by Ken Hewitt-White



SCUTUM'S TREASURE

Easy to overlook, the tiny, dim constellation Scutum is home to a star-rich chunk of the summer Milky Way. It also contains M11, one of the most impressive star clusters visible in a small telescope. Finding it is easy using the bottom stars of Aquila as a guide.

MAIN CHART CARTOGRAPHY BY GLENN LEDREW

ground—gleams like a midcluster nova, while a ninth-magnitude pairing shines prettily near the cluster's southeastern outskirts. The compact blaze of M11 is an alluring study in a typical backyard telescope, even when viewed in fairly serious light pollution. In my city-based 4¼-inch Newtonian reflector at 22x, M11 is only a textured haze around the glaring foreground star. But upping to 54x resolves the haze into faint specks fanning northwestward. The “nova” gleams southeast of centre, near the apex of the fan. More magnification pulls in more specks. At 93x, the cluster seems unevenly illuminated and slightly *squarish*.

A PERFECTLY RECTANGULAR CONSTELLATION only 12 by 9 degrees in extent, Scutum (SKEW-tum) is squeezed between two giant neighbours: Aquila to the northeast and Sagittarius to the south. The glittering Milky Way widens as it crosses these groups and simply overwhelms the shield's nondescript star pattern. In fact, it is the brightest discrete patch of Milky Way outside Sagittarius in the northern sky.

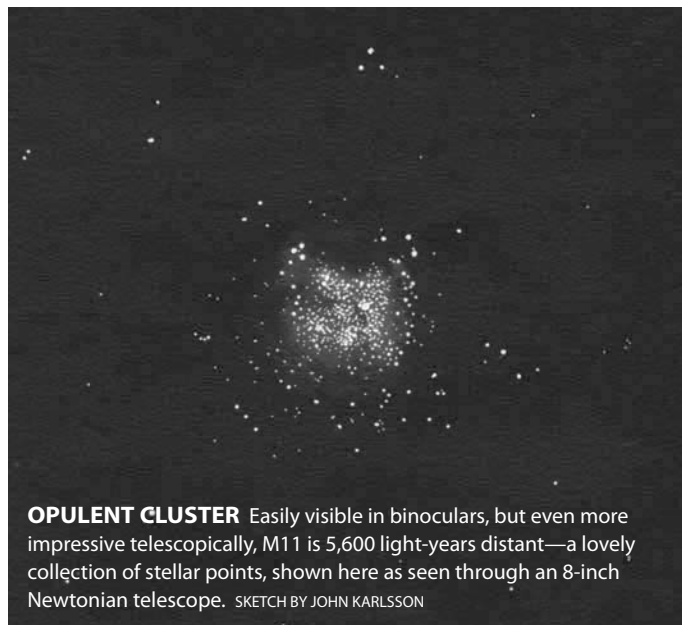
That patch is the **Scutum Star Cloud**, which nearly fills Scutum's northeast quadrant. From a rural observing site, my 8x56 binoculars show the star cloud spreading from fifth-magnitude epsilon (ε) Scuti to fourth-magnitude beta (β), almost four degrees to the north. The cloud is wedge-shaped; its eastern flank blends smoothly into the Milky Way, but its western and northern edges are sharp. Trending northeastward across the cloud is a two-degree-long chain of six or so sixth- and seventh-magnitude stars that opens into a quadrangle roughly ½ by ¼ degrees in extent. My vivid imagination morphs this lanky asterism into an upside-down golf club whose head swings toward a grainy “golf ball” called **Messier 11** (M11), on the cloud's northeast corner. If you identify the golf club in binoculars, you are in the middle of the Scutum Star Cloud.

The prize of Scutum is M11, a stunningly rich sixth-magnitude open star cluster 6,000 light-years from Earth. Although it is less than ¼ degree wide, M11 is packed with 700 suns 11th magnitude and dimmer. An 8.5-magnitude star—likely in the fore-

In 1844, retired British admiral (and active stargazer) William Smyth wrote that M11 “somewhat resembles a flight of wild ducks” in V-formation. Smyth's evocative description led to M11's being dubbed the Wild Duck Cluster. Begging the admiral's pardon, but I don't see your celestial flock of flyers. My larger backyard scope, a 10-inch Dobsonian, strengthens my perception of M11 as a “squarish” powder of pinpoints. At 116x, the cluster displays four fairly straight sides with a few short rows inside. To my eye, the boxlike pattern of bright lines and dark lanes suggests an aerial view of a small garden maze. This harmless hallucination (hey, it's no worse

than wild ducks!) is supported by Vernon, British Columbia, observer John Karlsson's backyard sketch of M11, using an 8-inch reflector telescope, that portrays a square-sided structure. The Garden Maze Cluster, anyone?

The 1.8 degrees of sky between M11 and beta Scuti contain the roughly rectangular head of the golf club asterism I mentioned earlier. Marking its northeast corner is **Herschel VI 50**, an orange 6.2-magnitude star with an 8.2-magnitude companion 111 arc seconds southward. On the southeast corner is **Struve 2391**, a binary with 6.5- and 9.6-magnitude components 38 arc seconds apart. The northwest corner is anchored by **R Scuti**, a yellowy variable that fluctuates between fifth and sixth magnitude, with occasional dips to eighth, on a timescale of weeks. When R reaches maximum, it out-



OPULENT CLUSTER Easily visible in binoculars, but even more impressive telescopically, M11 is 5,600 light-years distant—a lovely collection of stellar points, shown here as seen through an 8-inch Newtonian telescope. SKETCH BY JOHN KARLSSON

shines every other star in the golf club. Inside the head of the club is **Basel 1**, an obscure cluster that forms a clump of dim dots in my 10-inch beginning at around 100x.

Also visible along this same 1.8-degree corridor—in a pristine, dark country sky—

is the abrupt boundary between the Scutum Star Cloud and **Barnard 111** (B111), a large, crescent-shaped dark nebula blotting out the Milky Way. I like to aim my scope at the bottom of the glittery star cloud then, using medium magnification, sweep through the blizzard of stars into the almost starless void of B111. There, I pick up darker pockets. The blackest of these “nebulae within a nebula” are **B110**, $\frac{3}{4}$ degree east of beta Scuti, and **B113**, $\frac{1}{2}$ degree north-east of B110. These are not true starless regions but more opaque clouds of cosmic dust inward toward the core of the Milky Way Galaxy. Scutum may be

small, but its contrasting fields of dazzle and dark are captivating in any optics. ♦

Contributing editor Ken Hewitt-White has observed deep-sky fuzzies over southern British Columbia for more than four decades.

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OUR CHART SHOWS the major stars, planets and constellations visible from Canada and the northern United States within one hour of these times:

EARLY JULY: 11:30 P.M.; LATE JULY: 10:30 P.M.
EARLY AUGUST: 9:30 P.M.; LATE AUGUST: DUSK

THE EDGE OF THE CHART represents the horizon; the overhead point is at centre. On a moonless night in the country, you will see more stars than are shown here; deep in the city, you will see fewer. The ecliptic is the celestial pathway of the Moon and planets. The star groups straddling this line are known as the zodiac constellations. The Moon is shown for selected dates.

USING THE STAR CHART OUTDOORS: The chart is most effective when you use about one-quarter of it at a time, which roughly equals a comfortable field of view in a given direction. Outdoors, match the horizon compass direction on the chart with the actual direction you are facing. Don't be confused by the east and west points on the chart lying opposite their location on a map of the Earth. When the chart is held up to match the sky, with the direction you are facing at the bottom, the chart directions match the compass points. For best results when reading the chart outdoors, use a small flashlight heavily dimmed with red plastic or layers of brown paper. Unfiltered lights greatly reduce night-vision sensitivity.

THE PLANETS

MERCURY reaches its greatest elongation west of the Sun on July 12 in a favourable appearance in the eastern predawn sky. In mid-July, Mercury shines as a zero-magnitude object about 6° below Venus.

VENUS continues to shine brightly at magnitude -3.8, rising in the east just before the Sun. It drops closer to the Sun this summer, shining above Mercury in mid-July and passing a mere 20 arc minutes north of Jupiter on the morning of Aug. 18.

MARS can be seen in the southwest evening sky this summer, dimming from magnitude 0 to 0.6 as it travels eastward through Virgo into Libra. On July 13, it passes 1.2° above Spica, then meets up with Saturn on Aug. 24. On Aug. 31, the Moon, Mars and Saturn form a tight triangle low in the southwest evening sky.

JUPITER is in conjunction behind the Sun in July but emerges into the dawn sky in August. On Aug. 18, Venus and Jupiter pass each other in a spectacular close conjunction low in the morning twilight.

SATURN is visible low in the southwest evening sky as a 0.5-magnitude "star" in Libra. Mars, now moving eastward, lies to the west of Saturn until it passes the ringed planet on Aug. 24. Saturn stops its westward retrograde motion on July 21, after which it, too, begins to move slowly eastward against the background stars.

URANUS can be found as a 5.9-magnitude object in Pisces, rising about midnight and due south by dawn. On the night of July 17/18, the waning gibbous Moon passes just 10 arc minutes above Uranus.

NEPTUNE reaches opposition on Aug. 29, when it rises at sunset and lies due south at local midnight. It can then be seen as a 7.8-magnitude object in central Aquarius about 45 arc minutes north of the star sigma Aquarii.

CELESTIAL CALENDAR

JULY 1 ☾ Waxing crescent Moon 5° below Regulus low in evening sky

JULY 2 Venus 4° north of Aldebaran in morning sky

JULY 3 Earth at aphelion (farthest from the Sun; 152,093,481 km)

JULY 4 ☿ Asteroids 1 Ceres and 4 Vesta 10 arc minutes apart tonight and tomorrow night

JULY 5 ☾ First-quarter Moon; Moon 1° from Mars and 2° from Spica

JULY 7 Waxing gibbous Moon 1° from Saturn in evening sky

JULY 12 Full Moon, 7:25 a.m., EDT; Mercury at greatest angle (21°) west of Sun in morning sky

JULY 13 Mars 1.2° north of Spica in evening sky

JULY 15 Mercury 6° below Venus in morning sky for next four days

JULY 18 Last-quarter Moon; Moon passes 10 arc minutes north of Uranus in early-morning hours

JULY 21 Saturn stops westward retrograde motion

JULY 24 Waning crescent Moon 5° below Venus in morning sky; Jupiter in conjunction with (behind) Sun

JULY 25 Waning crescent Moon 5° below Mercury very low in morning sky

JULY 26 New Moon, 6:42 p.m., EDT

JULY 28 South Delta Aquarii meteor shower peaks (good moonless conditions)

AUG. 2 Waxing Moon 3° from Mars in evening sky

AUG. 3 First-quarter Moon; Moon 3° from Saturn in evening sky

AUG. 10 Full Moon, 2:09 p.m., EDT; "supermoon" (the largest full Moon of 2014, at close perigee of 356,896 km)

AUG. 12 Perseid meteor shower peaks (poor moonlit conditions)

AUG. 17 Last-quarter Moon

AUG. 18 ☿ Venus and Jupiter 20 arc minutes apart near Beehive cluster; waning crescent Moon near Aldebaran in Hyades cluster in morning sky

AUG. 23 Waning crescent Moon near Venus and Jupiter in morning sky

AUG. 24 Mars and Saturn 3.5° apart tonight and next two nights near alpha Librae (Zubenelgenubi) in evening sky

AUG. 25 New Moon, 10:13 a.m., EDT

AUG. 29 Neptune at opposition (closest to Earth and brightest for 2014) and close to 4.8-magnitude star sigma Aquarii

AUG. 31 ☾ Waxing Moon 2° from Mars and 3° from Saturn in a tight triangle low in evening sky

☾ Impressive or relatively rare astronomical event

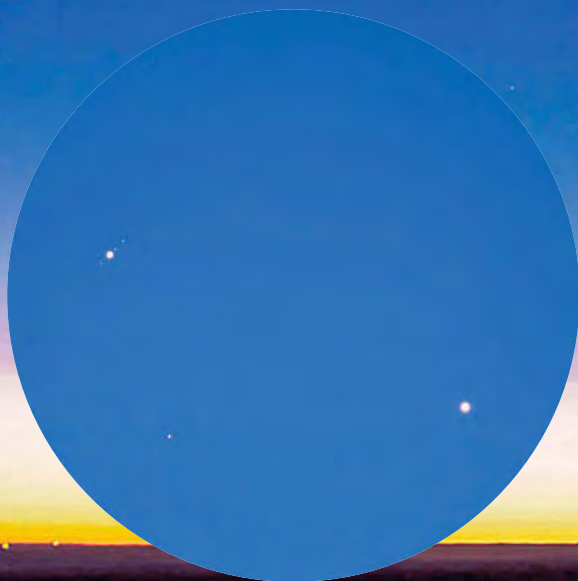
Cartography and design by Roberta Cooke. Base chart data derived from maps drawn by Roy Bishop for the *Observer's Handbook*, published by The Royal Astronomical Society of Canada.



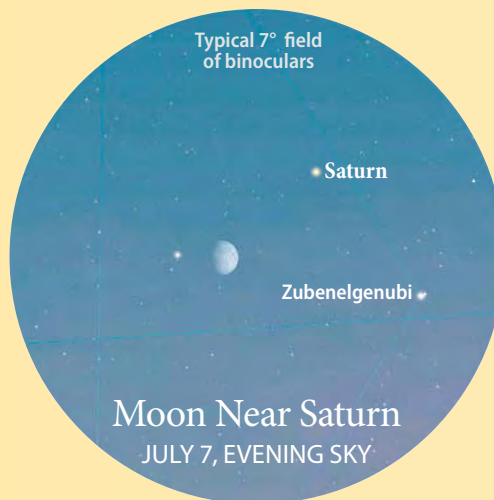
ROTATING NIGHT SKY: During the night, the Earth's rotation on its axis slowly shifts the entire sky. This is the same motion that swings the Sun on its daily east-to-west trek. The rotational hub is Polaris, the North Star, located almost exactly above the Earth's North Pole. Everything majestically marches counter-clockwise around it, a motion that becomes evident after about half an hour.

CONSTELLATIONS: The star groups linked by lines are the constellations created by our ancestors thousands of years ago as a way of mapping the night sky. Modern astronomers still use the traditional names, which give today's stargazers a permanent link to the sky myths and legends of the past.

DUAL PLANETS AT DUSK AND



2001: A PLANETARY CONJUNCTION On August 5, 2001, Venus and Jupiter appeared 1.3 degrees apart in the morning sky, close enough to be easily framed in a telescope at low power (inset). On the morning of August 18, 2014, these same two planets will appear even closer—a mere 0.3 degree apart. PHOTOS BY ALAN DYER



BINOCULAR MARS Binoculars are best for framing the July 5 gathering of the first-quarter Moon neatly nestled between Mars and Spica, then just four degrees apart.

BINOCULAR SATURN On July 7, the gibbous Moon sits two degrees from Saturn and three degrees from Libra's brightest star, Zubenelgenubi, a double star that is ideal for binoculars.

DAWN

This is a season of close passages:
Mars near Spica, Mars near Saturn,
Venus near Jupiter, the Moon near Uranus
and Ceres near Vesta

by Alan Dyer

THIS SUMMER, the sky contains two pairs of planets, one in the evening and one in the morning. Mars meets up with Saturn at dusk, while Venus visits Jupiter at dawn. Mercury also puts in an appearance below Venus in mid-July as an additional morning “star.”

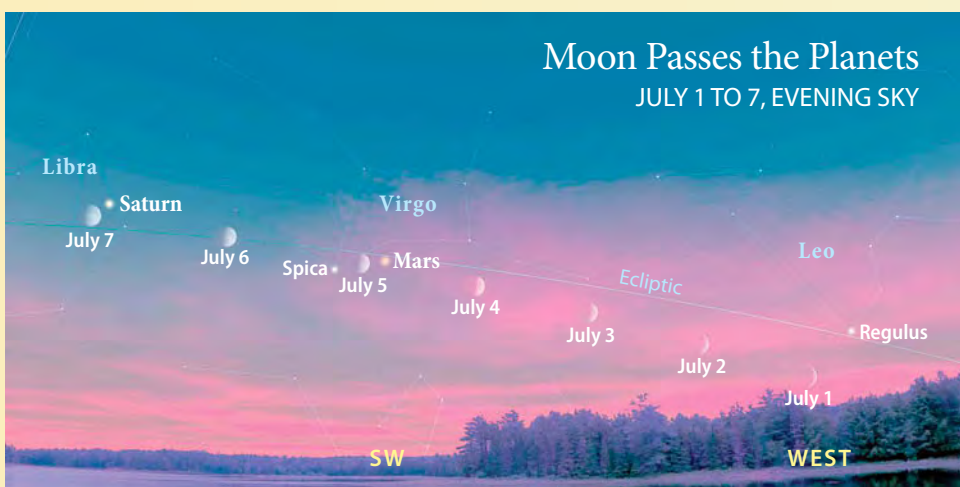
As a bonus, two of the biggest asteroids/dwarf planets, Vesta and Ceres, also pass incredibly close to each other, as seen from Earth, in early July.

In August, the main weekend for Canadian star parties delivers a photogenic conjunction of the waning Moon near Venus and Jupiter in the morning twilight, while Mars is close to Saturn in the evening twilight.

Unfortunately, a nearly full Moon washes out the popular Perseid meteor shower this year. As a consolation a few days later, we see a rare and very close conjunction of the sky’s two brightest planets as Venus passes just 20 arc minutes—less than a Moon diameter—above Jupiter on August 18. We haven’t seen these two worlds appear this close to each other since 1999.

MARS AND SATURN AT DUSK

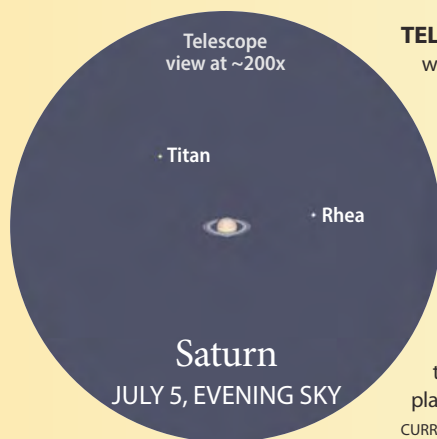
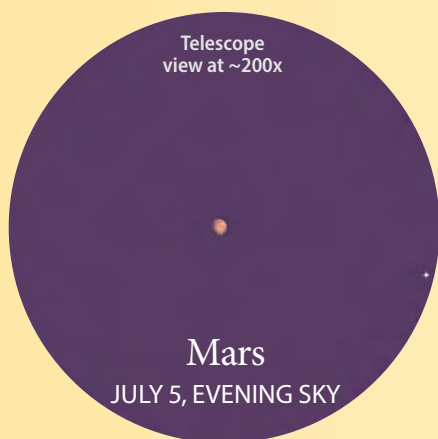
Our two evening planets serve as popular targets for telescopes this summer. Just be prepared for views that are less than ideal. Both Mars and Saturn appear low in the southwest, embedded more deeply in the Earth’s image-blurring atmosphere than they were this spring. Look as soon as you can in early July for the best views before



EVENING MOONS OF JULY

As July opens, the waxing Moon performs close passages by several of the evening sky’s brightest objects. On Canada Day, July 1, the Moon shines near Regulus, in Leo, low in the evening twilight. On July 5, the Moon appears between Mars and Spica, while on July 7, the Moon passes below Saturn.

COURTESY STARRY NIGHT PRO PLUS™/
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TELESCOPIC MARS Seeing detail on Mars in early July will be a challenge, as its disc is just nine arc seconds across. But bump up the power, and look for the subtle dark region called Acidalium in the northern hemisphere of Mars and Meridiani in the south. Look as soon as possible as the sky darkens.

TELESCOPIC SATURN Seen at the same 200x, Saturn appears much larger than Mars. Look for the dark shadow of the planet on the back side of the rings (seen here at left), giving the planet a 3-D appearance. Titan and Rhea, Saturn's two brightest moons, may also be visible near the planet. COURTESY STARRY NIGHT PRO PLUS™/SIMULATION CURRICULUM CORP. (BOTH)

both planets sink any lower this summer.

Mars now has the disadvantage of having its disc appear quite small. In late June, Mars' disc dropped below the arbitrary 10-arc-second-diameter threshold from its maximum size of 15.2 arc seconds when Mars was closest to Earth in mid-April. When the Martian disc appears smaller than 10 arc seconds across, even experienced observers have a tough time seeing notable details on the planet. Compound that with the low altitude of Mars, and at first glance through a telescope, all you are likely to see is a featureless reddish dot.

To improve the view, observe Mars as

soon as you can find it in the twilight. Then don't be afraid to bump up the magnification to as much as 200x. The north polar cap is now very small and will be hard to pick out. In early July, however, the prominent dark marking called Acidalia Planitia is turned toward North America in the evening, while by mid- to late July, the even darker Syrtis Major has rotated into view. So give Mars a go. We won't get a better view until spring 2016.

Saturn offers better viewing prospects. It sets later and, therefore, appears higher and sharper at nightfall. Nevertheless, look early in

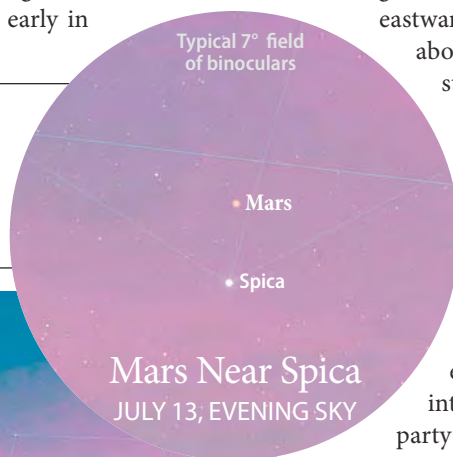
July. Saturn is sure to elicit a "wow!" from your friends and family members when they look through your telescope. The rings are now tilted 21 degrees to our line of sight, with the north face of the rings and the northern half of the planet tipped toward us. The geometry yields a classic picture-postcard Saturn. As with Mars, try to pick out Saturn as soon as you can at nightfall for the sharpest view.

While a telescope will reveal enticing views of Mars and Saturn, their main attraction this summer is their position among the stars. Mars shoots rapidly eastward this season, first passing above Spica, Virgo's brightest star, in mid-July. Mars is just 1.2 degrees north of Spica on July 13 and is the brighter of the pair. The colour contrast of rusty Mars near blue-white Spica will be striking, even to the unaided eye.

Mars continues its trek eastward, moving from Virgo into Libra in August. By star-party weekend on August 23 and 24, Mars and Saturn are 3.5 degrees apart. By coincidence, the two planets then appear exactly the same brightness, at magnitude 0.6. Both worlds are near the third-magnitude star alpha Librae, which also goes by the wonderful name Zubenelgenubi. This lyrical moniker comes from the Arabic for "southern claw," a reference from a time when the stars of Libra were considered part of Scorpius, next door in the zodiac. To the north lies Libra's other main star, Zubeneshemali, from the Arabic for "northern claw."

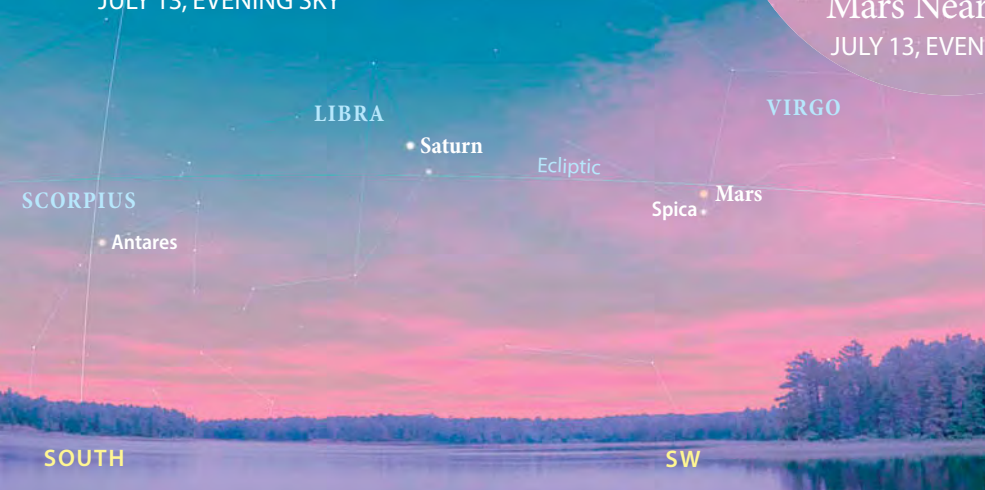
MARS-STAR CONJUNCTION On the evening of July 13, look southwest at nightfall to see reddish Mars shining just 1.2 degrees above blue-white Spica. Use binoculars (inset) or a telescope at low power to frame the contrasting pair.

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Mars Meets Spica

JULY 13, EVENING SKY



ASTEROID Crossing

The sky above Mars and Spica is crowded this summer, as Ceres and Vesta cross paths in Virgo, providing a rare opportunity to see two major asteroids at once

Every 17 years, the faster-moving asteroid 4 Vesta (one of the “big four” main-belt asteroids) catches up with and passes the largest asteroid, 1 Ceres, now also classed as a dwarf planet. Vesta passes below Ceres in early July, with the two worlds just 10 arc minutes apart on July 4 and 5. Vesta then shines at magnitude 7.1. Although Ceres is larger, it is more distant and, therefore, fainter, at magnitude 8.4.

As viewed from Earth, the orbital paths of the two asteroids actually cross, but there’s no worry about these worlds colliding—Vesta and Ceres actually lie 83 million kilometres apart in space.

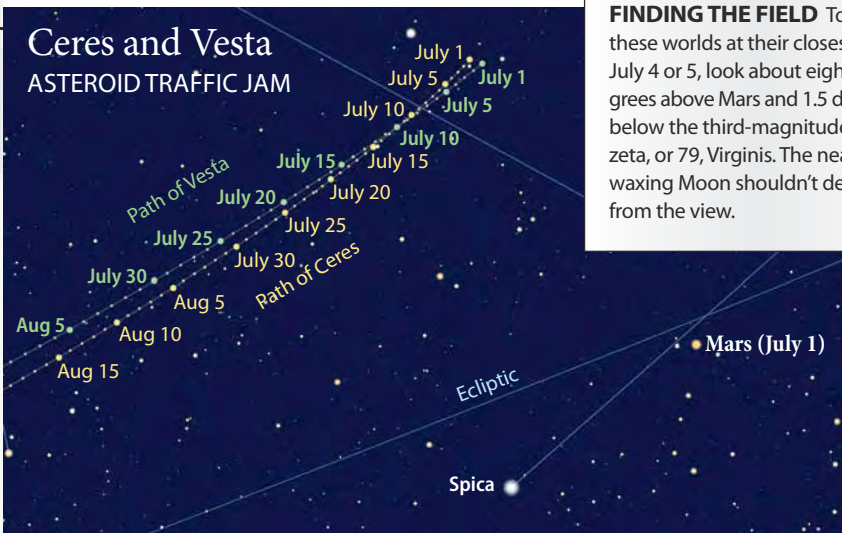
FINDING THE ASTEROIDS High-power binoculars, such as 11x70s, will nicely frame the field and reveal Ceres and Vesta as starlike objects amid a number of stars of similar sixth- to seventh-magnitude brightness.

VESTA FROM DAWN NASA’s Dawn space probe orbited Vesta in 2011 and 2012 and mapped the surface of this 570-kilometre-diameter asteroid. Dawn is now on its way to Ceres, a dwarf planet that is twice the size of Vesta, for a rendezvous in February 2015.

COURTESY NASA/JPL-CALTECH

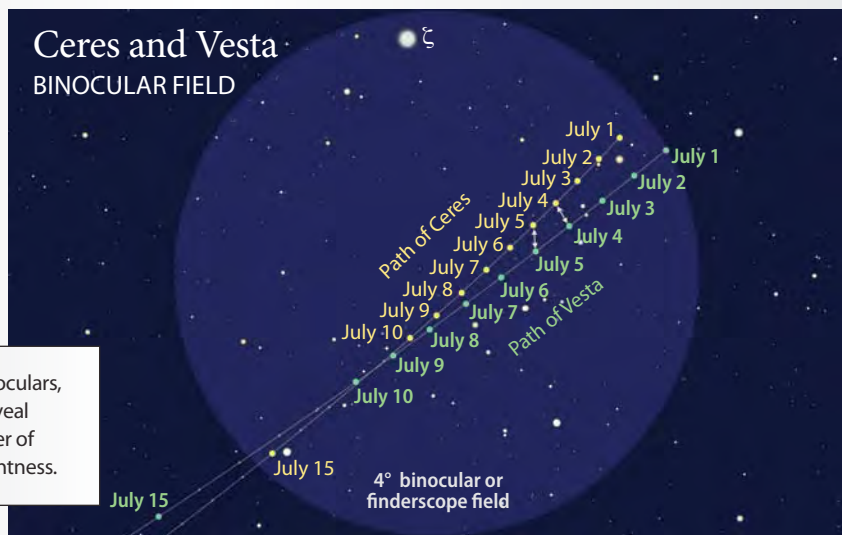


Ceres and Vesta ASTEROID TRAFFIC JAM

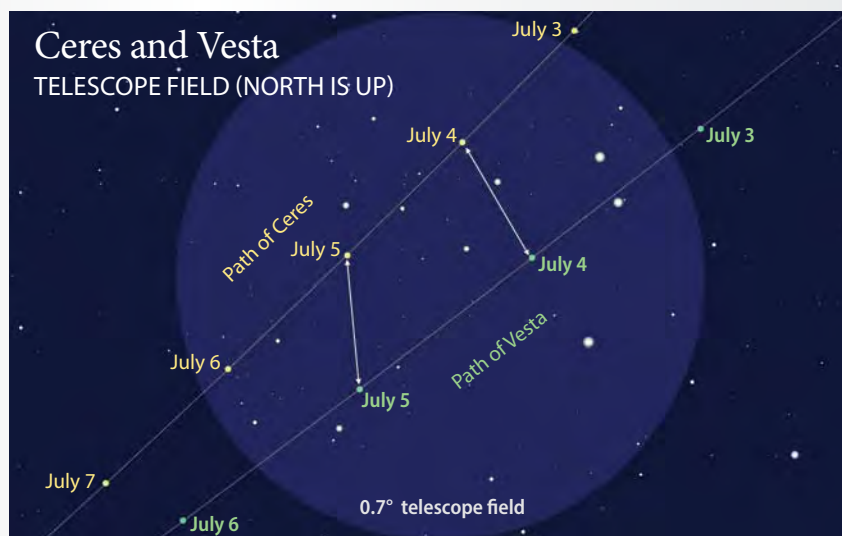


FINDING THE FIELD To find these worlds at their closest on July 4 or 5, look about eight degrees above Mars and 1.5 degrees below the third-magnitude star zeta, or 79, Virginis. The nearby waxing Moon shouldn’t detract from the view.

Ceres and Vesta BINOCULAR FIELD



Ceres and Vesta TELESCOPE FIELD (NORTH IS UP)



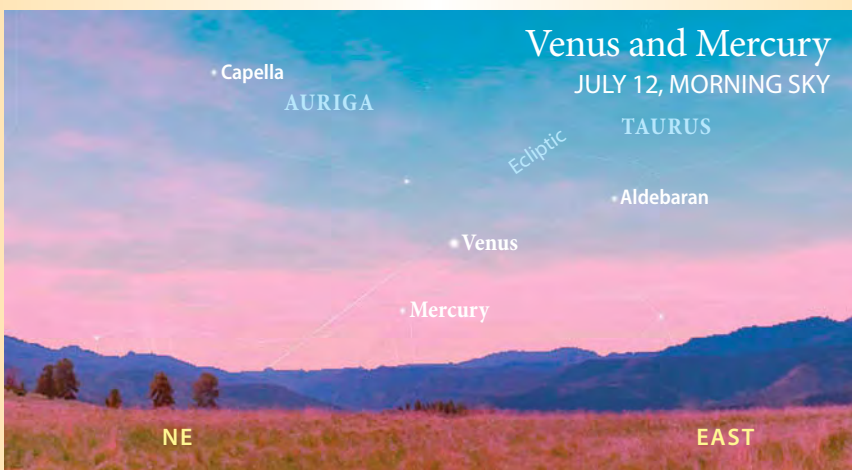
ZOOMING IN CLOSER A telescope at moderate power will help you pick out Ceres and Vesta. Your telescope will likely invert or flip the field from what is shown here. For a positive ID, sketch the field and return the next night to see which stars have moved.

COURTESY THESKYX™/SOFTWARE BISQUE (ALL)

VENUS IN THE MORNING Venus continues its morning-sky apparition this summer, participating in several meetings with its celestial neighbours in July.



MORNING 'STAR' AND ALDEBARAN As July begins, Venus passes above Aldebaran in the morning twilight, just as Mercury is rising into the dawn sky.



MORNING 'STAR' AND MERCURY On July 12, Mercury reaches its greatest angle away from the Sun and its highest position in the dawn sky, about a binocular field below Venus.



MORNING 'STAR' AND THE MOON By July 24, as Mercury and Venus are beginning to separate, the waning crescent Moon appears about five degrees below Venus.

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MERCURY, VENUS AND JUPITER AT DAWN

Meanwhile, in the dawn sky, Venus continues to dominate the morning twilight. On July 2, Venus passes above Aldebaran at the beginning of a two-week period for sighting Mercury. Putting in one of its best morning-sky appearances of 2014, Mercury briefly joins Venus in early to mid-July. Mercury reaches its greatest elongation west of the Sun on July 12, the start of a week when you can sight the innermost planet a binocular field below Venus in the morning twilight.

July 24 presents a photogenic meeting of the waning crescent Moon below Venus, with Mercury not far away as a bonus. Through a telescope, Venus appears as a tiny 11-arc-second disc, with a gibbous phase. Brilliant clouds of sulphuric acid perpetually hide any detail on its scorching volcanic surface. The deceptive charm of hellish Venus lies in its appearance to the unaided eye in our twilight sky.

Just as Mercury drops from sight close to the Sun in late July, Jupiter emerges from its conjunction behind the Sun. Rising higher into the dawn sky in August, Jupiter meets up with Venus on August 18.

AUGUST 18: CONJUNCTION SPECTACLE

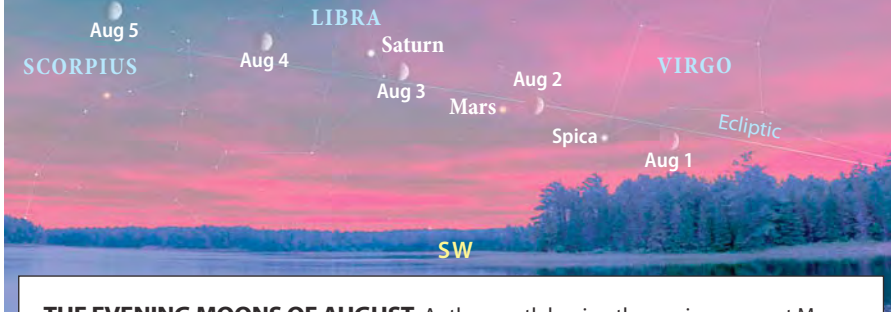
This date is the "red-letter day" of the summer stargazing season. On the morning of August 18, Venus appears just 20 arc minutes above Jupiter. That's closer than the 30-arc-minute diameter of the Moon. This is the closest observable conjunction of these two worlds since February 23, 1999, when Venus and Jupiter appeared 16 arc minutes apart in the evening sky.

On August 18, Venus and Jupiter actually approach as close as 12 arc minutes apart, but that minimum separation occurs in the middle of the North American night, when the two planets are below our horizon (at least from where most of us live). Travel to the High Arctic (to a latitude of about 73 degrees north), and you could catch Venus and Jupiter at their closest, shining low in the north in the middle of a bright Arctic night. Or, more practically, you could travel to Portugal or Spain, where closest approach occurs in the dawn sky.

For most of us in North America, by the time Venus and Jupiter rise on the morning of August 18, Venus has pulled slightly away from Jupiter, widening the gap to 20 arc minutes. This is still a very close conjunction of

Moon Passes the Planets

AUGUST 1-5, EVENING SKY

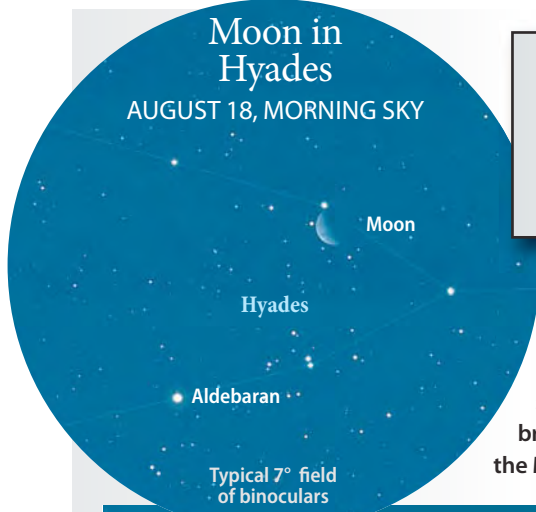


THE EVENING MOONS OF AUGUST As the month begins, the waxing crescent Moon appears west of Spica, in Virgo, on August 1, then is three degrees from Mars on August 2 and the same distance from Saturn one night later, on August 3. Look southwest just after sunset—the Moon and planets sit low in the evening twilight and will set early.

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Moon in Hyades

AUGUST 18, MORNING SKY



The August 18 MORNING SKY SHOW

Be sure to mark the morning of Monday, August 18, on your calendar, and plan to be at a location with a clear view to the east. Get up early to see a very close meeting of the sky's two brightest planets, plus a conjunction of the Moon in the Hyades star cluster.

Moon Near Aldebaran

AUGUST 18, MORNING SKY



LUNAR SIDESHOW On August 18, the waning crescent Moon rises in Taurus at about 1 a.m., local time. When Venus and Jupiter rise at 5 a.m., the Moon sits high in the southeast, shining amid the stars of the Hyades star cluster and three to four degrees from Aldebaran. Binoculars will provide the best view (inset). COURTESY STARRY NIGHT PRO PLUS™/SIMULATION CURRICULUM CORP. (BOTH)

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"Orion's Sword," by Sanjeev Sivarulrasa

DOUBLE STAR AT DAWN Although low in the bright dawn, Venus and Jupiter will be a striking sight in the twilight, appearing just 20 arc minutes apart. Look east between 4:30 and 5:30 a.m., local daylight time. As a bonus, the two planets are also close to Messier 44, the Beehive star cluster, but it will be washed out by the dawn light. While the inset depicts the view through binoculars, the planets and cluster are close enough to fit within the field of a medium-power telescope.

COURTESY STARRY NIGHT PRO PLUS™/SIMULATION CURRICULUM CORP. (BOTH)

Venus and Jupiter AUGUST 18, MORNING SKY

Beehive Cluster

Venus • Jupiter

Typical 7° field of binoculars

TWO-FOR-ONE TELESCOPE VIEW The last time Venus and Jupiter appeared this close together at dawn or dusk was in the evening sky on February 23, 1999. This photo captures that close encounter through a telescope. Note Jupiter's moons. PHOTO BY ALAN DYER

Venus and Jupiter Conjunction

AUGUST 18, MORNING SKY

Castor •

GEMINI

Pollux •

CANCER

Venus • Jupiter

Procyon •

NE

EAST

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Friday, Sept. 26, and Saturday, Sept. 27, 2014

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and Torrance Barrens Dark Sky Site



Saturday, 7 p.m., Opera House Theatre

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the sky's two brightest planets. And Venus and Jupiter appear in the same telescopic field as the Beehive star cluster (a.k.a. Messier 44). Pity this conjunction does not occur with the planets higher in a darker sky.

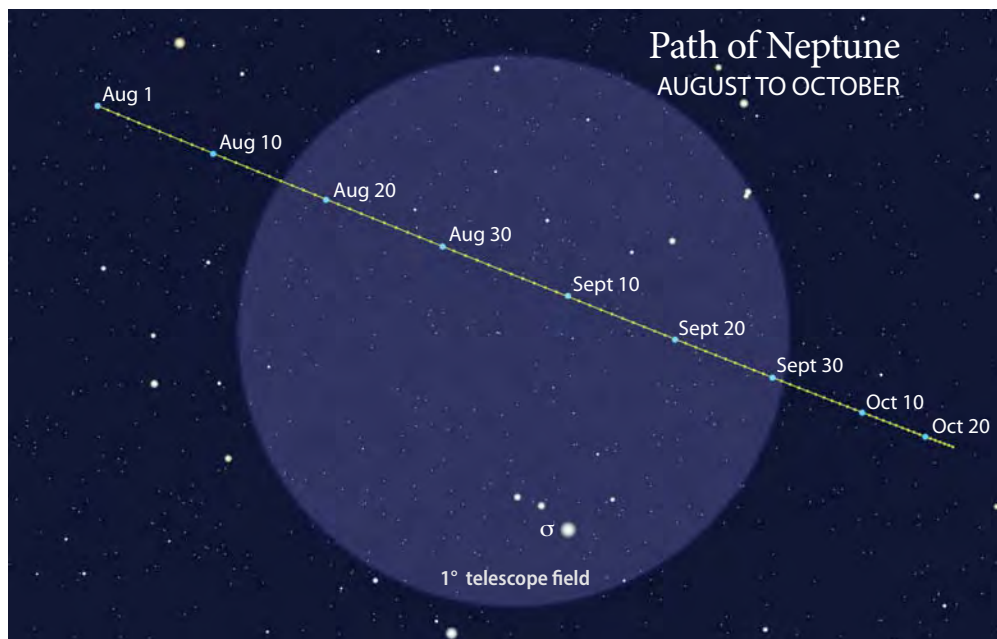
Instead, the two planets appear low in the east, deeply embedded in the bright twilight. While they are visible to the unaided eye, binoculars will provide the best view. But try to get a telescope on the scene as well, because Venus and Jupiter are so close that they will fit into the field of a medium-power eyepiece. Even though they will look fuzzy, owing to their proximity to the horizon, we don't often get an opportunity to see the two brightest planets together in a telescope field.

While 1999 was the last such close Venus-Jupiter conjunction, we won't have to wait nearly as long to see another as close as this August's event. The two worlds will appear 20 arc minutes apart on the evening of June 30, 2015, shining in the western twilight. An even closer conjunction occurs a year later, on August 27, 2016, when Venus passes a mere four arc minutes above Jupiter. The catch is, they will be just 22 degrees east of the Sun in the daytime sky at closest approach. By sunset, they will appear farther apart and will be tough to sight low in the west from Canadian latitudes.

The morning of August 18 has more on offer. If you get up early enough, before the sky becomes too bright, you'll see the waning crescent Moon near Aldebaran, among the stars of the Hyades cluster. August 18 is a Monday, but the celestial show that morning will make it worthwhile rising early to start a great week of stargazing.

SUPERMOON AND SHOOTING STARS

It's supermoon season again! Astronomers have come to loathe the media's fascination with the biggest full Moon of the year. But again, in August, you'll no doubt encounter endless web news reports of the "supermoon." The Sunday, August 10, full Moon coincides within minutes with perigee, the point in the Moon's monthly orbit when it is closest to Earth. In this case, the distance from Earth to the Moon on this night is 356,896 kilometres. This is the closest lunar perigee of 2014, making the August 10 full Moon appear a little bigger (34 arc minutes across) and brighter than other full Moons in the year. But the difference between a supermoon, as a perigean full Moon has come to be known in recent years, and a



RETROGRADING NEPTUNE On August 29, Neptune reaches opposition, when it is closest and brightest for the year. Neptune is then easy to find—simply aim a telescope at the fifth-magnitude star sigma (σ) Aquarii, and Neptune should be in the same low-power field. Look for a bluish 7.8-magnitude object north of sigma. Neptune retrogrades westward above sigma in August and September, passing just 28 arc minutes (less than half a degree) north of the star in mid-September.

COURTESY THESKYX™/SOFTWARE BISQUE

JUPITER'S MOONS

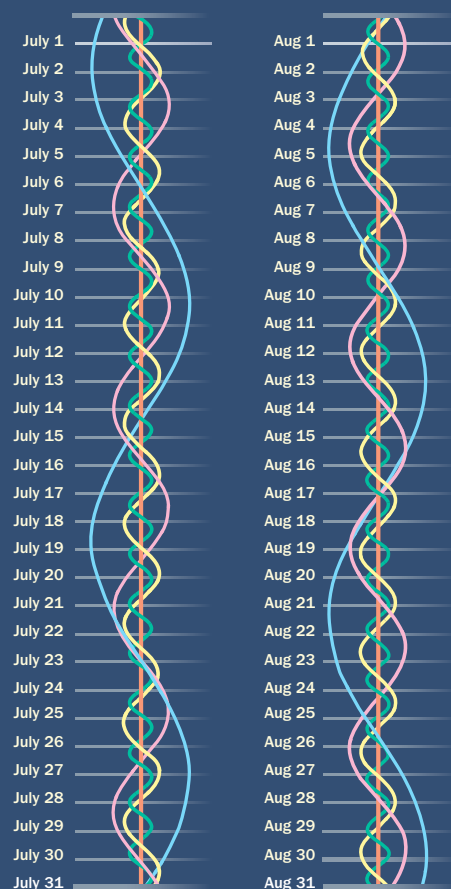
July and August 2014



The positions of Jupiter's four largest moons are shown for each night of the two-month period. Jupiter is represented by the central vertical shaft, while the moons are the four wavy lines. The horizontal lines mark 7 p.m., EDT, on the dates indicated. Time flows from top to bottom, so look proportionately below the line for later times on a particular date. East is to the left, and north is at the top, as seen in binoculars. From closest to farthest, the moons are Io, Europa, Ganymede and Callisto. Orbital periods are 1.8, 3.6, 7.2 and 16.7 days, respectively.

KEY:

Io Europa Ganymede Callisto



STAR PARTY SCENES Saturday, August 23, and Sunday, August 24, are the prime weekend dates for summer star parties across the country. The dawn and dusk star party skies contain some notable conjunctions.

Moon Near Venus and Jupiter

AUGUST 23, MORNING SKY



STAR PARTY DAWN Get up early on August 23 to see the waning crescent Moon rising together with Venus and Jupiter, which were in close conjunction five mornings previous to this. The gathering forms a beautiful backdrop to any star party scene.

TOGETHER AGAIN At star parties in August 2012, Mars and Saturn appeared close together and just above the star Spica, in Virgo. This year's gathering is a near repeat performance. PHOTO BY ALAN DYER



Mars Near Saturn

AUGUST 24, EVENING SKY



STAR PARTY DUSK On Sunday, August 24, look southwest to see Mars and Saturn shining 3.5 degrees apart in the evening twilight. The two worlds appear almost as close the night before and the night after, as Mars passes below Saturn.



A BINOCULAR DOUBLE Through binoculars, you'll discover the star Zubenelgenubi near Mars and Saturn. This fine double star has a fainter fifth-magnitude companion nearly four arc minutes away. The two stars are far apart in space, separated by a distance 180 times that from the Sun to Neptune. Nevertheless, the pair is travelling together and is a true related double star. COURTESY STARRY NIGHT PRO PLUS™/SIMULATION CURRICULUM CORP. (ALL THREE)

A Matter of DEGREES

The many conjunctions, or close passages, between various worlds this summer are measured in degrees and arc minutes. What are those units?



A full circle is divided into 360 degrees. The distance from the horizon to the zenith (the point directly overhead) is one quarter of a circle, or an angle of 90 degrees. Each angular degree is further subdivided into 60 arc minutes. Although it looks much larger, the full Moon is only 30 arc minutes, or $\frac{1}{2}$ degree, across. Many of this season's close conjunctions involve worlds that appear a mere 10 to 20 arc minutes apart, much less than the apparent diameter of the Moon.

SIZE OF THE MOON The disc of the full Moon typically subtends an angle of 30 arc minutes, but it can be as large as 34 arc minutes when full Moon coincides with perigee, the Moon's closest point to Earth, as it does on August 10. COURTESY THESKYX™/SOFTWARE BISQUE

normal full Moon is so slight that you can't detect the difference in size or brightness with the unaided eye.

Nevertheless, Facebook posts and trivia news sites will extol you to get out and see what they imply will be a "giant Moon." It will certainly be a pretty sight, rising in the southeast, but so is any full Moon. The one the following month, the Harvest Moon on September 8, occurs with the Moon only about 2,000 kilometres farther from Earth than it was a month earlier, making its disc just as impressive as the hyped August 10 supermoon.

While the full Moon of August does provide an opportunity for a fine photo of a rising full Moon, you'll be cursing the Moon two nights later. August 12 is the peak night of the annual Perseid meteor shower. The Moon, now a waning gibbous phase two days past full, rises just minutes after sunset. By the time twilight ends, the Moon is well up in the southeast, its light washing out many of the meteors. The less frequent bright meteors will still shine through, but you'll need a lot of patience to sit out and wait for their occasional streaks on this moonlit night.

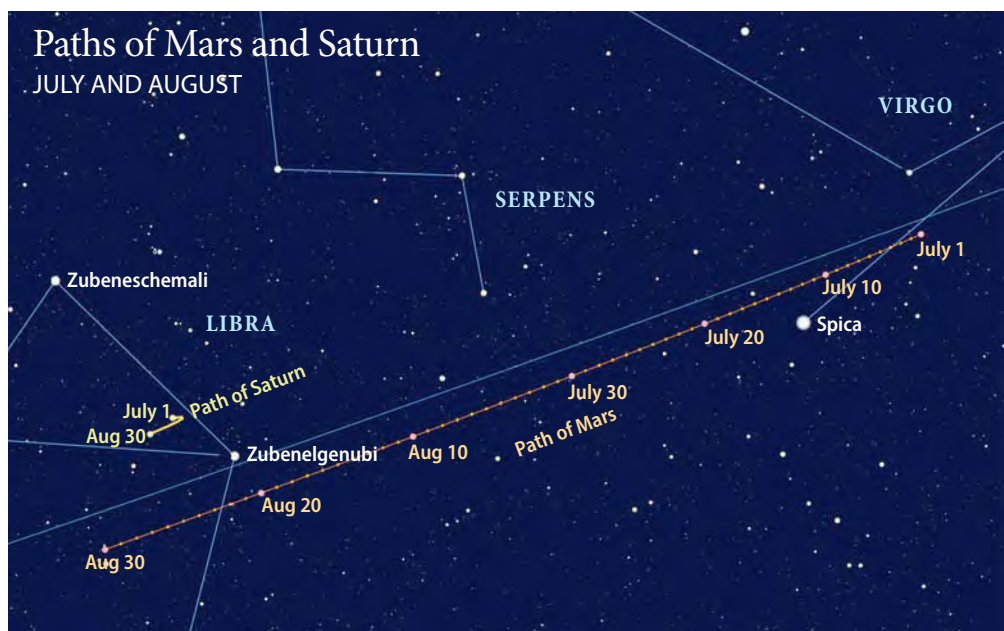
STAR PARTY SPECIALS

The prime weekend for summer stargazing this year falls on the dark-of-the-Moon dates of Friday, August 22, to Sunday, August 24. Many star parties will be in full swing around the country. On the morning of Saturday, August 23, look east at the end of an all-night observing session to see the waning crescent Moon near Venus and Jupiter in the dawn sky.

That evening or on any of the next three evenings, look southwest to see Mars and Saturn just 3.5 degrees apart in the twilight. They appear closest together on Sunday, August 24, and Monday, August 25. So extend your star party weekend to enjoy the view of this "dusk double planet" from a good site with a clear sight line to the southwest.

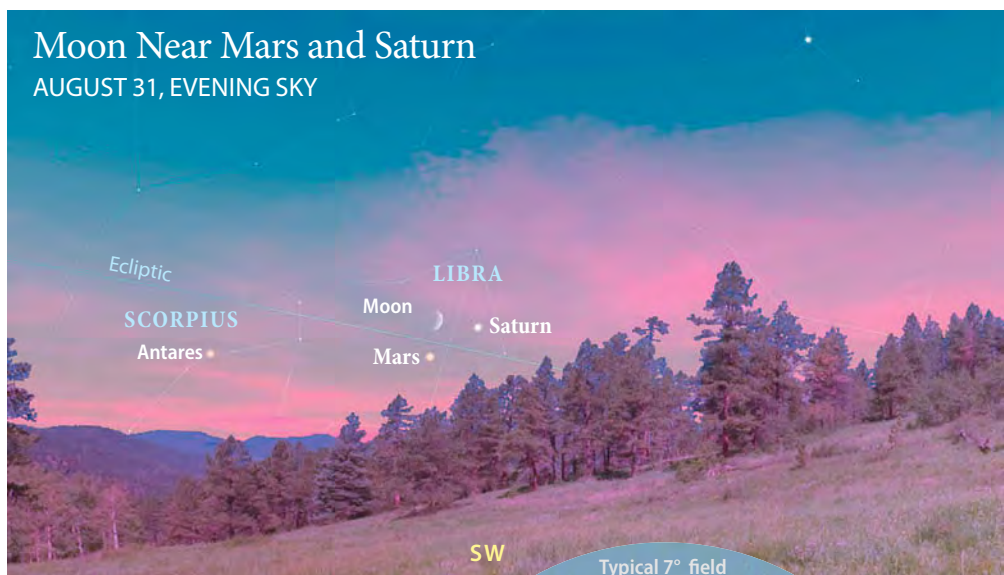
A FINAL ENSEMBLE

A week later, on Sunday, August 31, the summer stargazing season wraps up (the end of August always seems to be the end of summer, if only unofficially) with a tidy gathering of the waxing crescent Moon in the evening sky passing near Mars and Saturn. The three worlds form a tight three-degree-wide triangle, making for another fine photo opportunity. ♦



MARS SHOOTS TOWARD SATURN Mars really moves this summer, heading east from Virgo (where it passes above Spica in mid-July) into Libra to meet up with slow-moving Saturn in late August. Watching this motion is an easy way to enjoy Mars, even if telescopic views disappoint.

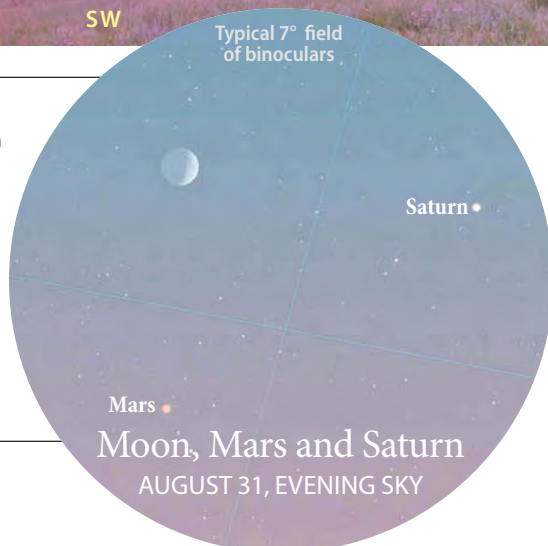
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EVENING SKY CONJUNCTION

A week after its August 24 meeting with the morning planets, the Moon joins the two evening planets. On August 31, the waxing crescent Moon shines near Mars and Saturn low in the southwest. The three worlds form a tight three-degree-wide triangle that is ideal for binoculars (inset).

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GIANT ELLIPTICAL GALAXIES AND GRAVITATIONAL WARPING

Containing up to 100 trillion stars, giant elliptical galaxies are the most massive galaxies in the universe, outclassing the largest spiral galaxies known

GIANT ELLIPTICAL GALAXIES are the largest and most massive galaxies in the universe. Each measuring up to 100 trillion times the mass of the Sun, these huge balls of seemingly countless suns appear, from a distance, as brilliant, featureless piles of merged starlight. They are the brightest objects in the image on the facing page. The faint blue streaks are more distant galaxies contorted by the immense gravitational warping caused by the combined mass of the giant ellipticals in the cluster.

This image of Abell 2744 is the first photo to come from the Hubble Space Telescope Frontier Fields observing program, which is using the magnifying power of enormous galaxy clusters to peer deep into the distant universe. Abell 2744 is thought to have had a very violent history, forming as the result of a cosmic pileup of several galaxy clusters over a period of 350 million years.

Astronomers using the Hubble Space Telescope previously observed Abell 2744 back in 2011, when they were exploring the cluster's history. They found that at least four galaxy clusters had crashed into one another to form Abell 2744 and, in the process, had caused a few weird and wonderful effects. This mix of cosmic phenomena, some of which had never been seen before, led to the nickname of Pandora's Cluster.

A mix of hazy elliptical galaxies and colourful spirals can be seen clumping together at the centre of this image. The effects of the cluster's gravity are evident in the blue arcs and warped shapes scattered across the frame, including galaxies that seem to bleed into the surrounding space. The arcs are actually the distorted images of galaxies far in the distance.

Abell 2744 is the first of six targets in a three-year, 840-orbit observing program known as Frontier Fields. Using the power of the Hubble Space Telescope to explore more distant regions of space than could otherwise be seen, this program will yield our deepest views of the universe to date by observing gravitational-lensing effects around six different galaxy clusters.

Gravitational lensing is a phenomenon caused by an object's

influence on the space-time around it. Massive objects like galaxy clusters warp and distort space-time. This causes the light from more distant objects hidden behind this makeshift lens of nature to be deflected and bent, leading to an array of bizarre optical effects. For example, gravitational lensing can create up to four magnified images of one galaxy, smear galaxies out into arcs and produce

multiple images of individual objects. More common are short lines or arcs, seen in profusion in the Abell 2744 image at right.

As well as creating these weird shapes, gravitational lensing magnifies the images, so astronomers are able to see more detail. Therefore, distant objects that would otherwise be too remote and faint to be seen become visible—a phenomenon that Frontier Fields aims to exploit over the coming years.

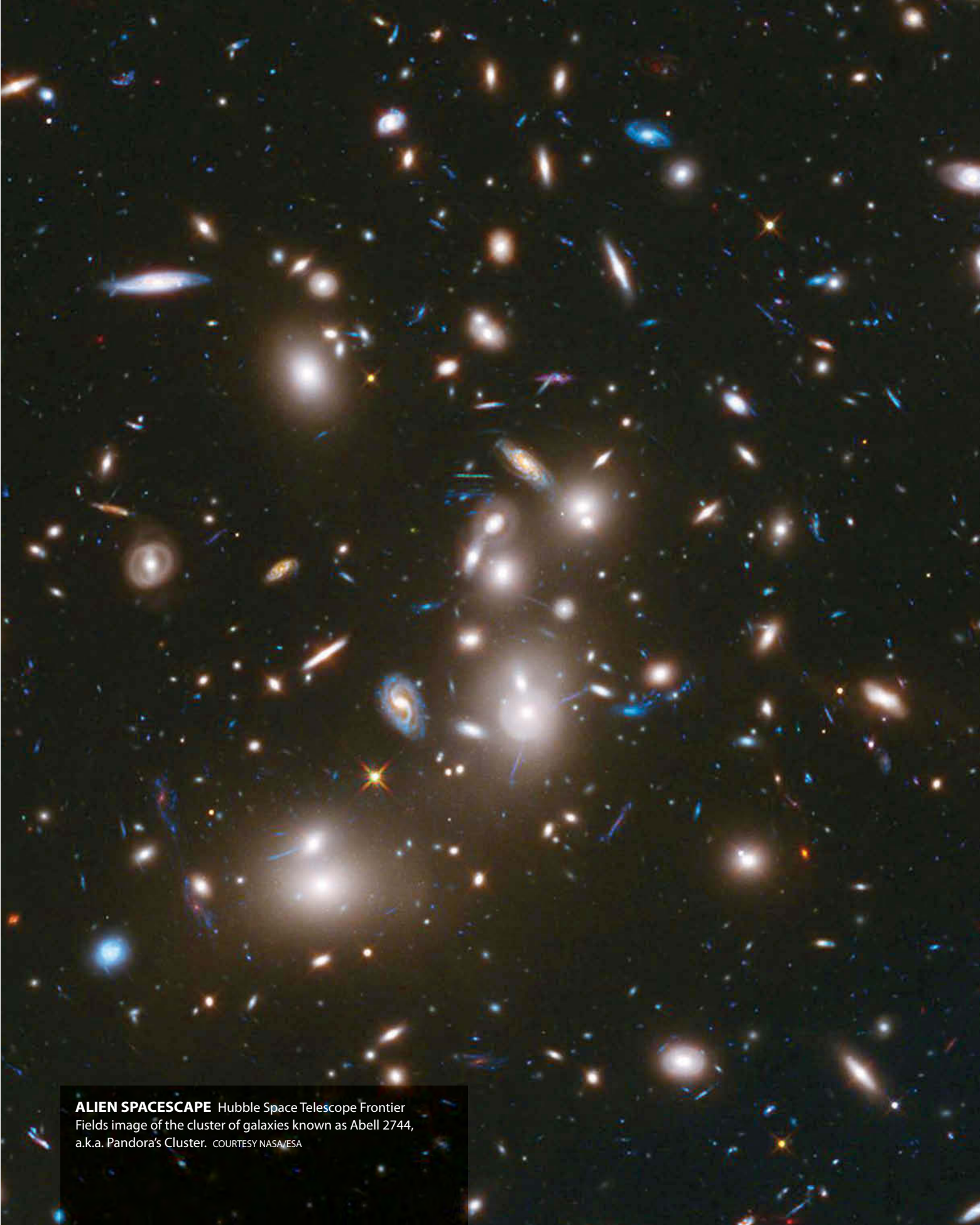
In addition to the giant ellipticals, the Abell 2744

cluster contains large spiral galaxies, most of them distorted to some degree by close encounters with the giant ellipticals as the galaxies slowly swing around the cluster's centre of gravity. Over billions of years, the spirals are gradually cannibalized by the more massive ellipticals, which gravitationally dominate the cluster of galaxies and ultimately control its evolution.

Although the galaxies in the cluster are clearly visible in the Hubble Frontier Fields image, they make up less than 5 percent of Abell 2744's mass. The rest of the cluster is gas (about 20 percent), which is so hot that it shines only in X-rays, and dark matter (around 75 percent), which is completely invisible. Dark matter is particularly elusive, as it does not emit, absorb or reflect light (hence its name) but makes itself apparent only through its gravitational attraction—the telltale distortions in the galaxies in the background of the Hubble image.

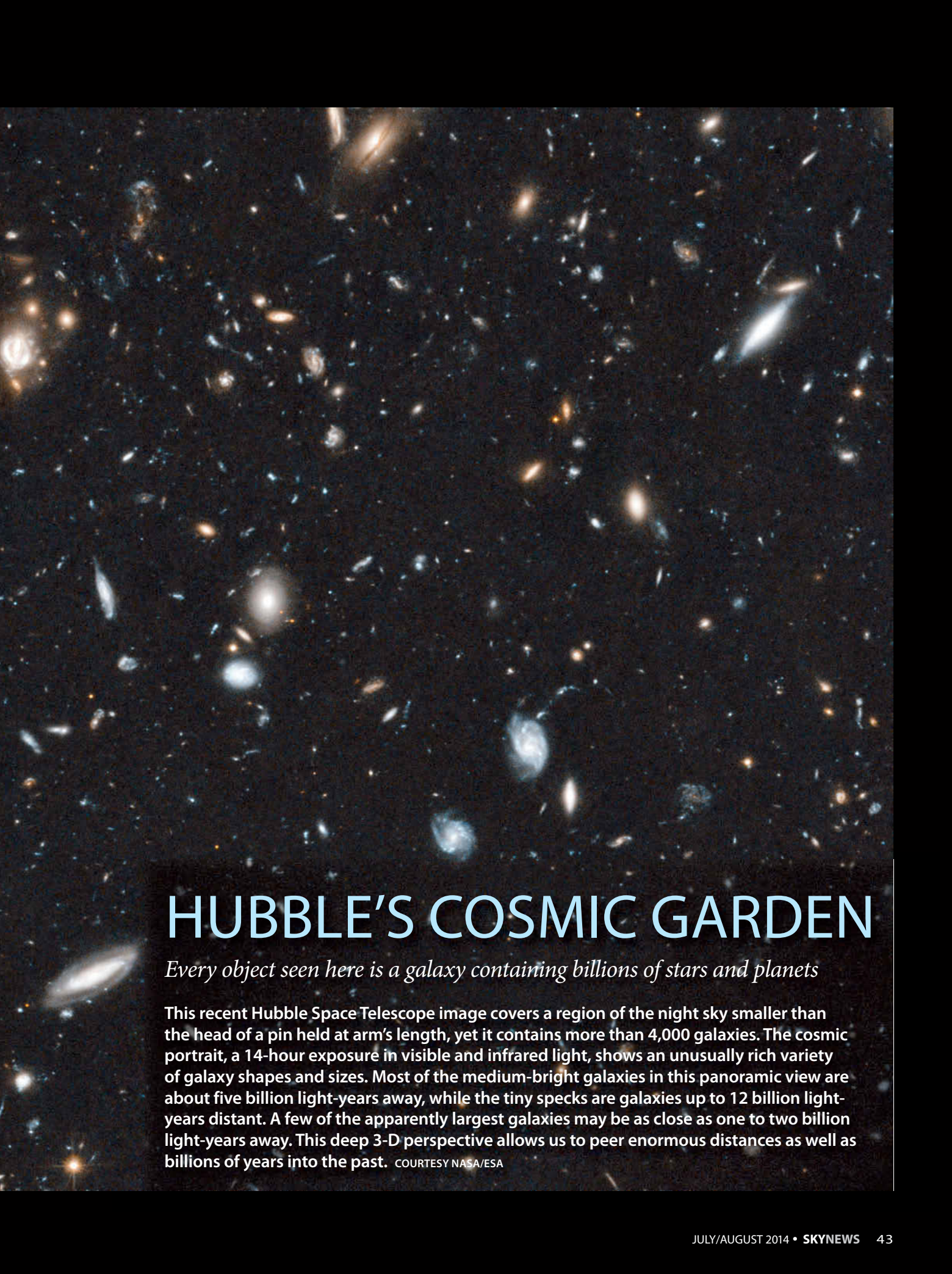
Galaxy clusters are the largest known structures in the cosmos, containing literally hundreds of trillions of stars. The way they form and develop through repeated collisions has profound implications for our understanding of the universe's evolution and its ultimate destiny. ♦





ALIEN SPACESCAPE Hubble Space Telescope Frontier Fields image of the cluster of galaxies known as Abell 2744, a.k.a. Pandora's Cluster. COURTESY NASA/ESA





HUBBLE'S COSMIC GARDEN

Every object seen here is a galaxy containing billions of stars and planets

This recent Hubble Space Telescope image covers a region of the night sky smaller than the head of a pin held at arm's length, yet it contains more than 4,000 galaxies. The cosmic portrait, a 14-hour exposure in visible and infrared light, shows an unusually rich variety of galaxy shapes and sizes. Most of the medium-bright galaxies in this panoramic view are about five billion light-years away, while the tiny specks are galaxies up to 12 billion light-years distant. A few of the apparently largest galaxies may be as close as one to two billion light-years away. This deep 3-D perspective allows us to peer enormous distances as well as billions of years into the past. COURTESY NASA/ESA

NORMAND FULLUM: A Master Craftsman

Offering some of the largest telescopes available to amateur astronomers

by Doug Cunningham

I love to look through the eyepiece of one of my telescopes and see the beauty of the universe. I tell myself that I made this possible with my own hands. I don't think there is a better feeling than that.

—Normand Fullum

MY WIFE Paula and I first met Normand Fullum at Starfest in southwestern Ontario in 2011. Normand lives in Hudson, Quebec, and makes superb telescopes at his shop in Vaudreuil-Dorion. At that time, we were looking to purchase telescopes for our new Four Elements Observatory at our cottage on the Bruce Peninsula. We had researched many manufacturers, all of them American—Obsession, Webster, Zambuto and Kennedy Optics. Each one marketed quality products. As we left the lecture tent for lunch, we encountered Normand's beautiful Dobsonian telescopes. Striking creations crafted out of specialty woods, they looked and felt like fine furniture. Normand explained that he made his own mirrors and that his telescopes had won many awards at the Stellafane astronomy convention. I was curious. Would these telescopes perform as well as they looked?

Later that night, I got my answer when Normand gave us a tour of the summer Milky Way using his 16-inch f/4.75 Dobsonian. The Ethos eyepiece views exceeded any we had seen in similar-aperture telescopes. Before Normand puts his name on any telescope he builds, it must meet his exacting standards. He is both an observer and a telescope maker. I liked that combination and wanted to learn more. Normand could construct complete telescopes having apertures in excess of 60 inches. I didn't know any other North American company that was manufacturing such large-aperture scopes for amateur astronomers. Yet here was a Canadian manufacturer producing quality, large-aperture mirrors and telescopes.

Normand's fascination with astronomy began when he was about six years old and viewed the Moon and Saturn through a neighbour's telescope. He was so impressed by what he saw in the small refractor, he promised himself that one day, he would own a big telescope. In the early 1990s, he built that big telescope: a 12.5-inch f/7 Newtonian. Because he had no experience in optics, he read the mirror-making books four times before he started

grinding the mirror. It took him 1½ years to finish that mirror. He recalled that the eyepiece views were very, very good. Encouraged by this early success, he built a second scope, a 7-inch f/4.5 Dobsonian, for his son Julian. This scope was a work of art. He decided to make Julian's complete scope out of maple. Normand loves the texture

and touch of various woods and is inspired by the rich tint that enhances the wood grain when the first coat of varnish is applied. This telescope would prove to be a major launching point in Normand's career.

In 1997, Normand's friends suggested that he enter this beautiful telescope in Stellafane's Telescope Competition. When he was awarded first place for craftsmanship, Normand was motivated to build other wooden telescopes, employing exotic woods from around the world. Between 1997 and 2006, Normand won numerous awards at Stellafane in the craftsmanship, mechanical and optical categories.

By 2006, so many telescopes crowded his living room that Normand decided to sell some of them. Apparently, there was a niche market for his exquisitely crafted telescopes, and he decided to take a big step. He quit his job as a colourist for a car paint company to make telescopes full-time, while taking a business course at night school. His wife Line is his main emotional support and helped him through the rough patches of a start-up entrepreneur. Normand called his company Telescopes Normand Fullum (now Optiques Fullum Inc.). His company offers some of the largest telescopes available to amateur astronomers, and his telescopes have been purchased by astronomers in Canada, the United States, France, the Netherlands, Spain, Italy, Austria, Germany, Switzerland, Mexico, Japan and Australia. Following the 2003 bushfires in Australia that engulfed Mount Stromlo and destroyed the "Great Melbourne Telescope," he was invited to provide a quote to make the replacement 50-inch mirror.



ASTRO-PERFECTIONIST Normand Fullum.
Left: M33 through a Fullum 17-inch mirror.

PHOTOS BY RICHARD JORDAN (ABOVE) AND DAN WILSON (LEFT)



ART & SCIENCE Fullum's 16-inch Dobsonian is as beautiful to look at as it is to look through.
Right: M51 using Fullum optics. PHOTOS BY DOUG CUNNINGHAM (ABOVE) AND DAN WILSON (RIGHT)



TELESCOPE NIRVANA Left: Normand Fullum surrounded by a collection of his telescopes. Above: Saturn with a Fullum 16-inch mirror. PHOTOS BY DOUG CUNNINGHAM (LEFT) AND ANTHONY WESLEY (ABOVE)

I have two 36-inch telescopes from Normand and, very soon, a 61-inch f/3.5. I trusted his polishing abilities the first time I met him several years ago. Last year, I resolved the double star beta Delphini at 0.2 arc second with my first 36-inch scope. Last September, I resolved the disc of asteroid 324 Bamberga, at a diameter of 0.3 arc second. Extragalactic globulars and H II regions in Local Group galaxies can be seen visually with these scopes. Indeed, individual stars can be resolved in the spiral arms of M31 and M33. This gives you an idea of the quality of Normand's optics.

—Jeff Viens, Université Laval,
Canada Excellence Research Chair
in Photonic Innovations

As he talks about the business challenges he has faced, it is immediately apparent that Normand Fullum is a tenacious problem solver. When he couldn't obtain large-aperture Pyrex mirror blanks fused the way he wanted, he turned to his friend Jeff Viens, a Canada Excellence Research Chair in Photonic Innovations at Université Laval. Jeff had patented a process for making lightweight "honeycombed" telescope mirrors. Employing Jeff's process, Normand is able to produce mirror blanks up to 65 inches or more in diameter.

Essentially, two Pyrex glass plates are attached to each other using special glass pillars and a slight amount of epoxy. This is placed in a specially built high-temperature oven, where it fuses together. The fused glass is put on a reusable mould made of firebrick, where it is shaped into a convex curve for a definite f-ratio and heated again until the glass takes the required configuration. Then the real work of grinding, polishing and testing begins.

Describing himself as an "old-school guy," Normand uses Foucault testing, Figure XP software and his judgment to manufacture his mirrors. He sets a quality goal in terms of wavelength correction and Strehl ratio, and when he achieves double those numbers, he stops correcting the mirror. The whole process of testing and adjusting a 36-inch f/3.5 mirror takes between 40 and 100 hours, and Normand says that he finds this aspect of mirror production the most interesting. The mirror is now ready for the aluminizing chamber. Sending a mirror greater than 30 inches in diameter to California for aluminizing was prohibitive in terms of cost, so Normand again turned to Jeff Viens and Université Laval for help. Their collaboration resulted in the construction of an aluminizing and overcoating chamber that can treat mirrors up to 65 inches in diameter and costs hundreds of thousands of dollars less than buying a commercially built vacuum chamber.

As owners of Normand Fullum telescopes, my wife and I know the quality of Normand's work. Last fall, we visited his manufacturing facility, and Normand and François St-Martin showed us around. The whole telescope-making operation is under one roof. When we entered the shop, we came face-to-face with Jeff Viens' huge 61-inch f/3.5 lightweight mirror on the grinding machine. At that point, more than 50 pounds of glass had been removed from

the mirror blank. Next, we saw the fusion oven that is used to make the huge mirror blanks, three grinding machines that are in continuous operation and the vacuum chamber that was aluminizing and overcoating a 30-inch mirror. Normand can complete a total telescope, such as a 36-inch f/3.5 scope, in about 10 months. We saw a 36-inch f/3.5 folded-optics telescope that was ready to be shipped to Italy and a 50-inch folded-optics f/3.5 Dobsonian that was 90 percent finished and destined for California. These large scopes use inverted aluminum A-frames, powder-coated black, and employ ServoCAT and Argo Navis for their slewing and tracking operations.

What does the future hold for Normand Fullum? First and foremost, Normand is beginning to actively promote the business and raise his profile within the astronomy community. He is heading to Italy this year to install one of his telescopes, and while there, he will showcase his telescope-making expertise to other amateur astronomers. Normand has also started producing mirrors for an Italian company and hopes to market his mirror-making skills to other European telescope and instrument manufacturers.

On the technical side, Normand will be working with co-op students at École Polytechnique de Montréal to develop a measuring system that can test his large-aperture mirrors. And he has recently received an inquiry about building a 140-inch telescope. Now that would really change his shop!

In the meantime, Normand will continue to do what he most enjoys: building and using impressive telescopes. And the

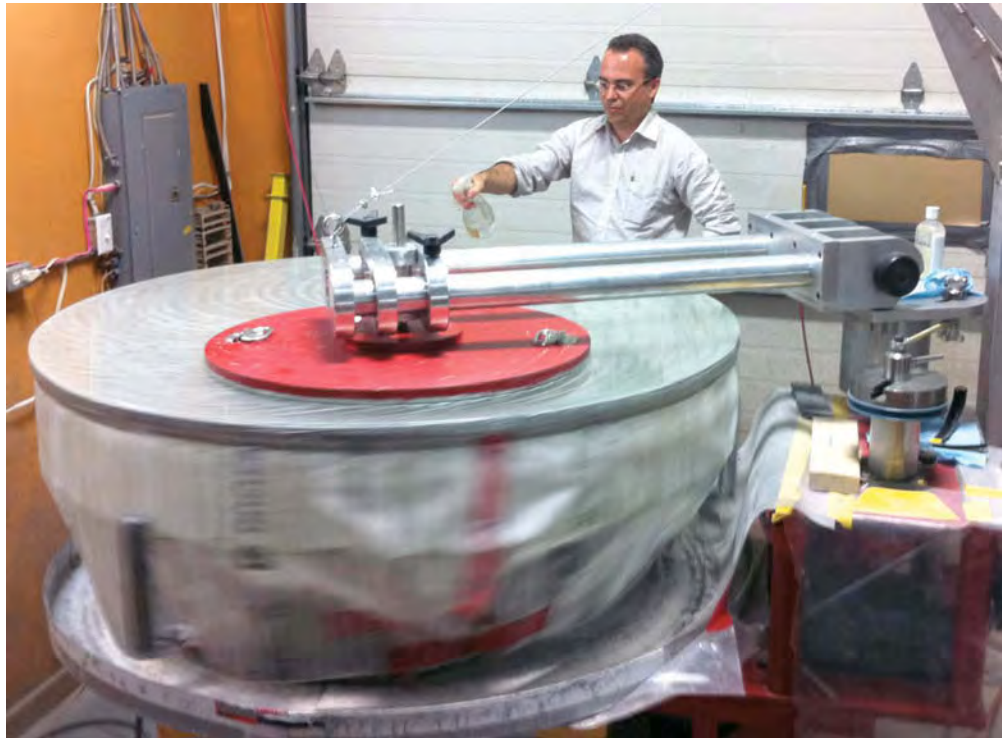
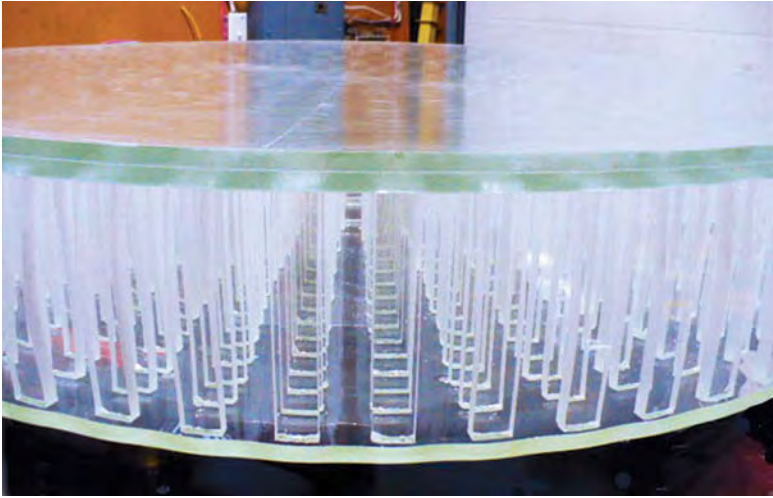
future for Canadian-built telescopes is looking up! ♦

Readers interested in more details can check out Normand Fullum's website (www.normandfullumtelescope.com/en).

Doug Cunningham, a retired science and outdoor-education teacher, has been an amateur astronomer for over 45 years. He and his wife Paula live in Lion's Head, Ontario, where they taught at the same school for decades and today are active in preserving the pristine dark skies of Ontario's Bruce Peninsula. During his 33-year career as a science educator, Doug received the Prime Minister's Award for Teaching Excellence and the National Youth Science Foundation Award.



Mars imaged by Anthony Wesley using a Fullum 16-inch Techno-Fusion mirror.



SERIOUS TELESCOPE BUILDING

Clockwise from top left: Side view of a 50-inch Fullum f/3.5 Techno-Fusion mirror ready for the aluminizing chamber; Jeff Viens stands beside a 61-inch mirror about to be tested; Jeff Viens assists with the polishing of the 61-inch mirror; Normand Fullum and François St-Martin view a 30-inch Fullum Techno-Fusion mirror after aluminizing; Normand Fullum and his 50-inch Dobsonian-mounted folded-optics telescope.

FIRST THREE PHOTOS BY NORMAND FULLUM;
FINAL TWO PHOTOS BY DOUG CUNNINGHAM

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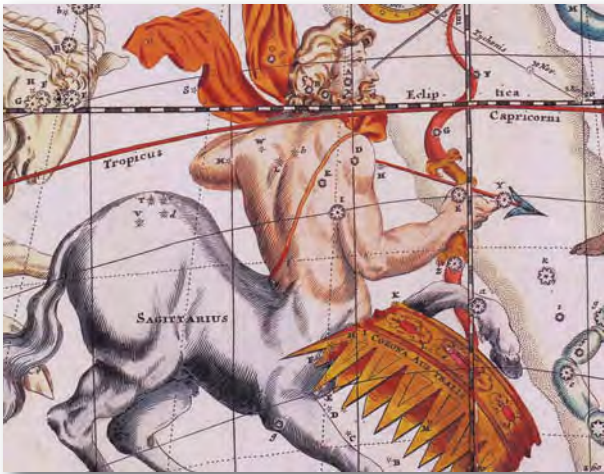
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The Canadian Magazine of Astronomy & Stargazing

SAGITTARIUS

This constellation may ride low in Canadian skies, but for the ancient Greeks, he galloped high in the south

by Ken Hewitt-White



GALLOPED? Yes. Sagittarius was a centaur, boasting the head, arms and chest of a man and the body and legs of a horse. A skilled archer, this creature was the ultimate fighting machine. We see his arrow aiming at the heart of nearby Scorpius the scorpion.

This celestial bow-and-arrow act is tremendously old. Sumerian cuneiform inscriptions dating back 5,000 years depict the star pattern as an archer. Its official title was Nergal, the god of war. Centuries later, the Greeks kept Nergal's military role but gave him a new name and body.

Other cultures envisioned ordinary animals in the Sagittarius region, among them a camel, a tiger and an ostrich. All are impossible to picture among these stars. For that matter, so is the weapon-wielding centaur.

Let's try something else. A handful of constellations form easy stick figures not related to mythology. In the case of Sagittarius, for example, we have a celestial teapot, whose eight-star outline is far easier to trace than that of a centaur.

The late George Lovi, an American astronomy popularizer, wrote that the area around Sagittarius provides an entire tea service. Above and to the left of the teapot's handle, several faint stars trace a rough teaspoon. To the right, a hazy swath of Milky Way rises like steam from the teapot's spout. Those who live in southernmost Canada can see more: Below and to the right of the spout, the scorpion's curving

tail makes a largish cup in which to pour the tea. Leftward, directly under the pot, the semicircle of Corona Australis forms a tasty slice of lemon.

Since Sagittarius has been a recognized constellation for approximately 5,000 years, the question arises: Do the constellations change over long time spans? The qualified answer is no. The stars are so remote that even though they are moving around the galaxy, their change in position in our sky over thousands of years is negligible by naked-eye tolerances. However, there is one overall alteration that a time-traveling astronomer would notice: precession. The 26,000-year wobble of the Earth's axis placed the Sagittarius sector of the night sky 13.5 degrees higher in 3000 B.C. than it is today.

Imagine it's 3000 B.C. Even from what is present-day Edmonton, Alberta, the complete Lovi tea service hovers above the south horizon. Also visible just left of the lemon slice (Corona Australis) is the 15th brightest star in Sagittarius. Oddly, this dim dot became alpha Sagittarii. ♦

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10 Fun Facts About the Moon

Our nearest neighbour is a fascinating place. Here are some factoids you can use at your next Moon-observing party.

1. Our Moon is the biggest satellite in the solar system relative to the planet it orbits. It's more than one-quarter the Earth's diameter, which, by some definitions, makes ours a double-planet system. And of the four rocky worlds nearest the Sun, Earth is the only one with a *real* moon. Mercury and Venus orbit solo, while Mars is accompanied by two tiny satellites that are most likely captured asteroids.

2. Driving to the Moon would take a long, long time. While Apollo astronauts managed to rocket into lunar orbit in only three days, driving there in your car would take more than five months. And even then, you'd have to go 100 kilometres per hour without stopping for gas or bathroom breaks. A trip to the Moon would probably void your vehicle's warrantee too.

3. There's no such thing as the "dark side" of the Moon. Far be it for me to contradict a popular song by a popular band, but both sides of the Moon receive exactly the same amount of sunlight. The lunar *far side* is simply the hemisphere hidden from earthly view, but of course, it receives as much daylight as the side we can see. Even Walter Cronkite, the iconic television anchorman of the Apollo program, got it wrong several times.

4. No one has walked on the Moon since December 1972. That's right. Not since bell-bottom trousers were fashionable and teenagers were discovering the modest thrills of a video game called Pong has anyone set foot on luna firma. Yet whenever I tell young kids this, they find it hard to believe, because space exploration seems so routine to them. Sometimes even I have a hard time believing it's been that long.

5. The dinosaurs looked up at the same Moon as we do. When dinosaurs roamed the Earth 65 million years ago, the familiar face of the Moon was already complete. All the main craters, maria and other surface features are much older than humanity.

6. The "silvery" Moon is actually dark grey. The lunar surface is about as bright as asphalt under the mid-



JUST MOONING AROUND The full Moon rises over a bank of clouds. PHOTO BY GARY SERONIK

day Sun. So why does it look so bright in the sky? Call it an extreme contrast effect: Set against the darkness of the night sky, the Moon only *seems* superbright. When you spot the Moon during daylight hours, you know how pale it really is.

7. The rising Moon isn't bigger than at any other time. Anyone who has seen a full Moon hovering above a distant horizon has witnessed the "Moon illusion" at work. Not convinced? Try this experiment next time. Cover the lunar disc with the eraser end of a pencil held at arm's length. Then try again when it's overhead. You'll find that you can erase the Moon equally well in both situations.

8. The best time to view the Moon is not when it's full. Friends who know about your interest in astronomy have probably asked you at one time or another whether you were "out last night looking at the full Moon." As impressive as it is to the unaided eye, the full Moon isn't nearly as interesting for telescope users as are the other phases because when the lunar surface is fully lit, there are no shadows, which make features stand out.

9. In total, we have gathered only about 950 pounds of Moon rocks. Most of these were collected by the Apollo astronauts, and some are from meteorites that originated on the Moon. By comparison, our stockpile of diamonds grows each year by 60 times this amount.

10. We may owe our lives to the Moon—literally. If one current theory is correct, none of us would be here if Earth hadn't had a big moon. The complex interactions between the stability of the Earth's rotation and axial tilt generated by the tides of the Moon ultimately led to the rich diversity of life we have on this planet. Without the Moon's tidal influence, conditions may have been too erratic and hostile for complex life to emerge. And "complex life" includes us. ♦

An award-winning author, Gary Seronik is the editor of this magazine's website, SkyNews.ca.

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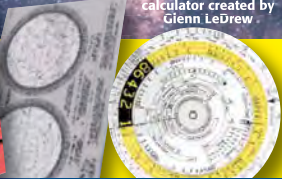
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Remembering John Dobson (1915-2014), Part 2

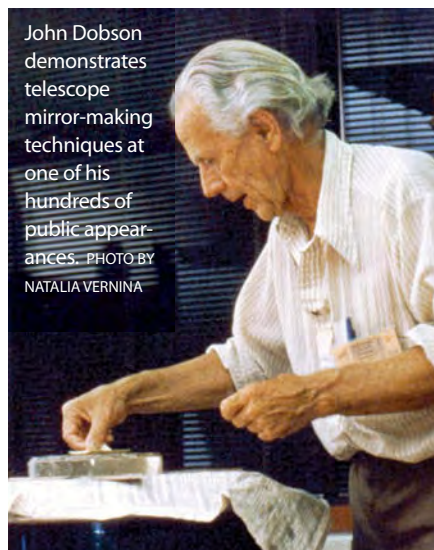
It was supposed to be the road trip of a lifetime—touring my favourite parks in British Columbia with John Dobson, the iconic inventor of the Dobsonian telescope. But the dream almost turned into a nightmare.

The year was 1982. Your agent was a lecturer and an outreach programmer at Vancouver's H.R. MacMillan Planetarium. I loved travelling around British Columbia in my camper van, presenting slide shows and conducting public observing sessions with a snazzy 12½-inch Newtonian reflector. That July, I was prepping for my usual summer circuit of provincial parks—and I was pumped. John Dobson was coming!

A former Vedantan monk with a gift for the gab, Dobson considered astro-outreach his *raison d'être*. Indeed, the man's business card read "Have Telescope, Will Travel." As spiritual leader of the San Francisco Sidewalk Astronomers, Dobson inspired a loyal band of followers to build bare-bones, thin-mirror "Dobsonian" telescopes for use in public stargazing on city street corners. The Sidewalkers also began visiting national parks in the western United States. By 1982, Dobson & Co. were touring in a donated motor home that hauled a giant 24-inch f/7 solid-tube Dobsonian on a trailer. My bold plan was to bring the whole lot to Canada.

Ah, yes, the best-laid plans. The crew of four was halfway here when my project was dealt a severe setback: A government workers' strike that had been brewing for weeks suddenly shut down our provincial parks. What to do? Working through the planetarium, I contacted Parks Canada to ask whether it would be willing to host, on short notice, an American astronomy organization renowned for its public service. The protocol was formal, the negotiations delicate, but I obtained permission for us to visit several spectacular national parks along the Rocky Mountains of British Columbia and Alberta. Whew!

It was a midweek morning when a cer-



John Dobson demonstrates telescope mirror-making techniques at one of his hundreds of public appearances. PHOTO BY NATALIA VERNINA

tain well-marked Winnebago, the 24-incher in tow, rolled to a stop at the border south of Vancouver. I was waiting at Canada Customs to greet my guests. Good thing too, because the procedure didn't go smoothly. The trailer-mounted cannon required considerable explanation, and a vehicle search turned up so many wacky telescopic contraptions that the customs agents embargoed the whole lot. A frantic call to my boss at the planetarium produced much yelling (in one direction only) and the hiring of a customs broker, the cost of which, I was assured, would come out of my hide. Hours passed before we were allowed to proceed.

Then more drama: Our three-week sojourn was plagued by overcast and rain. We didn't do much scoping, but there was lots of talking. My most vivid memory is of a damp amphitheatre packed with campers waiting for the starman from San Francisco. A park ranger invited me onstage, and I introduced John to loud applause. John faced

the crowd and started off—coily—by asking whether anyone had any questions. Oh, that clever Dobson dude. He managed to twist the ensuing Q&A session into a presentation of his contrarian views on the Big Bang and the early universe. After a drizzly hour on Einstein, gravity and "Hydrogen as the Primordial Apparition," the stunned audience looked as though it had been struck by a starship going at warp factor six.

Whenever the weather cleared, we were quick to deploy the Dobs. I recall a typical Rocky Mountain midnight when hundreds of campers surrounded our towering light-buckets, with John scurrying from scope to scope, guiding people up the ladders and challenging them to understand the various celestial wonders. It was vintage Dobson. Outspoken and eccentric? Sure. A ham? Sometimes. But make no mistake: John the evangelistic stargazer devoutly believed in the importance of taking telescopes to the masses. And while he'd happily set up on any city sidewalk, John understood the value of wilderness parks where, he said, "dark skies and the public collide."

Although John's mission embraced the wider public, his better-known legacy is in the arcane world of amateur astronomy. The apostle of the thin-mirror movement created telescopes so universally appealing—simple, inexpensive, portable—that even really large Dobsonians are considered mainstream equipment today. In short, John Lowry Dobson broke the aperture barrier. I'll always love him for that ♦

Three years after his summer tour with John Dobson, contributing editor Ken Hewitt-White acquired a "classic" homebuilt 17.5-inch Dobsonian that he still uses today.



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