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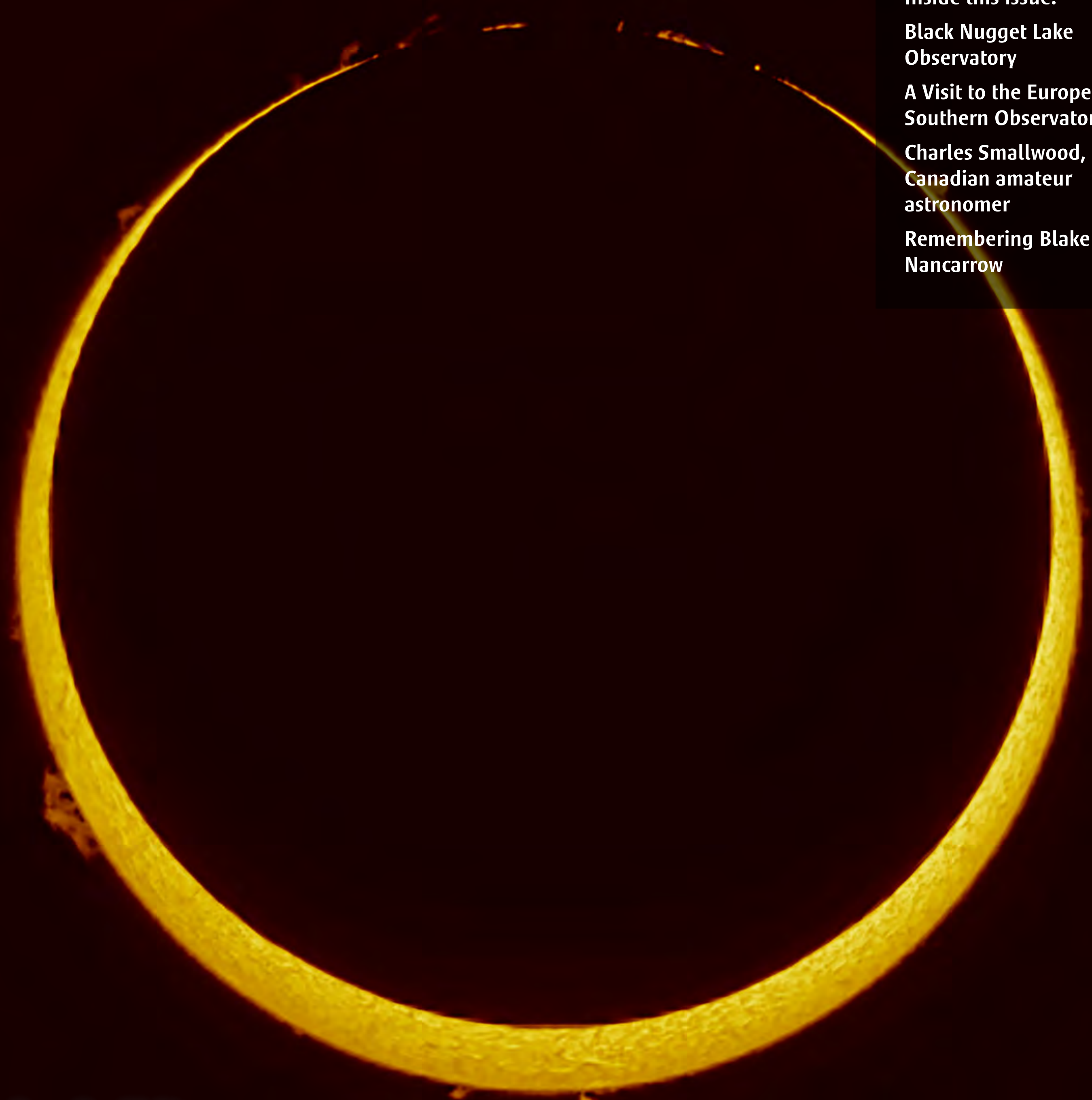

Annular Eclipse

Journal

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Andrea Girones captured the annular solar eclipse from Albuquerque, New Mexico, using a Lunt 40-mm solar scope and an ASI 174-mm camera, tracked on a Sky-Watcher Star Adventurer under "pristine skies" on 2023 October 14. "Wisps of the bright Sun can be seen between the caves and crevasses of the Moon, an effect known as Baily's beads," she notes. "Normally this is a total eclipse phenomenon, but not always."

Journal

The *Journal* is a bi-monthly publication of The Royal Astronomical Society of Canada and is devoted to the advancement of astronomy and allied sciences. It contains articles on Canadian astronomers and current activities of the RASC and its Centres, research and review papers by professional and amateur astronomers, and articles of a historical, biographical, or educational nature of general interest to the astronomical community. All contributions are welcome, but the editors reserve the right to edit material prior to publication. Research papers are reviewed prior to publication, and professional astronomers with institutional affiliations are asked to pay publication charges of $100 per page. Such charges are waived for RASC members who do not have access to professional funds as well as for solicited articles. Manuscripts and other submitted material may be in English or French, and should be sent to the Editor-in-Chief.

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President's Corner

Chasing the Ring of Fire, and Other Umbral Thoughts

by Michael Watson, President
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In August 2017, the Moon's umbral shadow had not passed over populated parts of North America for 26 years. The last total eclipses of the Sun that had been easily visible from anywhere on our continent, and from Canada, respectively, had been in July 1991 in México and February 1979 in the northwestern U.S. and Manitoba. For many RASC members, myself included, the 1979 total eclipse was our first, and got us hooked for our lifetimes on this most spectacular of all natural phenomena.

The Moon's umbral shadow visited again on 2017 August 21, and tens if not hundreds of thousands of Americans, Canadians, and eclipse aficionados from other parts of the globe flocked to Oregon, Idaho, Wyoming, Nebraska, Missouri, and half a dozen states further east to see what the news media called the Great American Eclipse. With my family and friends, I saw this event from western Nebraska in a wonderfully clear sky, but we had driven five hours from the centre of the state early that morning in dense fog before arriving at our final observing site north of Scottsbluff. We drove that distance in order to escape the cloud that was forecasted for Grand Island, where we had stayed the previous night and from which we had intended to see the eclipse.

Eclipsophiles have known for decades that the second Great American Eclipse within seven years will occur this coming Monday, April 8. The Moon's umbral shadow will start in the Pacific Ocean north of Bora Bora, cross México for a little more than 20 minutes, then enter the United States at the Texas border and make its way northeastward for 45 minutes through 14 states. Canadians in southern Ontario, Québec south of Montréal, then New Brunswick, the northwestern half of Prince Edward Island, a tiny part of northern Cape Breton Island, and then much of Newfoundland will have a chance to see the Sun's corona for up to 3 minutes 43 seconds on the north shore of Lake Erie, and somewhat less further east in the path of totality. Those who choose to observe from the United States can expect up to 4 minutes 26 seconds of totality. Hotels and campgrounds within or close to the U.S. part of the path of totality have been booked for months, and prices for accommodations have skyrocketed. This will no doubt be the most widely observed solar eclipse ever.

Most of us learned early in our astronomical lives an amazing coincidence of nature that exists in this epoch of the Earth-Moon system's existence: The Sun lies about 400 times as far

Figure 1 — Michael set up for the Annular solar eclipse (in Midland, Texas)

away from Earth as does our Moon, and the Sun is also about 400 times the diameter of the Moon. As seen from the surface of our home planet, therefore, the Sun and the Moon appear to be about the same size in the sky. We also know that Earth and the Moon revolve around a common centre of gravity (located just inside the surface of Earth), and since there is no such thing as a perfectly circular orbit, the Moon's orbit is decidedly elliptical. In the millennium between CE 1500 and 2500, the extreme values of the Moon's distance from Earth are 356,371 km at perigee (2257 Jan. 1) and 406,720 km at apogee (2266 Jan. 7), a difference of about 14% (Meeus, 1987).

When the Moon is at or near apogee at the time when it passes centrally across the Sun as seen from Earth, it is not large enough to cover the bright surface of the Sun completely. At mid-eclipse, a thin ring or "annulus" of the Sun's surface is still visible around the dark circle of the Moon. This is an "annular" as opposed to a total eclipse of the Sun; while annular eclipses are somewhat more frequent than total eclipses, only the keenest observers travel any great distance to see an annular eclipse, since the solar corona is not visible during such an eclipse. Some consider an annular eclipse as more of a geometric curiosity as compared with the dramatic spectacle of a total eclipse. As well, of course, during all phases of an annular eclipse, proper eye protection must be used, whereas the total phase of a total eclipse of the Sun can be safely observed with unprotected eyes (no solar filter necessary).

This is all a prelude to my little story about a quick trip that I made from Toronto to the southwest U.S. to see the 4 minute 56 second annular eclipse of this past Saturday, October 14. News media in Canada and the United States had been talking about this eclipse—which they dubbed the "Ring of Fire"—for weeks. The path of annularity would start in the Pacific Ocean, enter the U.S. in Oregon, then curve south across California-Nevada; then across the point where Utah, Colorado, New Mexico, and Arizona all meet each other; and finally Texas before leaving the U.S. for the Yucatán Peninsula and northern South America. I had been musing about seeing this eclipse for a year or so, but then some Labour Board hearings in which I was involved got scheduled for the Tuesday and Wednesday before the Saturday eclipse, and then also for the Tuesday and Wednesday of the following week. So I had only a five-day window to make my way to the eclipse and back. That would have been more than enough time if I were flying, but it would have been both risky and hugely expensive to fly my telescope, mount, and other equipment to New Mexico or Texas. So I had decided long ago that if I went to the eclipse, it would have to be a driving trip, and a long one at that; 5,600 km return.

Originally, I had picked Corpus Christi on the Texas Gulf Coast for an observing location, but ten days or so before the eclipse, it seemed that the weather prospects for Roswell, New Mexico, looked very good. So I changed my plan, reserved a hotel room in Roswell (and a back-up one in Hobbs, New Mexico, on the Texas border), and found online a couple of good observing sites about 32 km out of Roswell, right on the centre line of the eclipse.

My Labour Board hearing ended at 16:15 on the Wednesday before the eclipse, and 20 minutes later I was in the car, headed for Ft. Wayne, Indiana, 630 km away, for the night. The next day would be a long one, I knew, because I had to drive a little more than 1,200 km to Tulsa, Oklahoma, where I would stay on the Thursday night. When I got to Tulsa, I checked the weather forecast again, and it had changed—no surprise for an astronomer. Now it looked as though cloud was moving in over eastern New Mexico, and Corpus Christi would be completely socked in. But it appeared that there would be a several-hundred-kilometre-wide hole in the clouds over western Texas, so I decided to go instead to Midland (pop. 123,000). I quickly made a hotel reservation, cancelled the other three that I had in various other locations, and jumped into bed. I was up and on the road at 04:30 the next morning for the 950 km drive to Midland, where I arrived a little before noon on Friday. There was much eclipse talk in the city, at the local visitor centre and at the city's planetarium, where I

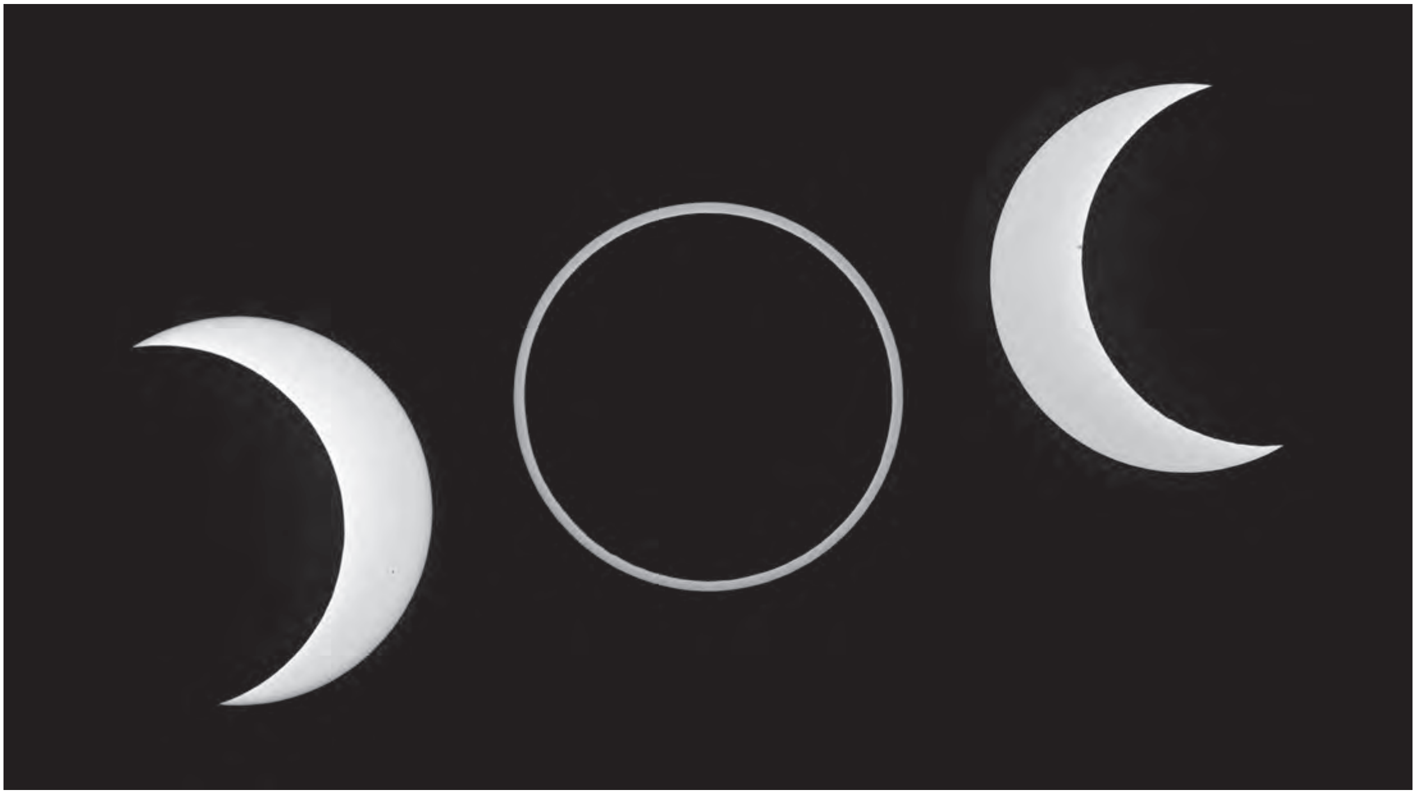

Figure 2 — Annular eclipse photo collage; the leading and trailing partial-phase photos were captured 20 minutes before and after mid-eclipse.

picked up a Midland eclipse tee-shirt, and saw the impressive schedule of eclipse events for the next day, which included a Native American astronaut. Then it was off to check various parks in the city for suitable observing locations. I found a good one at Beal Park, just 4 km from the centre line.

Saturday, October 14 dawned clear and cool, with brilliant Venus rising in the east ahead of the about-to-be-eclipsed Sun. The usual eclipse excitement washed over me, and I headed to the park to set up. Soon dozens of other keen observers were there, some with telescopes and all of them with eclipse safety glasses. The stiff wind that had been blowing for several days died down somewhat, so I was able to get some decent photos as the eclipse progressed.

What I did not expect, I have to say, was the stunning and really awe-inspiring sight of the thin annulus of Sun surrounding the black disk of the Moon when I looked up during the annular phase with my eclipse glasses on, and no optical aid. I hadn't recalled seeing that sight during the 1994 annular eclipse that I had observed with eclipse-predicter extraordinaire Fred Espanak in Ohio.

Everyone was in a celebratory mood as the trailing partial phase unwound. Well, everybody but maybe the congenial 30-something fellow who came by when the eclipse was almost over. This was the conversation: "What are all these people here with telescopes for?" "Uh, to see the eclipse." "Oh, is that tonight?" "No … it's the eclipse of the Sun that the newspapers and TV here have been full of for the last few weeks. It just ended." "Oh. Well I don't listen to any news. It's depressing. Bye!" And that was that. I got in the car, drove 2,800 km back to Toronto over the next couple of days, and was back at the Labour Board the following Tuesday. All in all, it was a hugely successful and exciting trip. I am so looking forward to this coming April's total eclipse, as are so many of my fellow RASC members! ✶

News Notes / En manchette

Compiled by Jay Anderson

TRAPPIST-1: one down, six to go

Astronomers led by a team at Université de Montréal have made important progress in understanding the intriguing TRAPPIST-1 exoplanetary system, which was first discovered in 2016 amid speculation it could someday provide a place for humans to live. Not only does the new research shed light on the nature of TRAPPIST-1 b, the exoplanet orbiting closest to the system's star, it has also shown the importance of understanding parent stars when studying exoplanets.

The findings by astronomers at UdeM's Trottier Institute for Research on Exoplanets (iREx) and colleagues in Canada, the U.K., and U.S. shed light on the complex interplay between stellar activity and exoplanet characteristics.

TRAPPIST-1, a star much smaller and cooler than our Sun located approximately 40 light-years away from Earth, has captured the attention of scientists and space enthusiasts alike since the discovery of its 7 Earth-sized exoplanets 7 years ago. These worlds, tightly packed around their star with three of them within its habitable zone, have fueled hopes of finding potentially habitable environments beyond our Solar System.

Led by iREx doctoral student Olivia Lim, the researchers employed the *James Webb Space Telescope* (JWST) to observe TRAPPIST-1 b. Their observations were collected as part of the largest Canadian-led General Observers (GO) program during the JWST's first year of operations. This program also included observations of three other planets in the system, TRAPPIST-1 c, g, and h. TRAPPIST-1 b was observed during two transits—the moments when the planet passes in front of its star—using the Canadian-made NIRISS instrument aboard the JWST.

Figure 1 — This artistic representation of the TRAPPIST-1 red-dwarf star showcases its very active nature. The star appears to have many stellar spots (colder regions of its surface, similar to sunspots) and flares. The exoplanet TRAPPIST-1 b, the closest planet to the system's central star, can be seen in the foreground with no apparent atmosphere. The exoplanet TRAPPIST-1 g, one of the planets in the system's habitable zone, can be seen in the background to the right of the star. The TRAPPIST-1 system contains seven Earth-sized exoplanets. Image: Benoît Gougeon, Université de Montréal.

By analyzing the central star's light after it has passed through the exoplanet's atmosphere during a transit, astronomers can search for the unique spectroscopic fingerprint left behind by the molecules and atoms found within that atmosphere.

"This is just a small subset of many more observations of this unique planetary system yet to come and to be analyzed," adds René Doyon, Principal Investigator of the NIRISS instrument and co-author on the study. "These first observations highlight the power of NIRISS and the JWST in general to probe the thin atmospheres around rocky planets."

The astronomers' key finding showed the importance of accounting for stellar activity and contamination when trying to determine the nature of an exoplanet's atmosphere. Stellar contamination refers to the influence of the star's own features, such as dark spots and bright faculae, on the measurements of the exoplanet's atmosphere.

The team found compelling evidence that stellar contamination plays a crucial role in shaping their transmission spectra of TRAPPIST-1 b and, likely, the other planets in the system. The central star's activity can create "ghost signals" that may fool the observer into thinking they have detected a particular molecule in the exoplanet's atmosphere.

This result underscores the importance of considering stellar contamination when planning future observations of all exoplanetary systems, the scientists say. This is especially true for systems like TRAPPIST-1, since the planets orbit a red-dwarf star that can be particularly active with starspots and frequent flare events.

"In addition to the contamination from stellar spots and faculae, we saw a stellar flare, an unpredictable event during which the star looks brighter for several minutes or hours," said Lim. "This flare affected our measurement of the amount of light blocked by the planet. Such signatures of stellar activity are difficult to model but we need to account for them to ensure that we interpret the data correctly."

Based on their collected JWST observations, Lim and her team explored a range of atmospheric models for TRAPPIST-1 b, examining various possible compositions and scenarios. They found they could confidently rule out the existence of cloud-free, hydrogen-rich atmospheres—in other words, there appears to be no clear, extended atmosphere around TRAPPIST-1 b. However, the data could not confidently exclude thinner atmospheres, such as those composed of pure water, carbon dioxide, or methane, nor an atmosphere similar to that of Titan, a moon of Saturn and the only moon in the Solar System with its own atmosphere.

These results are generally consistent with previous (photometric) JWST observations of TRAPPIST-1 b with the MIRI instrument. The new study also proves that Canada's NIRISS instrument is a sensitive probe of atmospheres on Earth-sized exoplanets at impressive levels.

Composed with material provided by Université de Montréal.

Largest telescope begins pouring final mirror

The Giant Magellan Telescope has begun the four-year process to fabricate and polish its 7th and final primary mirror, the last required to complete the telescope's 368-square-metre light-collecting surface. Together, the seven mirrors will allow astronomers to further unlock the secrets of the Universe by providing detailed chemical analyses of celestial objects and evidence of their origin.

In September, the University of Arizona Richard F. Caris Mirror Lab closed the lid on nearly 18 tonnes of the purest optical glass inside a one-of-a-kind oven housed beneath the stands of the Arizona Wildcats Football Stadium. Over a period of 12–13 weeks, the spinning oven will heat the glass to 1165 °C so that, as it melts, the semi-liquid glass will adopt a curved paraboloid surface, the first step on its way to a completed instrument. Measuring 8.4-metres in diameter—about two storeys tall when standing on edge—the mirror will then cool over the following three months before it is moved into the polishing stage.

At 50 million times more powerful than the human eye, "the telescope will make history through its future discoveries," shares Buell Jannuzi, Principal Investigator for the fabrication of the Giant Magellan Telescope primary mirror segments, Director of Steward Observatory, and Head of the Department of Astronomy at the University of Arizona. "We are thrilled to be closing in on another milestone in the fabrication of the Giant Magellan Telescope."

The previous, most recently completed primary mirror is ready for integration into a giant support system prototype early in 2024 for final optical performance testing. This testing will serve as the dress rehearsal for all seven primary mirrors. Once assembled, all 7 mirrors will work in concert as one monolithic 25.4-metre $f/8$ mirror, resulting in up to 200-times the sensitivity and 4-times the image resolution of the JWST.

The Giant Magellan Telescope will be the first extremely large telescope to complete its primary mirror array. With strong operational infrastructure completed at the telescope site in Chile, focused manufacturing is taking place on the telescope's critical subsystem before starting on the enclosure. The GMT is expected to achieve first light in 2029, at which point it will be the second-largest after the 39.3-metre Extremely Large Telescope operated by the European Southern Observatory, for which first light is planned in 2028.

The 39-metre-tall GMT structure is being manufactured at a newly built facility in Rockford, Illinois, and fabrication of the telescope's first of 7 adaptive secondary mirrors—a one-for-one pair with each of the 7 primary mirrors—is underway.

"The combination of light-gathering power, efficiency, and image resolution will enable us to make new discoveries across all fields of astronomy," shares Rebecca Bernstein, Chief Scientist for the Giant Magellan Telescope. "We will have a unique combination of capabilities for studying planets at high spatial and spectral resolution, both of which are key to determining if a planet has a rocky composition like our Earth, if it contains liquid water, and if its atmosphere contains the right combination of molecules to indicate the presence of life."

Composed with material provided by GMTO Corporation.

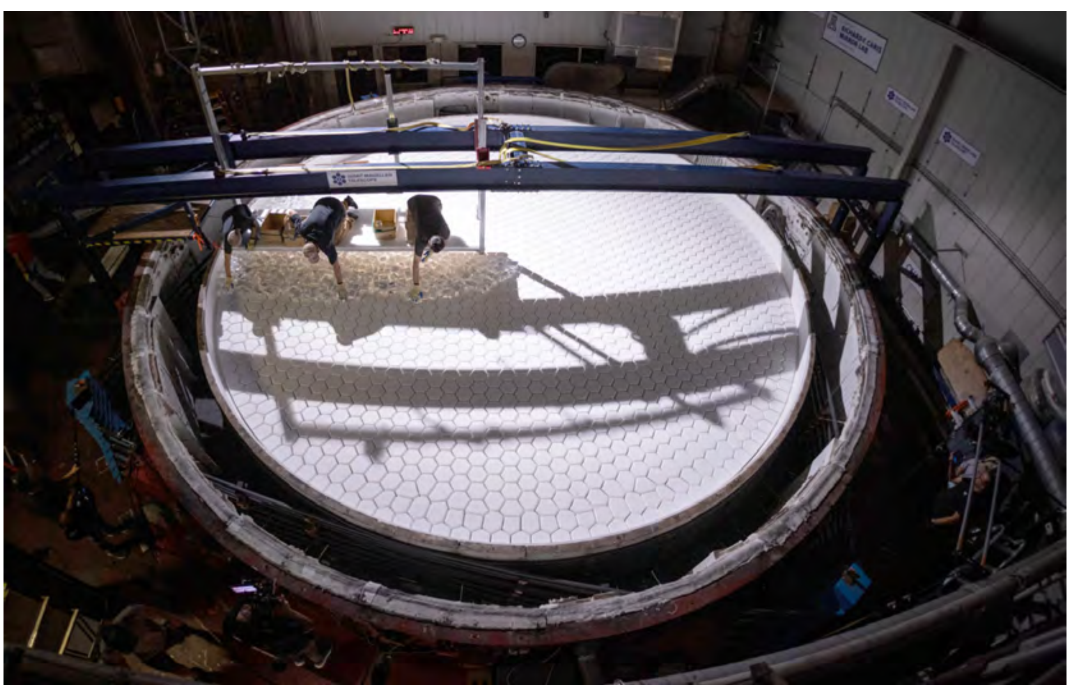

Figure 2 — University of Arizona Richard F. Caris Mirror Lab staff members placing nearly 18 tonnes of Ohara E6 low expansion glass into a mold for casting the Giant Magellan Telescope's 7th primary mirror segment, September 2023. Credit: Damien Jemison, Giant Magellan Telescope — GMTO Corporation

Depths of Shackleton Crater revealed

A new mosaic of the Shackleton Crater showcases the power of two lunar-orbiting cameras working together to reveal unprecedented detail of the lunar south-pole region. This mosaic was created with imagery acquired by LROC (*Lunar Reconnaissance Orbiter* Camera), which has been operating since 2009, and from ShadowCam, a NASA instrument on board a KARI (Korea Aerospace Research Institute) spacecraft called *Danuri*, which launched in August 2022. ShadowCam was developed by Malin Space Science Systems and Arizona State University.

Shackleton Crater, named after Sir Ernest Shackleton, an Anglo-Irish Antarctic explorer, is a cone-shaped crater approximately 21 kilometres across and 4.2 kilometres deep, with steep walls and a relatively flat floor. Because it lies directly over the South Pole, the crater floor has never been exposed to sunlight and its warmth. Over the years, Shackleton Crater has been examined from orbit by at least seven spacecraft and even physically smashed by an impactor—all in a sustained scientific effort to learn its secrets, particularly whether it harbours a significant amount of ice.

The permanently shadowed polar regions are of great interest for science and exploration because they are thought to contain ice deposits or other frozen volatiles that may have been caught and trapped there for millions or billions of years. The ice deposits could serve as an important resource for exploration because they are composed of hydrogen and oxygen that can be used for rocket fuel or life-support systems.

LROC can capture detailed images of the lunar surface but has limited ability to photograph shadowed parts of the Moon that never receive direct sunlight, known as permanently shadowed regions (PSRs). ShadowCam is 200-times more light-sensitive than LROC and can operate successfully in these extremely low-light conditions, revealing features and terrain details that are not visible to LROC. To do so, ShadowCam relies on sunlight reflected off lunar geologic features or the Earth (earthshine) to capture images in the shadows.

ShadowCam's light sensitivity, however, renders it unable to capture images of parts of the Moon that are directly illuminated, as these would be saturated by the brightness. When each camera is exposed for the specific lighting conditions found near the lunar poles, analysts can combine images to create a comprehensive visual map of the terrain and geologic features of both the brightest and darkest parts of the Moon. The permanently shadowed areas, such as the interior floor and walls of Shackleton Crater, are visible in such detail because of the imagery from ShadowCam. In contrast, the sunlit areas, like the rim and flanks of the crater, are a product of imagery collected by LROC.

With ShadowCam, NASA can image permanently shadowed regions of the Moon in greater detail than previously possible, giving scientists a much better view of the lunar south pole region. Scientists are interested in Shackleton Crater and other lunar PSRs, which lie at both the north and south lunar poles and have internal regions that never see sunlight due to the Moon's low 1.5° axial tilt. These dark refuges could also provide scientific insights into the formation and evolution of the Moon.

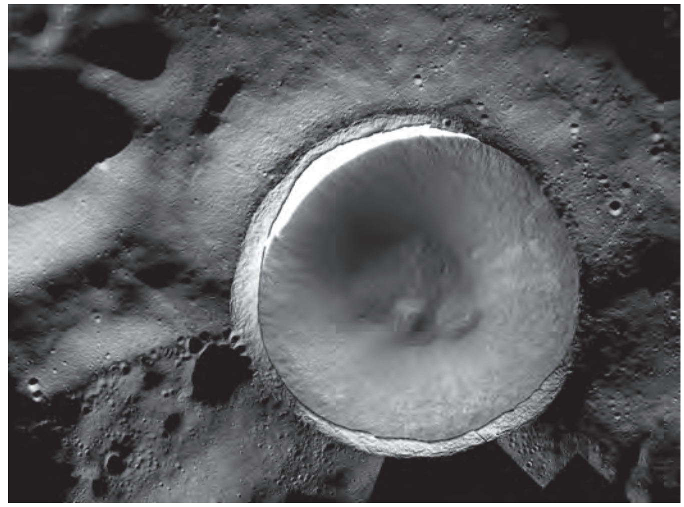

*Figure 3 — A new mosaic of the Shackleton Crater. Image: Mosaic created by LROC (*Lunar Reconnaissance Orbiter *Camera) and ShadowCam teams with images provided by NASA/KARI/ASU.*

Compiled with information provided by NASA.

Oncoming winter changes circulation on Saturn

A team of planetary scientists has found that Saturn's late northern summer is experiencing a cooling trend, with huge planetary-scale flows of air reversing direction as autumn approaches. The new observations have also provided a last glimpse of Saturn's north pole, with its enormous warm vortex filled with hydrocarbon gases, before the pole begins to recede into the darkness of polar winter. This interplanetary weather report is thanks to new images from the JWST analyzed by a team led by the University of Leicester. They have provided new insights into the changing seasons on the massive outer planet.

Like Earth, Saturn has an axial tilt and experiences seasons in the same way. However, Saturn takes 30 years to orbit the Sun, so the seasons last for 7.5 Earth years. Saturn is heading for its northern autumn equinox in 2025, which means the north poles of both Earth and Saturn are heading for extended periods of polar winter.

The Leicester team used the Mid-Infrared Instrument (MIRI) on JWST to study Saturn's atmosphere in infrared light, which allows them to measure the temperatures, gaseous abundances, and clouds from the churning cloud tops to stratospheric regions high in the atmosphere. MIRI splits the infrared light into its component wavelengths allowing scientists to see the spectral fingerprints of the rich variety of chemicals within the planet's atmosphere.

In the image, created by combining just a few of the wavelengths observed by MIRI, the bright thermal emission from the north pole stands out in blue. The warm 1500-km-wide north polar cyclone (NPC), which was first observed by the *Cassini* mission, can be seen at the north pole. This is surrounded by a broader region of warm gases called the north-polar stratospheric vortex (NPSV), which formed in Saturnian spring and has persisted throughout its northern summer.

These are warm vortices high in the stratosphere, heated by the Sun's warmth during the long summer season. As autumn equinox approaches in 2025, the north polar stratospheric vortex will begin cooling down and will disappear as the northern hemisphere recedes into the darkness of autumn.

By modelling the mid-infrared spectra, the scientists noticed that the distributions of stratospheric temperatures and gases at this particular point in Saturn's seasonal cycle were rather different to those observed by the *Cassini* mission during northern winter and spring. Saturn has a large-scale stratospheric circulation pattern with warmer temperatures and excess hydrocarbons, like ethane and acetylene, in the northern midlatitudes in winter, signifying sinking of hydrocarbon-rich air from above. Air was thought to rise in the southern summer midlatitudes, cross the equator, and sink into the northern winter midlatitudes.

The MIRI Medium-Resolution Spectrometer results taken in November 2022 revealed that this stratospheric circulation has now reversed and cool stratospheric temperatures and low hydrocarbon abundances are seen between 10°N and 40°N, suggesting upwelling of hydrocarbon-poor air in the summer, which will then be flowing toward the south.

Professor Leigh Fletcher, from the University of Leicester School of Physics and Astronomy, said: "The quality of the new data from JWST is simply breathtaking—in one short set of observations, we've been able to continue the legacy of the *Cassini* mission into a completely new Saturnian season, watching how the weather patterns and atmospheric circulation respond to the changing sunlight.

"JWST can see in wavelengths of light that were inaccessible to any previous spacecraft, producing an exquisite dataset that whets the appetite for the years to come. This work on Saturn is just the first of a programme of observations of all four giant planets, and JWST is providing a capability beyond anything we've had in the past—if we can get so many new findings from a single observation of a single world, imagine what discoveries await?"

Saturn was chosen as an early target for JWST as a test of its capabilities. Dr. Oliver King, a postdoctoral researcher in Leicester's School of Physics and Astronomy, explained:

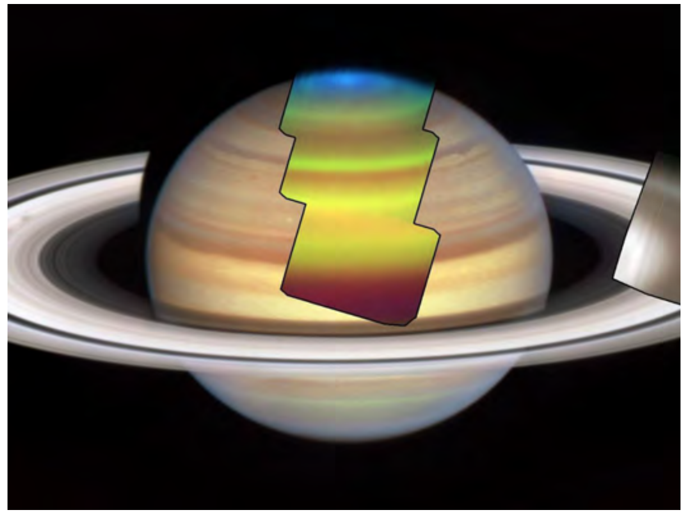

Figure 4 — The montage of JWST MIRI/MRS observations of Saturn in November 2022 requires four tiles to study Saturn's northern hemisphere and rings. Saturn's colours are a combination of blue (11.6 μm, which senses stratospheric temperature), green (10.1 μm, a probe of upper tropospheric temperature), and red (10.3 μm, sensing lower tropospheric temperature) using MIRI's MRS Channel 2. The ring tile uses a different combination of filters: blue (13.5 μm), green (14.6 μm), and red (15.5 μm) from MRS Channel 3, which provides a slightly wider field of view. A Hubble visible-light observation, acquired in September 2022, is shown in the background for comparison. Image: NASA, ESA, and Amy Simon (NASA-GSFC); Image Processing: Alyssa Pagan (STScI).

"Because it is big, bright, rotating, and moving across the sky, it provides a challenge for the small fields-of-view of the MIRI instrument—MIRI can only see a small area of Saturn at any one time, and we're at risk of saturating the detectors because the planet is so bright compared to JWST's usual targets. The observations were taken as three tiles, stepping from the equator to the north pole, and then out to the rings for a final tile."

Professor Fletcher adds: "We started designing these Saturn observations more than eight years ago, so when that first data landed in late 2022, it was certainly a career highlight: the Leicester team of planetary scientists crammed around a computer screen, astonished by the quality of the new data, and maybe sipping some sparkling wine to celebrate. It would not have been possible without the wider team of experts that contributed to the Saturn programme, especially the folks at Space Telescope who put up with our endless questions and problems as we dealt with all the challenges of a brand-new telescope.

"No spacecraft has ever been present to explore Saturn's late northern summer and autumn before, so we hope that this is just the starting point, and that JWST can continue the legacy of Cassini into the coming decade." ✶

Compiled with material provided by the University of Leicester

Feature Articles / Articles de fond

A New Window on the Universe: Black Nugget Lake Observatory

by Warren Finlay, Edmonton Centre

Edmonton Centre RASC recently unveiled its newly fabricated 32″ diameter telescope at Black Nugget Lake Observatory (BNLO). Located at a Bortle 3 dark site approximately 80 km southeast of Edmonton, Alberta, the telescope is a folded Newtonian configuration. It was custom designed and built in-house by Roman Unyk, a member of the BNLO Committee, around a 32″ Barry Arnold *f*/4 dielectric coated primary mirror donated to the project by longtime Edmonton Centre member Bob Drew. In honour of their contributions, it is named the Unyk-Drew Telescope (UDT).

Although the first steps of the project were approved by Edmonton Centre RASC Council in 2004 and the site was cleared in 2006, construction of the telescope itself didn't begin until funding for it was secured in 2017. Ground was broken for the 14′ diameter observatory in 2018. A 12′ × 24′ modular building on skids was placed on site in 2019 and serves as a Visitor Centre. Construction of the domed observatory and telescope were completed during 2017–2023 by the Black Nugget Lake Observatory Committee (BNLO), a dedicated team of 7 volunteers that tallied approximately 10,000 hours during its design and construction.

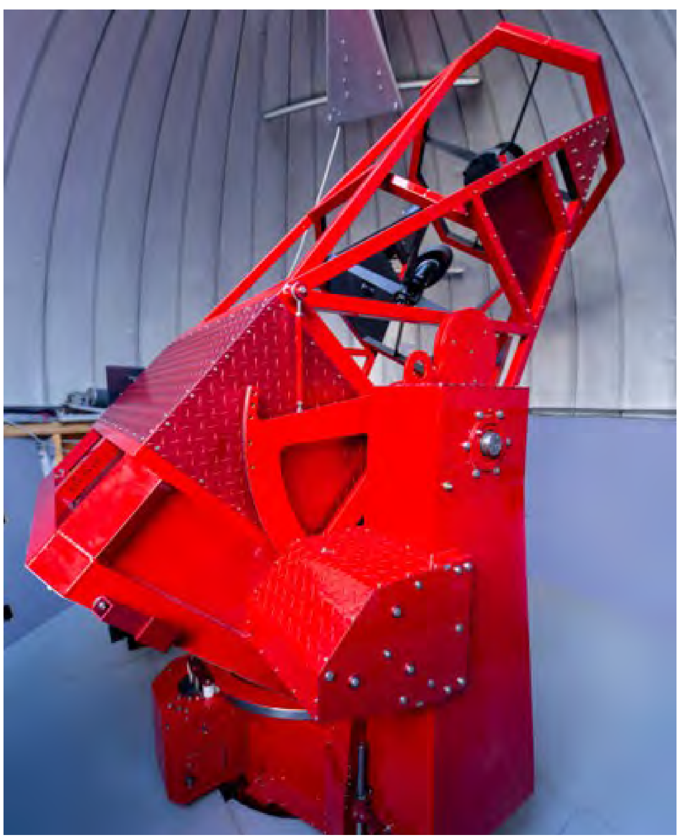

Figure 1 — The 32″ Unyk-Drew Telescope (UDT). The dielectric coated 11.2″ Ostahowski flat and 5.7″ Barry Arnold diagonal mirrors can be seen inside the optical tube assembly.

Figure 2 — The UDT seen from outside its dome the day after it was installed in July 2023. The 32″ f/4 primary mirror can be seen at the base of the optical tube assembly.

The telescope mount was fabricated from steel by Roman Unyk and is a direct-drive altitude-azimuth fork design with 26-bit Renishaw absolute encoders and a SiTech ForceOne controller. The altitude shaft bearings are self-aligning preloaded roller bearings, while the azimuth bearing is a four-point contact ball bearing with custom Belleville spring to give additional preloading. Brushless DC open-frame motors were purchased and assembled into housings fabricated by Roman, allowing very high slew rates. The all-metal optical tube assembly, mirror box, drives, and alt-az mount together weigh in at 3200 pounds and sit on an isolated 14,300 pound concrete pier resting on five double-helix screwpiles installed to a depth of 24 feet below the pier.

The volunteer skilled labour of the BNLO Committee dramatically reduced the cash cost of the telescope, observatory, and visitor centre down to $168,446. An additional $414,352 of in-kind donations were received, including the used Ash Dome donated by the University of Alberta from its decommissioned nearby Devon Observatory. Water-jet cutting of steel telescope components was generously donated by Technical Cutting Solutions. While the BNLO Committee submitted two dozen funding applications since 2016, most were unsuccessful and the Edmonton Centre RASC contributed the majority of the cash, with National RASC supplying $2000, Beaver County (where the telescope resides) $2500, the Government of Alberta $40,859 and Bob Drew generously donating $25,000.

Figure 3 — The Black Nugget Lake Observatory Committee in September 2022; left to right: Kent Martens, Susan Bramm, Roman Unyk, Alan Hobbs, Warren Finlay, Luca Vanzella, and Rick Bramm. Photo by Colin Bramm.

Besides COVID-19, a major challenge encountered during construction of the telescope that stymied the project for nearly a year was machining the direct-drive wheel and sector to a tolerance that would meet our specifications for acceptable telescope drive operation. American Telescope and Optics firm DFM Engineering helped select the proper materials that finally resolved this challenge.

Views through the telescope were stunning on its augural night in August 2023 and during five consecutive nights of observing by attendees of Northern Prairie Star Party, held on site in September 2023. NGC 6995 (the East Veil Nebula) showed many stunningly bright knots and filaments spanning more than two eyepiece widths. The dark lane in NGC 891 was spectacular, with the edge-on galaxy filling the entire eyepiece. On one night, two of the lensed quasars in Einstein's Cross were visible as tiny pinpoints (mag. 17.4) on the edge of the lensing galaxy, a confirmation of the outstanding optics of this unique telescope. A sketch of the view of the Crescent Nebula (NGC 6888) made at the eyepiece of the UDT by Edmonton RASC member Berta Beltran in the wee hours of 2023 September 16, during Northern Prairie Star Party is shown in Figure 4.

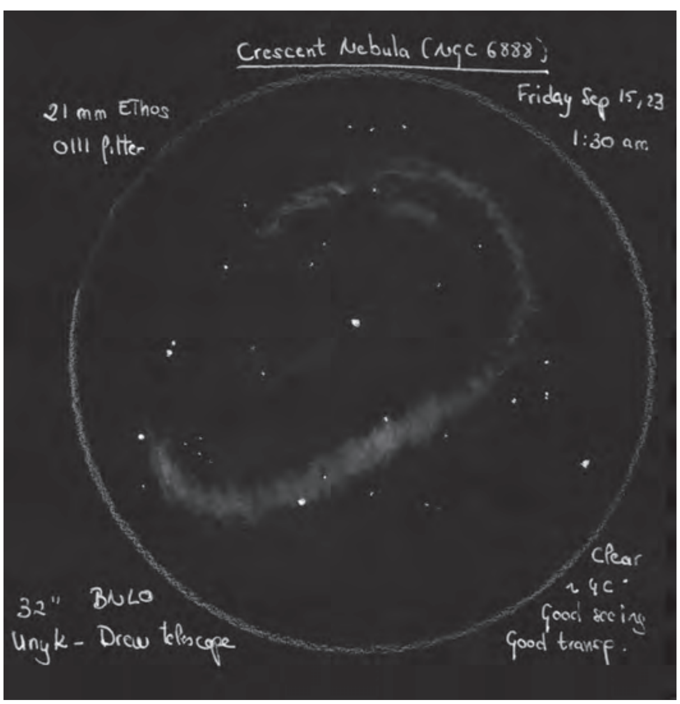

Figure 4 — Sketch of NGC 6888 made at the eyepiece of the UDT by Berta Beltran on 2023 September 16.

The Unyk Drew Telescope is one of Canada's largest telescopes for public viewing at a dark site. It is a testament to what can be accomplished by a highly dedicated team of volunteers with support from their RASC Centre. It is a one-of-a-kind telescope that will thrill Albertans with views of the heavens for generations.

A more detailed description of the project and its progression, from inception in the early 2000s to its completion this year, is given in the June 2023 issue of Stardust (edmontonrasc.com/stardust/stardust202306.pdf). ✶

Figure 5 — Black Nugget Lake Observatory photographed during Northern Prairie Star Party in September 2023.

Figure 6 — Black Nugget Lake Observatory at night.

Research Article /
Article de recherche

Charles Smallwood, a Canadian amateur astronomer of the mid-19th century (Part 1)

by Peter Broughton (pbroughton@rogers.com)

Abstract

Those interested in the history of science in Canada will recognize the name Charles Smallwood (1812–73) primarily as an avid meteorological observer. Since his death 150 years ago, almost nothing has been written about his astronomical accomplishments. The purpose of this article, and another to follow, is to resurrect that aspect of Smallwood's work—this installment mentions his manufacture of a speculum mirror and deals with his observations made with the naked eye (comets, aurorae, and zodiacal light) or with a small telescope (eclipses); the next installment will provide some insight into his telescopic observations made with an 17-cm *f*/19 refractor and some information about that remarkable instrument, perhaps the largest in British North America at the time.

A visit to Smallwood's observatory

At 3 p.m. on Tuesday afternoon, the 1856 25 March, some members and guests of Montréal's Natural History Society (NHSM) gathered in front of the society's museum at 10 Little Saint James Street (now the east end of rue Saint-Jacques, near the courthouse). They had two sleighs lined up to take them 20 kilometres out of the city to inspect the observatory of Dr. Charles Smallwood. The weather was fine, but an early spring thaw had turned the roads into a mess. Two stout horses on each sleigh struggled for more than three hours to reach the destination—the village of Saint-Martin on Île Jésus (See Figure 1). One traveller wrote of the journey, "Up and down, jolting and jumping, and tossing, and smashing—it is a wonder soul and body were kept together."[1]

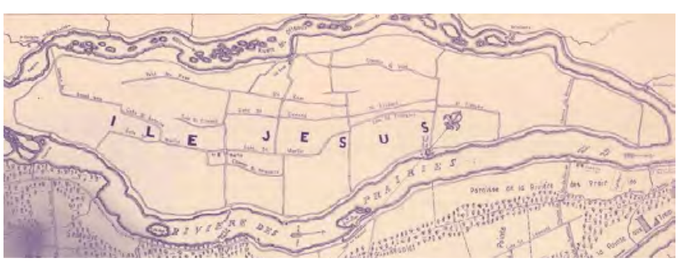

Figure 1 — Smallwood's home and observatory were located at St. Martin shown here between the two words "ILE" and "JESUS." (Excerpt from 1834–4, Map of the Island of Montréal. Map made in 1834 by A. Jobin, copy drawn in 1964 by Gérald Lalonde. Archives of the City of Montréal. CA M001 VM066-3-P042.)

Once the party arrived at Saint-Martin, Smallwood gave them a thorough tour and explanation of all the equipment. It was primarily a meteorological observatory and the good doctor had, for at least fifteen years, been faithfully recording many aspects of the weather at least three times a day. His description of the instruments (many made by himself) and their uses can be found elsewhere[2]; the illustration of his observatory (Figure 2) gives an idea of the scope of his work. However, since astronomy is the main focus here, I will mention only that Smallwood had a small transit telescope which was adequate for providing him with the local time, and a reflector that he made himself to measure terrestrial radiation. In the words of a visitor,

> The mirror, of speculum metal, (… composed of copper, tin, and arsenic …) was made by Dr. Smallwood again, with a parabolic curve yielding a focal distance of about eight feet. This was a labour requiring a great nicety in

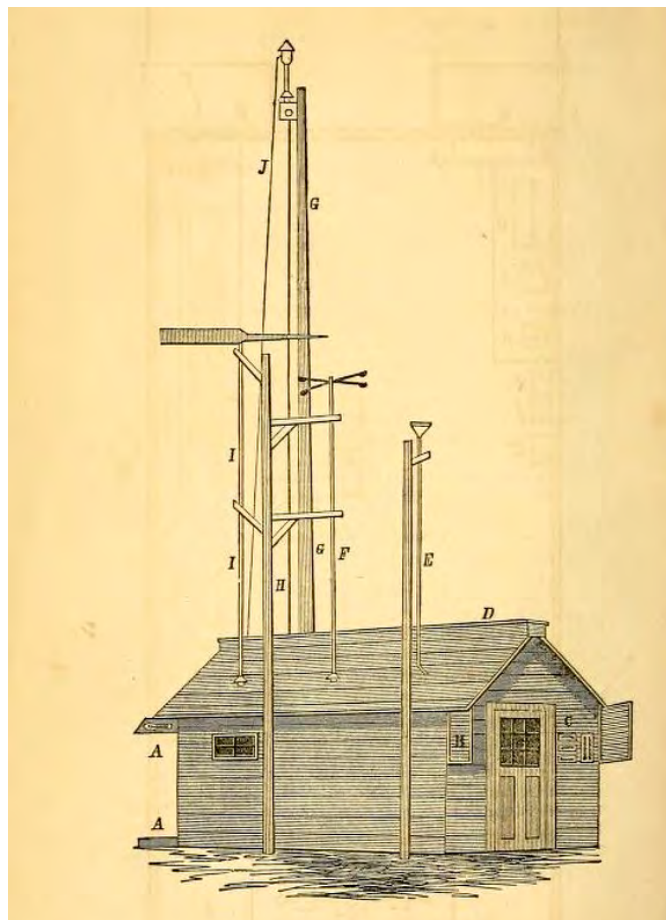

*Figure 2 — Contemporary wood engraving by "Dr. Hall" showing Smallwood's observatory at St. Martin, Île Jésus. The tallest mast (24 m) was used to collect atmospheric electricity; the ridge in the roof, aligned north-south, could be opened to allow the use of a transit telescope inside the observatory. A complete description of each of the lettered features and all the instruments is found in the original publications. Though not reproduced here, Hall also made a plan of the interior, showing the placement of the various instruments. Annual report of the Board of Regents of the Smithsonian Institution for 1856, 312. (*The Canadian journal of industry, science and art. *n.s.: v.3 (1858), 281-92)*

> execution and involving the sacrifice of much time; but perseverance, even here, conquered the difficulties. … In fact, placed in a telescope it has, we were informed, proved itself capable of resolving those singular stellar curiosities—the double stars.[3]

From this very brief account, we infer that Smallwood was an early Canadian example of an amateur telescope maker, although it seems that he normally pointed the mirror downward to gather the [infrared] radiation from the earth and bring it to a focus where the temperature was measured. A somewhat fuller account explains that, "Terrestrial radiation is indicated by a spirit thermometer of Rutherford, which is placed in the focus of a parabolic mirror 6 inches in diameter and of 100 inches focus."[4] Astronomically, Smallwood's use of the speculum to resolve some double stars is an indication that he already had some knowledge of astronomy beyond the rudiments required for timekeeping. The visitors on that occasion made no mention of a large telescope intended for astronomical viewing.

After the observatory tour, the party adjourned to the local inn where they enjoyed a cold supper, toasts, and speeches. The Moon rose about 10:45 p.m. and lit their way home. Choosing a different route, they were favoured with better road conditions and arrived back in town in good spirits after only two hours.

The visitors were so impressed that they urged the council of the NHSM to petition the government for a grant "in aid of Dr. Smallwood's efforts; for the establishment of a Provincial Observatory in Montreal or its neighbourhood; and for the general advancement of Meteorological Science in Lower Canada."[5] Informally, the visit and subsequent newspaper accounts of it would have heightened local interest in Smallwood's work. Five years later, the government did respond with a very modest grant of $500 for equipment (compared to $4800 in annual expenses for the Toronto observatory).[6]

Who was Smallwood?

Short biographical articles about Charles Smallwood appear in many places, but a standard source is Marshall (1972). Smallwood was born in Birmingham, England, in 1812 and trained as a medical doctor at University College, London, before emigrating to Canada in 1833. He was licenced to practice medicine in Lower Canada on 1834 July 16. By July 1836, he, along with his wife Diana, had settled in Saint-Martin, on Île Jésus, about 20 kilometres northwest of Montréal, where he served as the community's first postmaster. As an educated person working in a rural community, he fulfilled many roles. Appointed a "Commissioner for the Summary Trial of Small Causes," he was involved in some of the fallout from the Rebellion of 1837.[8] As a man of faith, he helped to establish the Anglican church of St. Stephen (1841–97).[9] He was also a school commissioner and secretary of the county agricultural society. One marvels that he could have attended to all these part-time duties, while having a full-time medical practice. We get a glimpse of Smallwood as a doctor and as one of the original founding members of the College of Physicians and Surgeons of Lower Canada, when he wrote in a medical journal about the death of one of his patients.[10] It was, he said, "the first case of rupture of the uterus that has come under my observation, either in England or in this country … during a period of 13 or 14 years' practice in the country, and in upwards of three thousand cases." (Smallwood 1848).

Three years later, and in the same journal, we find his first article about his meteorological work. He wrote about his instruments, their use, and the way he analyzed the collected data. The equipment included a barometer, thermometers (standard dry bulb, wet bulb, maximum and minimum), rain gauge, evaporating gauge, anemometer, anemoscope. As well, "the electrical state of the atmosphere is observed thrice daily. The conductor is 55 feet high, and perfectly insulated. —The instruments used … are Volta's electrometers, Henly's electrometer, Bennet's electroscope, a distinguisher, and a discharger. Observations are also taken by Peltier's electrometer. Ozone, observations of the clouds, atmospheric phenomena including thunderstorms and aurora. … Most of the instruments are self-registering; this dispenses with a great amount of labor to the observer." (Smallwood 1851). As pointed out by meteorologists Marshall and Bignell (1969), Smallwood's ingenuity in building autographic recorders incorporating photography (still in its infancy) was remarkable and was just one example of his adoption of the latest technology.

Remembering that Smallwood arrived in Canada at a time of great cholera epidemics and that there was widespread suspicion of links between disease and climate, it comes as no surprise that he would combine these two studies so extensively.[11] Perhaps, like his better-known contemporary Samuel Thompson (1884) who also arrived in 1833, he was quarantined on the infamous Grosse Isle for a time. Later developments in Smallwood's career will be postponed to the second part of this paper.

What did he accomplish in the field of meteorology?

Since my purpose is to highlight Smallwood's astronomy, I will give only a very brief summary of his very extensive meteorological work at Saint-Martin. To put it in context, meteorology was the focus of much effort in mid-19th-century science. All aspects of the weather, along with measurements of terrestrial magnetism, were recorded at a worldwide network of observatories beginning in 1829 with observatories from China to Europe that cooperated with von Humboldt in Germany.

Britain with its vast empire was well suited to expand the network across the globe (Cawood 1979). The Canadian part of that was "Her Majesty's Magnetical and Meteorological Observatory at Toronto," established in 1840, and staffed by Royal Artillery officers until 1853, when it was turned over to the provincial government of Canada. To modern eyes, it may seem strange that two such disparate fields as magnetism and meteorology would be combined, but at the time there was strong motivation to look for empirical laws that would connect various phenomena in the way that solar activity, the aurora, and terrestrial magnetism had recently been related.

Smallwood worked entirely at his own expense, and as far as we know, without any assistants. His records were even more comprehensive than those made at Toronto where there was a staff of four at the time. He began to keep weather records in 1841 or perhaps even earlier, his earliest surviving "Monthly meteorological register, at St Martin, Île Jésus, Canada East," begins in 1849.[12] Internationally, he began contributing observations to the Smithsonian Institution in 1852 and wrote three papers for the British (later Royal) Meteorological Society between 1853 and 1856. He had also joined the American Association for the Advancement of Science (AAAS) in 1853 and contributed articles to their publication, the *American Journal of Science and Arts*.[13]

Although Smallwood had been publishing summaries of his meteorological journal in the *Montreal Gazette* since 1852, his local renown really began to take off after the visit to his observatory in 1856. It didn't hurt that one of the guests on that occasion was James Hall, soon to be President of the AAAS. Hall was probably sizing up the situation in anticipation of a formal proposal to hold the association's next annual meeting in Montréal—the first one outside the U.S. At that meeting in August 1857, Smallwood spoke again about his observatory and the averages he had found from seven years of observation; these provided a good idea of the climate at Saint-Martin. Joseph Henry, a renowned American scientist and first Secretary of the Smithsonian Institution, attended. He oversaw a growing network of hundreds of meteorological observers that he hoped would include all of North and Central America (Rothenburg et al. 1998). He spoke highly of Smallwood's results saying that they "were not only better than any [the Smithsonian] had received from this quarter; but also better than any they had ever received from any part of the States."[14] It was reported that Henry "had had the pleasure of seeing Dr Smallwood's observatory and had examined it with great interest, the apparatus of which he had constructed with his own hands. He considered that Dr. Smallwood deserved the highest credit for his observations, which were of importance in determining the meteorology not only of this place, but of the whole continent and of the world, and he trusted that means would be afforded him of continuing a work of so much importance."

While meteorology was central to Smallwood's subsequent reputation, here we are concerned with his naked-eye observations that required no measurement and that might broadly be considered astronomical; they are sometimes found in the "remarks" column of his journals, or in the space at the bottom if more room was required (See Figure 3). Fortunately, for those (like me) who do not have easy access to the McGill archives where Smallwood's records are kept, published versions and summaries exist in various newspapers and journals of the time. It is these rather than the original journals, that I have relied on for the most part in the following discussion. Perhaps this approach will suffice to whet the appetite of anyone interested and able to study the originals. At least for the meteorological records, in the future, it may also be possible to use digitized versions of Smallwood's journals, a project now underway as part of the Canadian Historical Climate Data Rescue Project.

Figure 3 — This double page from Smallwood's meteorological register covering 1856 April 11–30, exemplifies the records he kept for about 30 years. Even at a glance, one can see the extent of Smallwood's observations. There are three rows for each date: 8 a.m., 2 p.m., and 10 p.m. The bottom third of each page was used to summarize or analyze the data, giving means, maximums and minimums of temperature, air pressure, humidity, wind speed and direction, precipitation, electrical state of the atmosphere, and ozone levels. On each page, the 6th, 5th, and 4th column from the end all deal with the aurora and, naturally, there are only entries in every third row, namely at 10 p.m. At the bottom of these columns are totals showing the number of nights the aurora was visible (2 for the entire month), the number of nights it might have been seen since the conditions were clear (21) and the number of nights it was impossible to see (7). (McGill University Archives RG 0032, container 0955, file 06271; photo by Julia Zucchetti).

His observations of zodiacal light

The zodiacal light is a faint, but large wedge of light seen in the western sky after the end of evening twilight or before morning twilight in the eastern sky (see Figure 4). It is caused by sunlight scattered from interplanetary dust particles and its visibility depends on a number of geometric factors (Leinert et al. 1998). Because the wedge is centred on the ecliptic, the zodiacal light is most easily seen in the tropics where the ecliptic is nearly perpendicular to the horizon; at Canadian latitudes the best opportunities occur in the evenings before the time of spring equinox or in the morning sky after the autumnal equinox when the ecliptic is steeply inclined to the horizon. With a brightness roughly comparable to the Milky Way, city dwellers never see it nowadays.

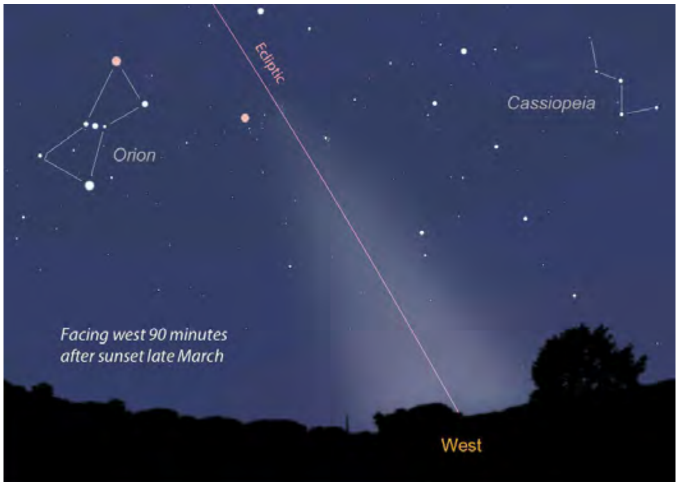

Figure 4 — The zodiacal light is the faint triangular patch of light centred on the ecliptic (or zodiac). (Created with Stellarium.*)*

Smallwood observed and recorded the zodiacal light 105 times between 1853 and 1862, inclusive, according to his meteorological reports in the *Canadian Journal.* His is a remarkably rich record of the phenomenon as seen in Canada. In a yearly summary for 1857, he stated, "The Zodiacal Light was unusually bright in the evening observations, but the morning observations did not show any such increased brightness," so he obviously did not restrict his observations to the usual 10 p.m. as one might infer from the registers (Smallwood 1858a). Unfortunately, he only specified the time of night when he made his zodiacal light observations on three occasions, all in 1853: one on March 4 at 7 p.m., another on November 10 at 6 a.m., and the third April 26, for which he found, "zodiacal light bright and well-defined from sunset until 8 p.m." This last one is hard to believe, for in late April at his location, there is still (astronomical) twilight until 9 p.m. Perhaps he was just seeing the glow of twilight.

He sometimes recorded that the zodiacal light was especially bright or well-defined, but only noted its extent on a couple of occasions: on 1855 November 5,, "its elongation did not exceed 50°"[15] and on the 1853 February 25, 26, and 27 "Elongation 47°"[16] He was presuably speaking of the angle along the ecliptic between the position of the Sun and the tip of the light glow whose position he could have determined from nearby stars.

He generally recorded most of his zodiacal light observations in the register as if they were made at 10 p.m.—his usual time (along with 9 a.m. and 2 p.m.) for making his meteorological measurements. At his location, from September 3 to April 9 the Sun is more than 30° below the horizon at 10 p.m., so the zodiacal light would be unlikely to extend much above the horizon. Therefore, it is very doubtful that the seven observations he recorded in early April were made at 10 p.m. Of course, the Sun has to be far enough below the horizon so that twilight does not overwhelm the zodiacal light. Astronomical twilight occurs when the Sun is more than 18° below the horizon so, as expected, Smallwood did not record any zodiacal light during the short summer nights and in fact did not record any between April 26 and November 10. The graph (Figure 5) shows the monthly distribution of his observations.

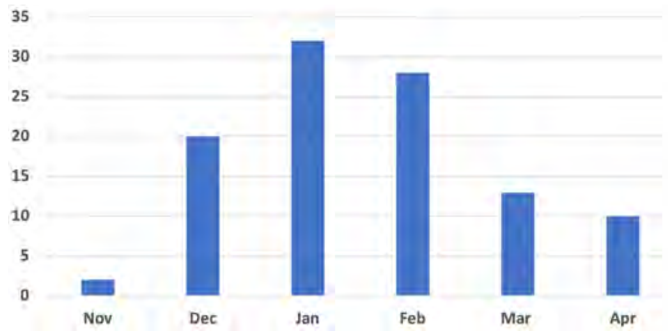

Figure 5 — Monthly distribution of Smallwood's observations of zodiacal light (1853–62). Only one observation (in November) is known to have been made in the pre-dawn sky. He did not record the time of most of these observations but presumably the large majority were made in the evening.

His observations of aurora

In the first of Smallwood's meteorological reports published in the *Canadian Journal*, he stated "The Aurora Borealis was visible on thirty-six nights [in 1852], at the following hours …" (Smallwood 1853). He then proceeded to describe each appearance in considerable detail. Here is one of the most colourful:

> February 19th [1852], at 6:30 P.M., the heavens presented a curtain or canopy of auroral light; streamers of yellow, green and crimson were sent up in rapid succession from the horizon to the zenith, where they formed a cupola or corona near α Aurigae; at the horizon, the arch extended from E. to N.W. Stars of the 4th and 5th magnitude were visible through these magnificent curtains of auroral light. …

In the same report, Smallwood also summarized, "Lunar halos visible on six nights. A lunar rainbow was also visible on February 29. Fogs were observed on six mornings. Shooting stars were seen on the 18th of July, and 8th and 10th of August [Perseids]. A slight shock of an earthquake was felt on the 11th of February at 5:40 A.M." In other reports, Smallwood sometimes recorded aurora even at 3 a.m. or 4 a.m. Any phenomenon seemed worthy of his attention, whatever the time of night!

But we can hardly imagine that he stayed up every clear night, and the transitory nature of the aurora makes any statistical analysis of historical records difficult. If he sometimes observed throughout the night and on other occasions just made his regular observations at 10 p.m., such irregularity would make comparative counts very dubious. In fact, as his detailed descriptions of 1852 show, though he recorded aurora on 36 dates, only 25 occurred at 10 p.m. By 1856 (as seen in Figure 3), he was using a register with columns where he would indicate with a tally mark if an aurora was seen at the dedicated hour, so statistically speaking, the records from 1856 onward ought to be more consistent.

Another problem with auroral-frequency statistics is the possibility that a string of cloudy nights would suppress the number of aurorae recorded. Smallwood did attempt to account for this in some of his published monthly summaries, where he not only included the number of times aurora was seen, but also the number of nights when weather conditions would have permitted such observations. Unfortunately, he did not consistently use this information in his published reports, and I did not try to extract the data from his original records.

While realizing the many difficulties, I nonetheless have presented Smallwood's auroral counts in Figure 6. Smoothing the data by using a rolling average over three years is a fairly standard technique; it does clarify general trends though it has the effect of making peaks and troughs less evident. The graph does suggest that there was a minimum in 1856 and a maximum in 1859 for both Saint-Martin and Toronto. The approximate agreement in the number of aurorae seen annually at both locations especially from 1854 onward, is also reassuring.

Traditionally, scientists trying to make sense of historic auroral data have collected records from around the world, hoping that variability due to random effects would average out. One of the first to do so was Harvard professor, Joseph Lovering (1864). His amazing collation of nearly 12,000 worldwide auroral observations includes Smallwood's 403 contributions from

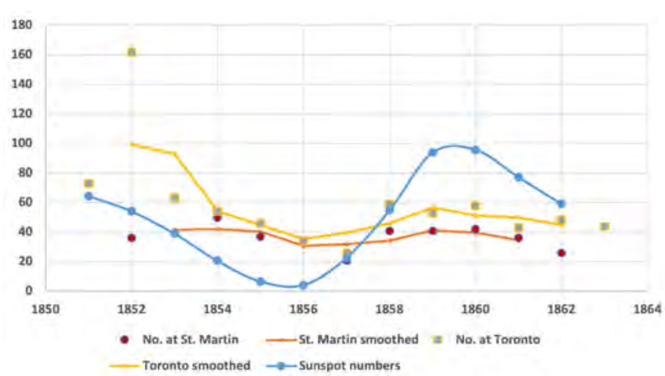

Figure 6 — Individual dots indicate the number of nights on which aurora was recorded at 10 p.m. local mean time at St. Martin and (for comparison) at Toronto. (The Toronto observations are part of a much longer series.) The data are then smoothed using a three-year rolling average, and the results are joined by straight line segments. Both hint at a minimum in 1856 and a maximum in 1859. Meanwhile, international sunspot numbers, a proxy for solar activity, show a minimum in 1856 and a maximum in 1860. Here they are joined by a smooth curve for easy visualization.

his Saint-Martin observatory from 1852–62 as well as 1,242 observations from Toronto (1840–67) and smaller numbers over shorter intervals from other British North American locales. Lovering presents the data in a chart showing each month of each year; from this, the annual peak of auroral activity in March and September is very evident. Using Lovering (an American source) also highlights the fact that these Canadian auroral observations were a significant contribution to international science—an uncommon claim for any field of Canadian science at the time. It is Smallwood's data as adopted by Lovering that I have used in Figure 6 in the hope that these data are the most reliable. I have added to Figure 6 the yearly mean sunspot counts as a proxy for solar activity.[17]

Smallwood (1859) wrote only one paper specifically dealing with the aurora, and that was "On the Aurora Borealis of the 28th of August, 1859." Aside from describing the display which covered nearly the whole sky, Smallwood attempted to look for other related phenomena. He noted "the great and unusual amount of atmospheric electricity … an amount equalled only during the Thunder storms of summer… The indications of the electrometers were such as is present during the passage of clouds charged with electricity, and this phenomenon seems to have extended to the wires of the Electro-Magnetic Telegraph." He recalled that the aurora of 1852 February 19 (described above), gave rise to similar effects. While we may rightly recognize Smallwood as a pioneer investigator of the electrical aspect of auroral displays, we must also recognize that he mused about the "immense eruption on Mauna Loa" on the same night and "slight shock of an earthquake" on the morning of 1852 February 11. Almost any natural phenomenon was fair game in the search for explanations.

The aurorae of late August and early September 1859, were truly spectacular on a worldwide scale and were related in part to a brilliant white solar flare that Richard Carrington sketched at his home observatory in Surrey, England. The significance of the near-conjunction of the two phenomena was a centrepiece of a popular book, *The Sun Kings*, by Stuart Clark (2007). While the main events in his story were the flare of September 1 that Carrington observed between 11 a.m. and noon and the aurorae that raged 18 hours later, Clark also described another great magnetic storm and the accompanying aurora that commenced in the late evening of August 28. While Clark didn't mention Smallwood, it is interesting to note that Smallwood did report "Splendid Aur. Bor." on August 28 and "Aurora Borealis" on August 29 and September 2; he also noted "Rain" on August 30, and September 1 and 3 (all at 10 p.m.) so he would have missed the spectacular display arising from Carrington's flare.[18]

Some other astronomical observations

During the years (1853–62) covered by his published records from Saint-Martin, Smallwood mentioned that he observed sunspots, comets, and eclipses and the occasional meteor. While he recorded very few specific details, it is evident that he had telescopic aid at least for the sunspots. In summaries for the year 1860 and 1861, Smallwood (1861 and 1862) wrote that "observations on the Solar Spots formed a part of the records" but the records do not seem to have survived.

Comets

On a few occasions, Smallwood noted a comet in the remarks column of his meteorological journal or in his yearly summaries. He mentioned eight altogether, as listed in Table 1.

Usually, Smallwood gave only the briefest indication in his register that he saw a comet on a given date. His observations therefore are of little importance but do suggest that the decade was a good one for bright comets. He did add a few details in his report for August 1853. "Comet first seen here on the 22nd day, in N.W., at 8 p.m., [in nautical twilight] in constellation Leo; 27th, Comet visible, tail 15°long. On the 29th, at 7.30, its R.A. was 11^{h}. 40^{m} 10^{s}., and dec. N. 15°0′22″. An ephemeris generated using ssd.jpl.nasa.gov/horizons/app.html#/ shows that on the time stated, the nucleus of the comet was about 5.4° above the western horizon and its apparent RA and Dec were 11^{h} 34^{m} 33^{s} and 15°27′45″. As we shall see below, Smallwood was likely just estimating the coordinates from nearby stars.

On 1862 February 6, a few months before he moved from Île Jésus, Smallwood reported to the press that Encke's Comet, which he had seen earlier, was now approaching perihelion and would therefore not be visible. He rounded out his report with remarks about the comet's history.[19] Smallwood's only publication on a comet was "Some Observations on Donati's Comet of 1858," written on December 1 of that year (Smallwood 1858b). It was certainly the most spectacular comet since 1811 and probably surpassed it in splendour. Smallwood took up most of his article with a description and history of comets in general, with attention paid to those that might have been Donati's comet at an earlier apparition; on the last page, he got around to local circumstances:

> It was seen in Canada as early as the 6th or 7th of September [1858]. On the 12th at 8 p.m., M[ontreal] T[ime], its appearance was bright and nebulous, the tail was slightly curved upwards, and it was near the star *Xi* of the constellation *Ursa Major*, being nearly in line with the pointers *Merak* and *Dubhe*. Its position (nearly*) was Right Ascension 11h. 20m., and North Polar distance 54°23′. It was seen after sunset and before sunrise (which led to the [erroneous] supposition of two distinct visible comets).

His "nearly*" referred to a footnote where he explained that "The measurements are taken only approximately from stars in [the comet's] neighborhood." From this, one may infer that Smallwood was describing his own observations, at least up to this point. But as he continued to describe the changing position and appearance of this magnificent comet until November 22, when it was still seen "in some of the United States Observatories south of us," the narrative seems to refer to observations of others.

Meteors

There are few observations of meteors (or shooting stars as Smallwood consistently called them) and I have not bothered to list them here. He gave no indication that he was looking for meteor showers. Nonetheless, his comment on the Perseids of August 1852, has already been noted and he did mention "Shooting Stars very numerous on the nights of 7th, 8th, 9th, 10th, & 13th" of August 1853. This was the comment supplementing his published record but in the published register itself in the 10 p.m. column, the dates of shooting stars (among a string of clear nights) were recorded only as the 6th, 7th, 8th, and 9th.

Occultations

In one of his yearly summaries, Smallwood (1861) wrote "The transits of Venus and Jupiter by the Moon were visible in April [1860]." He must have meant occultations rather than transits. On April 24 near 9 p.m. there was an occultation of Venus

Modern designation	Old designation	Old name	When Smallwood saw it	Reference
C/1853 L1	1853 III	Klinkerfues	August 22-29*	www.canadiana.ca/view/oocihm.8_04982_14/25
C/1854 F1	1854 II	Great	April 3, 7	www.canadiana.ca/view/oocihm.8_04982_23/26
C/1858 L1	1858 VI	Donati	See article	Smallwood 1858a, 1858b
C/1860 M1	1860 III	Great	June 25, several nights	www.canadiana.ca/view/oocihm.8_05122_29/73 www.canadiana.ca/view/oocihm.8_05183_13/17
C/1861 G1	1861 I	Thatcher	May	Smallwood 1862, 15
C/1861 J1	1861 II	Great (Tebbutt)	June 30, July 3, several nights	Smallwood 1861, 17 and 1862, 15
2P/Encke	1862 I	Encke	October	Smallwood 1862, 15
109P/Swift-Tuttle	1862 III	Swift-Tuttle	August 22	Ref. note. 19

Table 1 — Comets seen by Smallwood

but Smallwood's meteorological register shows "Snow" at 10 p.m. on April 26 near midnight and shortly before moonset there was a close encounter with Jupiter less than a minute of arc from the limb of the Moon. Smallwood had recorded 8/10 cloud cover at 10 p.m., casting doubt on whether he actually saw either of these events; taking him literally, he never claimed to have done so.

Eclipses

During the decade when Smallwood was reporting his observations from Saint-Martin (1853–62), there were ten occasions when he theoretically could have seen the Moon wholly or partially eclipsed.[20] He reported that the Moon was invisible or that conditions were cloudy on four of those nights and that an eclipse was visible on five. He made no mention at all of the eclipse of 1859 February 17, which lasted from about 4 a.m. until sunrise. Even on the dates when he did say the eclipse was visible, he gave no details of its appearance or that he timed any phase of it. The only record that arouses a bit of interest is in the journal of Archibald Hall, a Montreal doctor who also kept meteorological records, though far less extensive than Smallwood's. He noted that he had seen the lunar eclipse of 1858 February 27 from Dr. Smallwood's house.[21] In this case, almost the entire eclipse was over before moonrise with the last phase of the partial eclipse occurring just after 6 p.m. when the Moon had an altitude of only 6°.

Smallwood's documentation of solar eclipses was somewhat better. During the 19th century, Montréal was not in the path of totality or annularity for any solar eclipse. However, partial phases of five solar eclipses were theoretically visible during Smallwood's active period at Saint-Martin 1853–62.[22] He mentioned neither the 1858 March 15 nor the 1861 December 31 eclipses, but his meteorological registers show that the sky was completely cloudy on both dates with snow as well on the latter date. On 1859 July 29, at maximum, only 12 percent of the Sun was obscured; Smallwood only mentioned that the eclipse was visible. His accounts of the remaining two eclipses are more interesting.

On May 26, Smallwood (1854) briefly wrote, "Annular eclipse of the sun … at 4h. 11m. 3s." If this was an exact observation of first contact, the time could be useful in improving our knowledge of where Smallwood's observatory was situated. While he always gave his coordinates as 45°32′N, 73°36′W, that location is near what is now the Rosemont Metro station (for those who know Montréal), or about 16 kilometres east of Saint-Martin, and not even on Isle Jésus. We cannot be too hard on Smallwood for this error in longitude since the telegraph (needed for accurate time and longitude) probably did not reach such a rural location at the time. His latitude, much easier to find, would have been correct within a minute of arc, probably within a kilometre, plus or minus. If his timing of first contact had been exactly correct, he would have had to be almost exactly at the west end of Île Jésus, which he most certainly was not. On the other hand, if his timing was 30 seconds late (the likely scenario), he would have been very near the old village of Saint-Martin (see Figure 1 above). So, to sum up, Smallwood's observation on its own cannot narrow down his location sufficiently to be of interest.

The remaining eclipse, 1860 July 18, was the subject of an actual paper by Smallwood (1860). In it, he devoted nearly all his discussion to meteorological changes observed during the eclipse. Astronomers might be more interested in the fact that he "erected" an apparatus "for the purpose of examining Herr Fraunhofer's black lines in the spectrum…both with direct and reflected light." Though he observed no significant change during the eclipse, his experimental interest in spectroscopy makes him unusual and perhaps unique among Canadians at the time. Continuing in the same paper, he wrote a paragraph under the heading "Photometric Scale":

> Sensitive paper prepared and exposed for a given period of time, gave very positive and interesting results, the shades varying considerably during the increase and decrease of the partial covering of the solar disc. Chromotype paper also furnished similar result from given period of exposure. Our very clever photographic artist, Mr. Notman [William Notman (1826–91)] of Montreal, who by my desire obtained and to whom I am indebted for photographs of the eclipse, found similar result.

Unfortunately, Notman's photographs of the partial phases of this 1860 eclipse have not been found. However, reproductions of his similar photos taken during a solar eclipse nine years later do exist and will be part of the next installment. ✶

Endnotes

1. This passage and the information following is derived from "DR. SMALLWOOD'S OBSERVATORY AND SCIENTIFIC APPARATUS," *Montreal Herald and Daily Commercial Gazette*, Friday March 28, 1856, p. 2, columns 4–5; accessed at numerique.banq.qc.ca/patrimoine. Apparently, the account was copied from another Montreal paper, the Transcript where it had been published the previous day
under the heading "PURSUIT OF KNOWLEDGE UNDER DIFFICULTIES."
2. "Description of the observatory at St. Martin, Isle Jésus, Canada East," *Annual Report of the Board of Regents of the Smithsonian Institution … for the year 1856, 316*; an identical account in *The Canadian journal of industry, science and art*. n.s.:v.3 (1858), 281–92.
3. See endnote (1)
4. See endnote (2)
5. *Montreal Herald and Daily Commercial Gazette*, 5 April 1856, p1, cols. 9–10, accessed at numerique.banq.qc.ca/patrimoine The April meeting of the NHS was also reported in full in the *Canadian Journal 1* (no. 4) (July 1856), 408–11; accessed at www.canadiana.ca/view/oocihm.8_05122_4. There were also high hopes that the Smithsonian Institution would publish

Smallwood's observations, but that plan was scrapped "on account of want of funds." (Rothenburg et al.)

6 *Montreal Herald and Daily Commercial Gazette*, 26 April 1861, p1, col.7; accessed at numerique.banq.qc.ca/patrimoine

7 *Gazette de Québec publiée par autorité, jeudi 28 juillet 1836*; accessed at numerique.banq.qc.ca/patrimoine

8 *The Literary transcript and general intelligencer: Vol. 1, no. 2* (Jan. 16, 1838), www.canadiana.ca/view/oocihm.8_04301_2/1; Report of the state trials before a general court martial held at Montréal in 1838-9: www.canadiana.ca/view/oocihm.40100/1

9 *The Gazette* (Montréal), 14 Jun 1897, p.3.

10 "First meeting of the corporation of the College of Physicians …," *The British American journal of medical and physical science, Vol. 3, No. 6* (Oct. 1847), 162 accessed at www.canadiana.ca.

11 As an example, see "Editorial Notices," *The Upper Canada journal of medical, surgical and physical science, Vol. 2, no. 2* (May 1852).

12 Meteorological observations and registers are part of Record Group 0032, McGill University Archives.

13 Meteorological contributions from Smallwood along with those Lefroy in Toronto and Henry Poole of Pictou were the only ones from "British Possessions" noted in *Annual report of the Board of Regents of the Smithsonian Institution for 1852*, 79.

14 *Montreal Herald and Daily Commercial Gazette*, 20 August 1857, p1, col. 6, accessed at numerique.banq.qc.ca/patrimoine

15 *The Canadian naturalist and geologist Vol. 3, no. 2* (Mar. 1858), 115, accessed at www.canadiana.ca/view/oocihm.8_04260_14/40

16 *The Canadian journal of industry, science, and art, new ser. v. 1, no. 1* (Jan. 1856), 96, accessed at www.canadiana.ca/view/oocihm.8_05122_1/100

17 I have used the yearly mean sunspot numbers posted on the ASWFC website: www.sws.bom.gov.au/Educational/2/3/6

18 Smallwood's Monthly Meteorological Registers for August and September 1859 are found in *The Canadian Naturalist and Geologist, 4, no. 5* (Oct. 1859), 401

19 *Montreal Herald and Daily Commercial Gazette*, 6 February 1862, p2, col.3, reprinted from the *Pilot*; accessed at numerique.banq.qc.ca/patrimoine

20 "Eclipse Predictions by Fred Espenak and Chris O'Byrne (NASA's GSFC)," eclipse.gsfc.nasa.gov/JLEX/JLEX-NA.html

21 *The Canadian naturalist and geologist 3* (1858), 240 accessed at babel.hathitrust.org/cgi/pt?id=mdp.39015049809570&seq=224&q1=Lunar+eclipse

22 "Eclipse Predictions by Fred Espenak and Chris O'Byrne (NASA's GSFC)," eclipse.gsfc.nasa.gov/JSEX/JSEX-NA.html

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The February 2026 *Journal* deadline for submissions is 2023 December 1.

See the published schedule at rasc.ca/sites/default/files/jrascschedule2023.pdf

A Visit to the European Southern Observatory

by Guenter Hoernig, South Okanagan

A little while ago, March 2023, while travelling around Chile and Argentina, I fulfilled yet another item on my bucket list, namely visiting Cerro Paranal Observatory in Chile, also called the Very Large Telescope (VLT). With its four combined 8.3-metre mirrors, it is probably the most powerful optical instrument astronomers currently have. Once a week, on Saturdays, there is a tour, 10:00 a.m. to 12:00 p.m., free of charge (prior registration via the internet is required).I accessed the observatory from the little hamlet of Taltal, about 150 kilometres to the south. The taxi ride to the observatory would have cost 100,000 Pesos, or $120 USD, but I was lucky to have good acquaintances to drive me there. Alternately, a freelance driver, named Diego—associated with the observatory—offered rides from Antofagasta, 160 km to the north, for $180.00 USD.

Figure 1 — It's 150 kilometres from Antofagasta or Taltal to the European Southern Observatory on the Altiplano, where not even a single blade of grass grows.

From Taltal it's a one-hour drive along a most spectacular winding ocean highway, then steeply climbing for almost another hour to the 2,500-metre high Altiplano. Along the coast, only a few cacti survive here and there, but higher up nothing grows at all. After all, there are regions on the Altiplano where precipitation has never been recorded. Reaching the vicinity of the observatory, one takes a small road west, leading to the visitor's centre, only four or five kilometres distant.

Here registrations are checked, and when I was there, I saw about 30 or so other visitors, most of them from Europe. After all, that is where the funds to operate the observatory come from. Most of them had arrived by rented automobiles out of Antofagasta, but there were also a few adventurers on motor bikes. Instructions were given, helmets handed out, and a bus took us a few more kilometres to the top of Cerro Paranal Mountain, at an elevation of 2,600 metres. Absolutely pristine blue skies and unrelenting sunshine exist up there, but it was chilly once you stepped into the shade.

Here, we were split into Spanish and English groups, which were then even further divided to just six people, led by one or two guides, volunteers—mostly students—from Antofagasta. After admiring the gigantic enclosures from the outside, we then entered one of them. The tour guides explained everything, particularly the operation of 140 actuators needed for adaptive optics operation, computer guidance,

Figure 2 — This photo shows the visitor's centre, and in the far distance the observatory itself. You are not allowed to proceed on your own but must take the tour bus.

and the incredible technology of guiding images from four telescopes to a nearby laboratory where they would be combined. We also saw the temblor dampers, to protect the delicate optics and its mechanism from possible earthquakes. Pictures were allowed, but the bottom cage and instrument clusters of the telescope were out of bounds.

We then climbed several stories to admire the massive mirror itself, but no flash photography was allowed. Dark up there, and hence no photos of the optical wonder. The blank came from Germany, ground and polished in France, and shipped here. It cost $25 million USD for the glass alone, the guides mentioned.

The tour concluded by viewing the mechanism of the rotating dome, its unique ventilation system, air-conditioning, different machinery, and so on. Especially the crane system used to handle the mirrors when they needed to be re-silvered in a nearby support facility. That is also where some 150 physicists, mathematicians, software gurus, engineers, technicians, and other workers reside to keep the observatory in operation 345 nights a year.

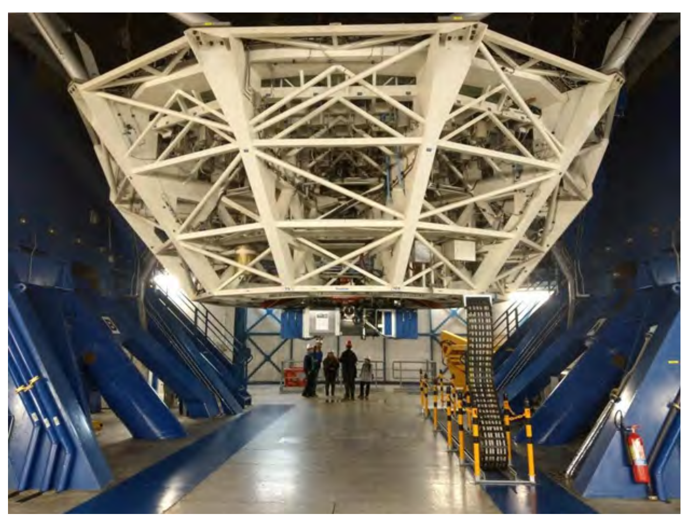


Figure 3 — In the cage pictured are housed the 140 actuators for the mirror, plus many other components. It was not possible to go near it.

Continues on page 250

Figure 1 — This beautiful image of the Ghost of Cassiopeia is seen here in the HSS palette. Steve Leonard, who took this bicolour image from Markham, Ontario, said he processed it in order "to bring out the detail in the ghost while retaining some of the outer nebulosity, and features both the ghost and the wing-like shape in the upper left portion of the image." Steve used an Astro-Tech AT115EDT 4.5-inch triplet refractor at ƒ/5.6, on an EQ6-R mount. He used N.I.N.A, an ASI 1600MM Pro camera, Chroma Hα and SII filters, Astrodon RGB filters, and processed in PixInsight. Integration was 9 hr, 10 hr SII, 3 hr RGB.

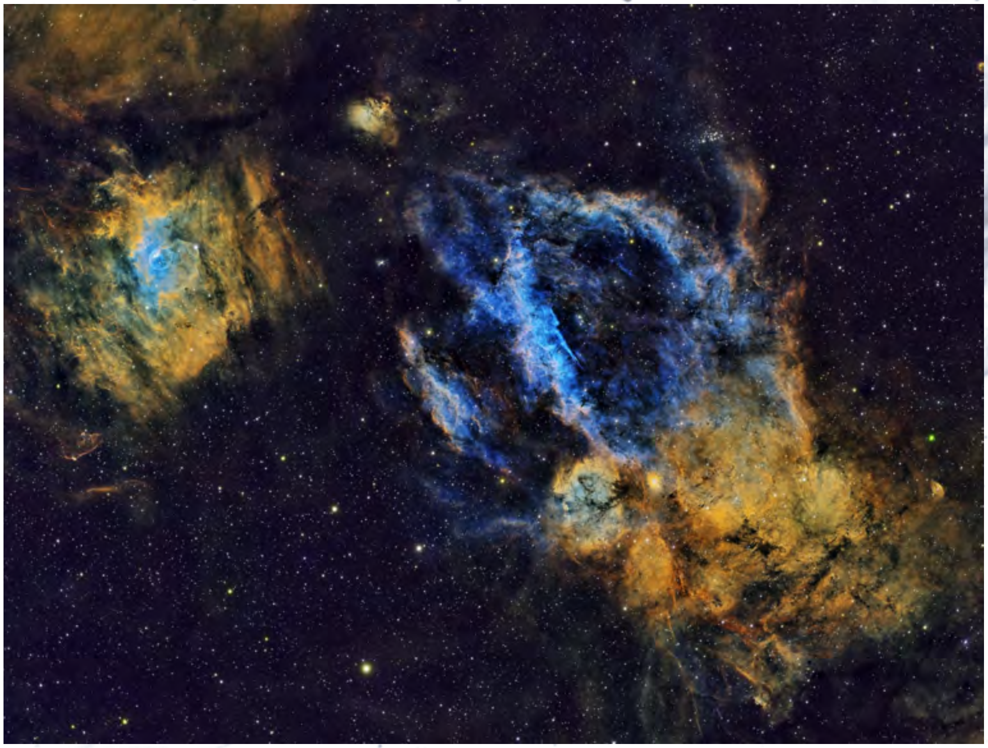


Figure 2 — Malcolm Loro imaged the Lobster Claw Nebula (Sharpless 157) to the right, together with the Bubble Nebula (NGC 7635, Sharpless 162, or Caldwell 11), both emission nebulae in the constellation Cassiopeia. Malcolm used an Astro-Tech AT92 apochromatic refractor with a Hotech Field Flattener on an iOptron GEM equatorial mount. He used a ZWO ASI2600MM Pro monochrome camera with Antlia EDGE 4.5-nm Hα, OIII, and SII filters and ZWO LRGB filters along with N.I.N.A software. The final processing was done in PixInsight for a total integration time of 32 hours and 32 minutes.

Continues on page 249

What's Up in the Sky?

December/January

Compiled by James Edgar and Scott Young, Winnipeg Centre

Observing Highlights for December 2023

December provides early sunsets and long winter nights for observing, provided the observer and their gear are prepared for the cold temperatures. This month we have the best meteor shower of the year, as well as the return of the winter constellations to early evening prominence.

Planetary Highlights

Saturn is low in the south as darkness falls and sets into the southwest by mid-evening. Its low altitude will make clear telescopic views of the rings a challenge from Canada. Snowbirds will have a better view as Saturn will be higher in the sky from more southerly latitudes.

Jupiter is well up in the east-southeast as darkness falls and is high in the south by mid-evening, providing clear views for Canadian observers. Binoculars show some of its four largest moons, and a telescope will reveal cloud bands and structure in the gas-giant planet's atmosphere.

Venus rises about 4 a.m. local time at the beginning of December. It stands about 20 degrees up in the southeast before dawn but rises later and loses altitude throughout the month. By the end of December rises about 5:30 a.m. local time and only rises to half the height it did on Dec. 1.

Mercury begins to creep above the eastern horizon at dawn toward the end of the month but is more easily visible in the first week of January. Even so, Canadians north of 45 degrees latitude will have a tough time spotting the inner planet so close to the horizon in a dawn sky.

Mars is too close to the Sun to be visible in the morning sky this month.

The Moon passes near the planets and some bright stars as it orbits Earth. This month, the following events happen at convenient times for Canadian observers:

- Dec. 9 (morning): The waning crescent Moon is 4° to Venus's lower right.
- Dec. 17 (evening): The waxing crescent Moon is about 3° below Saturn.
- Dec. 21 (evening): The waxing gibbous Moon is far to Jupiter's right.
- Dec. 22 (evening): The waxing gibbous Moon is far to Jupiter's left.

(Distances are given for the Central Time Zone and are approximate since the Moon moves rapidly relative to the background stars. Observers farther east will see the Moon shift slightly to the "right" in the sky relative to the stars; Observers farther west will see a corresponding shift to the "left.")

Other Events

December 13–14: The annual **Geminid meteor shower** peaks overnight, with the nearly new Moon providing dark skies. With a theoretical rate of over 100 meteors per hour for most of Canada, this is the meteor shower to see. You'll want to get to dark rural skies and be well prepared for a long night of winter observing. Pay particular attention to your vehicle if the temperatures are low, as being stuck in the middle of nowhere on a cold December night can be dangerous.

Figure 1 — Dec 2023: Venus shines high above the thin crescent Moon on the morning of December 9. The bright star Spica is visible at upper right. The image shows the scene at 7:15 a.m. local time.

Continues on page 248

The Sky December/January

Compiled by James Edgar with cartography by Glenn LeDrew

Celestial Calendar *(bold=impressive or rare)*

Dec. 1 Pollux 1.6° north of waning gibbous Moon

Dec. 4 Moon at apogee (404,346 km)

Dec. 5 Moon at last quarter

Dec. 9 Venus 4° north of Moon

Dec. 12 new Moon at 6:32 p.m. EST (lunation 1249)

Dec. 14 Geminid meteors peak at 2:00 p.m. EST

Dec. 16 Moon at perigee (367,901 km)

Dec. 17 Saturn 2° north of Moon

Dec. 19 Moon at first quarter

Dec. 21 Winter solstice at 10:27 p.m. EST

Dec. 22 Ursid meteors peak at 11:00 p.m. EST

Dec. 26 full Moon at 7:33 p.m. EST

Dec. 30 double shadows on Jupiter

Jan. 1 Moon at apogee (404,909 km)

Jan. 3 Earth at perihelion (147,100,632 km)

Jan. 3 Moon at last quarter

Jan. 4 Quadrantid meteors peak at 4 p.m. EST

Jan. 8 Antares occulted by Moon

Jan. 8 Venus 6° S of Moon

Jan. 9 Mercury 6.6° north of thin crescent Moon

Jan. 11 new Moon at 6:56 a.m. EST (lunation 1250)

Jan. 12 Mercury greatest elongation west (24°)

Jan. 13 Moon at perigee (362,267 km)

Jan. 15 Neptune 0.9° north of Moon

Jan. 17 Moon at first quarter

Jan. 18 Jupiter 3° south of Moon

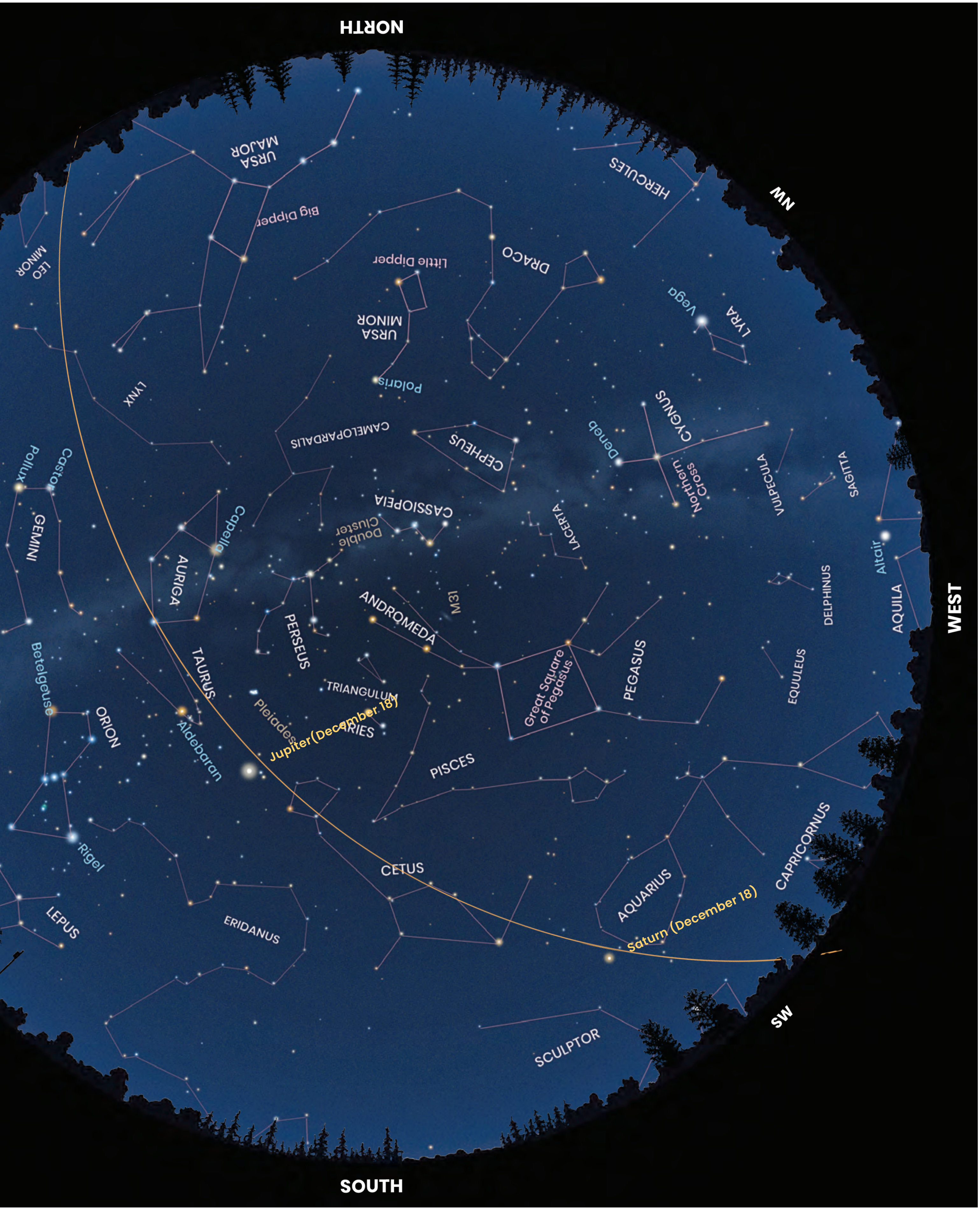
Jan. 25 full Moon at 12:53 p.m. EST

Jan. 27 Mercury 0.2° north of Mars

Jan. 29 Moon at apogee (405,777 km)

Planets at a Glance

	DATE	MAGNITUDE	DIAMETER (″)	CONSTELLATION	VISIBILITY
Mercury	Dec. 1	–0.5	6.2	Sagittarius	Dusk
	Jan. 1	0.5	8.6	Ophiuchus	Dawn
Venus	Dec. 1	–4.2	17.1	Virgo	Dawn
	Jan. 1	–4.0	14.1	Scorpius	Dawn
Mars	Dec. 1	—	3.7	Scorpius	—
	Jan. 1	—	3.9	Sagittarius	—
Jupiter	Dec. 1	–2.8	47.9	Aries	Evening
	Jan. 1	–2.6	44.0	Aries	Evening
Saturn	Dec. 1	0.8	16.9	Aquarius	Evening
	Jan. 1	0.9	16.2	Aquarius	Evening
Uranus	Dec. 1	5.6	3.7	Aries	Evening
	Jan. 1	5.7	3.7	Aries	Evening
Neptune	Dec. 1	7.9	2.3	Aquarius	Evening
	Jan. 1	7.9	2.3	Pisces	Evening


NORTH
NW
WEST
SW
SOUTH
URSA MAJOR
Big Dipper
HERCULES
LEO MINOR
Little Dipper
DRACO
Vega
LYRA
URSA MINOR
Polaris
LYNX
CAMELOPARDALIS
CEPHEUS
Deneb
CYGNUS
Northern Cross
Pollux
Castor
GEMINI
Capella
CASSIOPEIA
Double Cluster
LACERTA
VULPECULA
SAGITTA
Altair
AURIGA
ANDROMEDA
M31
DELPHINUS
AQUILA
PERSEUS
TAURUS
Betelgeuse
TRIANGULUM
Great Square of Pegasus
PEGASUS
EQUULEUS
ORION
Pleiades
Jupiter (December 18)
ARIES
Aldebaran
PISCES
Rigel
CETUS
CAPRICORNUS
AQUARIUS
LEPUS
ERIDANUS
Saturn (December 18)
SCULPTOR

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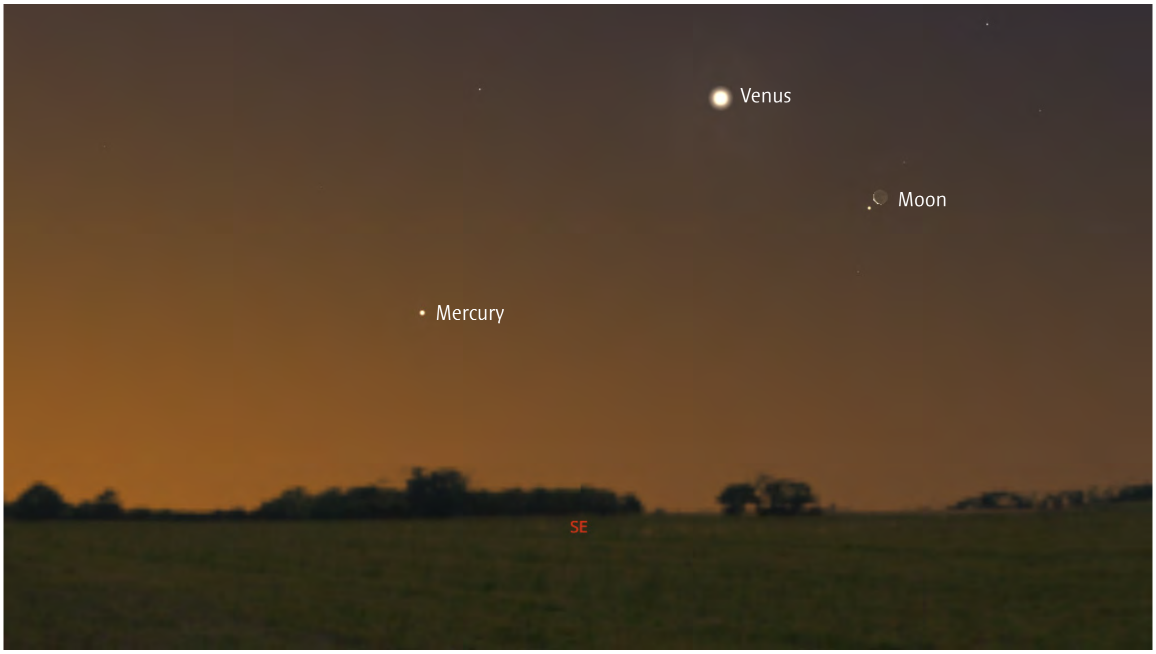

Figure 2 — Jan 2024: A challenging grouping of Mercury, Venus, the crescent Moon and the bright star Antares occurs on the morning of January 8. The image shows the view at 7:15 a.m. CST. The Moon will occult Antares less than an hour later, altering the dawn view for those farther west.

Observing Highlights for January 2024

The new year brings with it some of the lowest temperatures of the year for much of Canada. For those who brave the cold, though, the January sky is full of beautiful sights. Diamond-studding star clusters, beautiful nebulae, and more bright stars than any other season are good reasons to bundle up and head into the January night.

Planetary Highlights

Saturn begins the month low in the southwest as darkness falls and starts to drop into the twilight glow before the end of the month. You'll have to catch it early if you want a last look at the rings before Saturn disappears for the season.

Jupiter is high in the southeast as evening twilight ends—at its best in early evening. Like Saturn it will slip slowly westward into the glare of the Sun by the end of the month, but it is bright and high enough to remain visible throughout the winter and into early spring.

Venus is low in the southeast before dawn, remaining in roughly the same spot each morning, as its motion and the Earth's motion around the Sun briefly cancel each other. Also see Mercury below.

Mercury is visible low in the southeast for those in southern Canada for the first week of January or so, below and to Venus's left. The crescent Moon joins the scene on January 8, but this grouping occurs very close to the Sun and so will be best seen (in Canada) from the tropical latitudes of southern Ontario. Also see Mars below.

Mars is still too close to the Sun to be easily seen this month. It has a daytime close approach with Mercury on the morning of January 27, which will be a challenging observation, again most likely from southern Ontario.

The Moon passes near the planets and some bright stars as it orbits Earth. This month, the following events happen at convenient times for Canadian observers:

- Jan. 13 (evening): The waxing crescent Moon is 8° below Saturn.
- Jan. 14 (evening): The waxing crescent Moon is about 7° to Saturn's upper left.
- Jan. 18 (evening): The waxing gibbous Moon is about 3° to Jupiter's upper left.

(Distances are given for the Central Time Zone and are approximate since the Moon moves rapidly relative to the background stars. Observers farther east will see the Moon shift slightly to the "right" in the sky relative to the stars; Observers farther west will see a corresponding shift to the "left.")

Other Events

January 3–4: The annual Quadrantid meteor shower peaks in the early morning hours of January 4. This very short-lived shower is well placed for North Americans this year as the predicted peak is at 10 UT on the 4th, which translates into pre-dawn time for most of Canada, the best time to observe meteor showers due to orbital geometry. Unfortunately, the Moon is near last quarter and will be close to the radiant, washing out the fainter meteors. Still worth setting your alarm for! ✶

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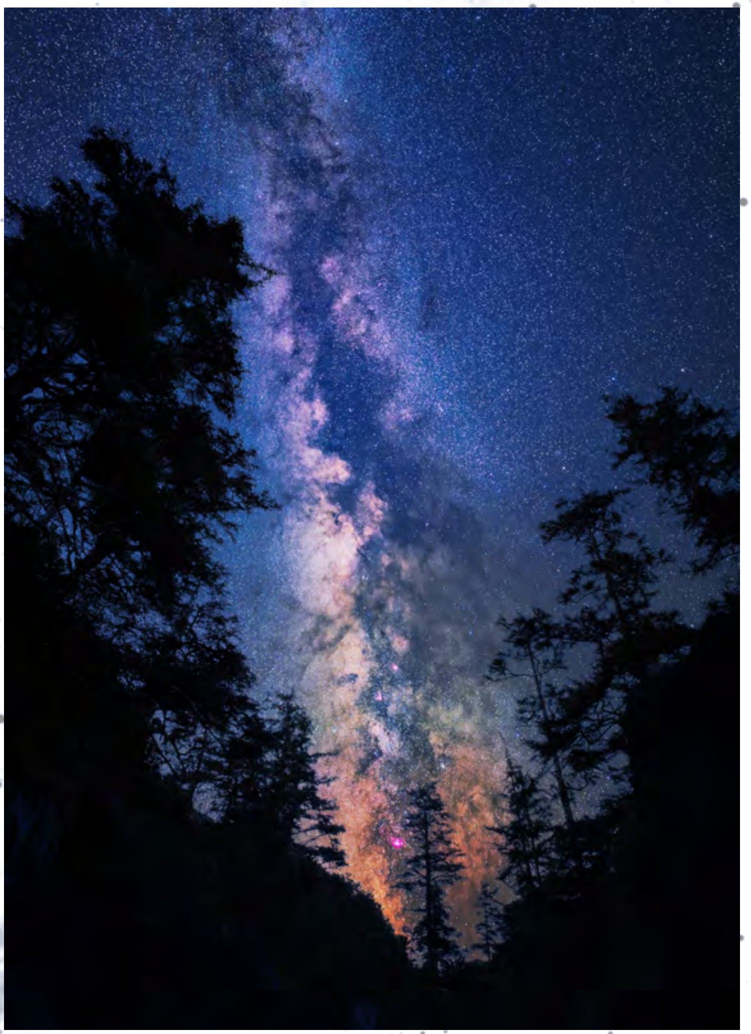

Figure 3 — The Milky Way stretches over Tofino, B.C., in this spectacular image from Rob Lyons.

"With [a] new Moon and a Bortle 2 sky, it was a breathtaking view of the night sky to say the least," he says. "The composite image contains 12 shots at 30 seconds for the Milky Way, and a single 8-second exposure for the trees in the foreground." Rob used a full-spectrum modified Sony A7R and a Kolari Vision UV/IR Cut with an Hα pass filter and a Sony 20-mm ƒ1.8 lens.

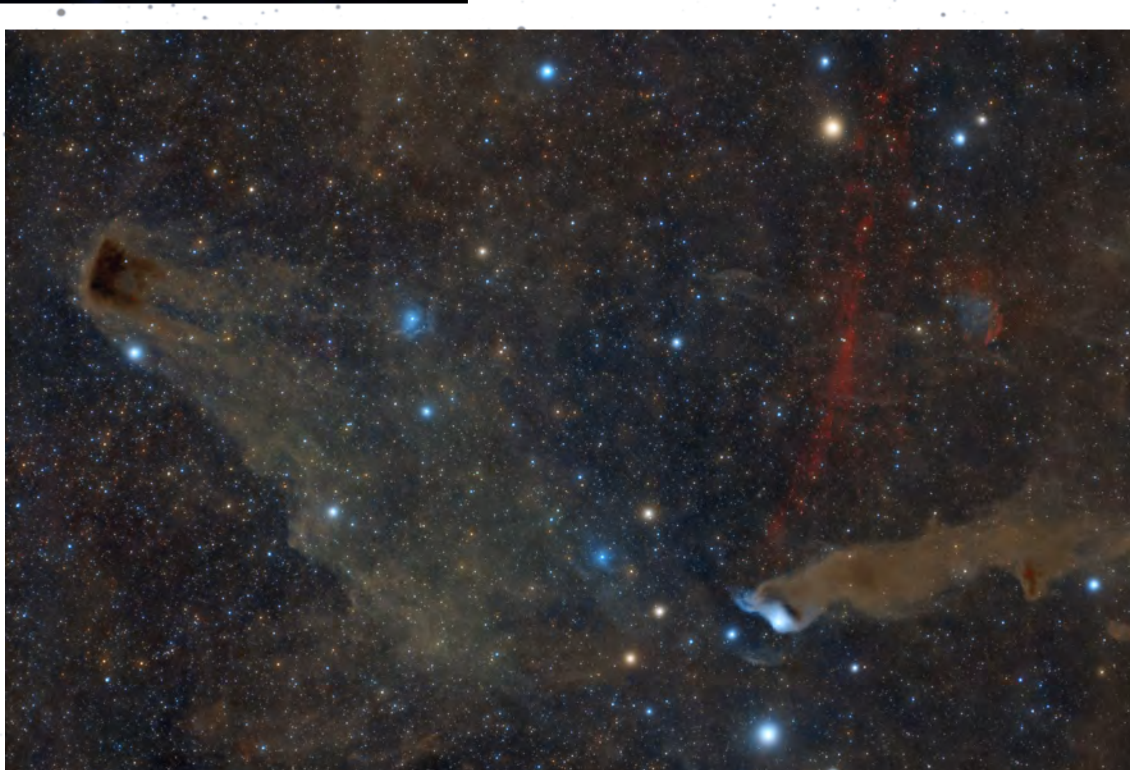

Figure 4 — Both the Dark Worm and Dark Octopus nebulae (VDB 152 and LBN532) are seen in this image from Dave Dev. He took the image at the North York Astronomical Association's Starfest in Mount Forest, Ontario, in August 2023. He used an ASI 2600c on an Askar 500-mm refractor for a total exposure of 6 hours.

Continued from page 243

When asked what was presently being viewed, the guides did not know. They said precious observing time is allocated to all kinds of observations, booked years in advance. Results of observations, in the terabyte range every night, are sent via fibreoptics to the town of Garching in Germany, headquarters of the ESO, where it would be correlated, analyzed, and eventually published.

Let's hope that our European friends will keep footing the bills, because it is from here that some of the questions humanity has asked about the cosmos and our existence might come forth one day.

Back in the visitor's complex, there was a 3-inch, 40x refractor, fixed permanently within sight upon a mountain, 35 kilometres away, where currently the Extra Large Telescope (ELT) is being constructed, also belonging to the European Southern Observatory consortium. (Fourteen countries, www.eso.org.) When looking through the eyepiece, it clearly showed many cranes busily erecting structures for the 30-metre behemoth! ✶

Figure 4 — Right, the author, with his friends from Taltal.

Obituary

Remembering Blake Nancarrow (1963-2023)

by Grace Horvatin, Toronto Centre

Blake Nancarrow passed away peacefully on Friday, 2023 September 1, at the St. Thomas Elgin General Hospital. He had put up a valiant fight against the prostate cancer he had been diagnosed with a little over a year before. Blake leaves behind his mother Marie (nee Hall), and was pre-deceased by his father, the late Donald A. Nancarrow. Loved brother of Donna Nancarrow and brother-in-law Steve Proud. Dear nephew of Bill and Peggy Nancarrow and Fred Nancarrow.

Blake's love and devotion to astronomy was obvious to everyone who knew him. Upon joining the RASC Toronto Centre in 2007, he jumped right in as a prolific volunteer. His roles included Toronto Centre Councillor, E.C. Carr Astronomical Observatory Committee member, senior operator of the 74″ telescope operator at the David Dunlap Observatory (one of his personal points of pride), DDO Committee member, Education and Public Outreach Committee member, and he acted as IT Committee lead and Volunteer Coordinator.

At the national level, Blake chaired the National Observing Committee and developed the courses and team to deliver online Stellarium software training for RASC members. He wrote a regular column on astronomy software for the *Journal,* was a regular contributor to *SkyNews* magazine, and maintained an informative astronomy-themed blog called Lumpy Darkness, where he frequently posted deep-sky images gathered with another of his favourite tools: the robotic telescope of the Burke Gaffney Observatory at SMU in Halifax.

Blake loved to share his knowledge and passion willingly with members of RASC and the public. Many a RASCal is a better observer for Blake's coaching and advice. Blake's legacy will live on in RASC's Double Star Observing Certificate program. A personal passion of his, he observed, measured, and logged thousands of double stars in a life list.

I worked on many events with Blake: from his "How to Use Your Telescope" workshop at the David Dunlap Observatory to Open Houses and Awards Picnics at the E.C. Carr Observatory, and many, many public outreach events. Many of his presentations can be found on the Toronto Centre's YouTube channel. He was always well organized and willing to lend a hand where needed.

In 2022, Blake inaugurated the Astronomer in Residence Program at Killarney Provincial Park. In true Blake fashion, he embraced the role and helped iron out the bugs in this new position for future astronomers in residence.

Blake's other passion was his Motorsport racing. He ran many events at the Shannonville Motorsport Park. He shared his driving tips readily, and I often hear his voice in my head while driving: ten and two hand position on the wheel, use the apex of the curve, don't change your tires until the temperature is right, and many more tips.

Upon hearing of Blake's passing from Donna, I felt a great sadness for the loss of a treasured friend and mentor. It seems appropriate that he passed as the stars came out in the clear night sky. We now have yet another star up there. I will think of you, Blake, when I see the "stuuupid Moon" in the sky or pour a pint of Guinness. Shine bright my friend, you will be missed and fondly remembered. ✶

Blast From the Past

Compiled by James Edgar
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With this Department, we bring to life an article from a previous Journal, *most of which are available at the NASA ADS site (Astrophysics Data System). The site is searchable in several ways, one of which is by publication. In our case, search for "JRASC" at ui.adsabs.harvard.edu.*

Vol. 1 JANUARY–FEBRUARY, 1907 No. 1

Introduction

THE object of the Royal Astronomical Society of Canada is to extend and popularize the study of Astronomy, Astrophysics and related branches of science. It hopes to be a bond uniting workers in the field of knowledge in all parts of the land, whether professionals or amateurs.

Heretofore the Society has issued yearly volumes of Transactions, but it has long been felt that publication at shorter intervals would be much more advantageous. The astronomical worker is encouraged by seeing the results of his labor published with reasonable promptness, and in addition great interest and mental stimulus come from the timely announcement of discoveries such as are continually being made in Astronomy. The JOURNAL is begun as a bi-monthly, but it is hoped soon to have it appear every month.

There are few technical articles in astronomy. Which, if clearly written have not a real value to the amateur, while the work of the latter is always of interest to his professional brother. There will be room for both in the pages of the JOURNAL. If all unite, the result will be highly creditable to Canadian science.

C.A.C.

[Clarence Augustus Chant, 1865–1956, was first editor of the Journal, and also edited the Observer's Handbook for 50 editions.]

Progress in Astronomy and Astrophysics During 1906.

by C. A. Chant

(President's address, annual meeting, 1907 January 8)

No striking discovery or outstanding achievement characterises the year just closed, but in every department of Astronomy great advances have been made, and a brief account of some of these will be given, arranged under suitable headings.

The Sun

The Sun is a subject of study for two chief reasons, first, because it is a typical star, and second, on account of its relation to terrestrial phenomena. As a star, comparatively so near that we can study it in detail, we hope to obtain an insight into the process of stellar evolution; as the ruler of our system we hope to determine its cycles and correlate them with our seasons, weather and other terrestrial variations,—ultimately to reach results of the highest practical importance to the dwellers on the earth.

The most pretentious equipment for such study, is that at the Carnegie Solar Observatory on Mount Wilson in California, and its director, Prof. G. E. Hale has now under way a comprehensive programme of work. It consists in (1) direct photography, (2) spectroheliograph researchs, (3) spectroscopic investigations (4) studies of total solar radiation, and (5) allied laboratory investigations. The chief instrument is the Snow horizontal telescope which includes a 30-inch coelostat mirror, a 24-inch plane mirror and a 24-inch concave mirror of focal length 60 feet. It has been found that it can best be used an hour after sunrise or the same time before sunset, a high sun and a windless day changing in a very decided manner the figures of the mirrors.

There have been several valuable publications from this observatory, some of the most recent dealing with the spectra of sun-spots. Mr. Adams confirms the conclusion published by Lockyer in 1904, that the spectra of sun-spots and of Arcturus are similar. From this evidence the deduction is made, that the physical conditions prevailing in the atmosphere of Arcturus are nearly identical with those existing in sun-spot vapors. If we consider the spots cooler than the general solar photosphere, Arcturus and similar stars would be placed on a lower temperature level than the sun. Messrs. Hale and Adams state, that many of the spectral lines are changed in the spots, those of titanium showing greatest mean change of density, while the silicon lines are much weakened.

During the year, numerous results obtained at the Eclipse of August 30, 1905, have been published. The Hamburg Observatory has issued an account of valuable work. The station chosen was in Algeria and the weather conditions were perfect. Excellent photographs of the inner corona were obtained with a camera of focal length 20 metres, an especially interesting feature being the recording of three or four oval, ring-formed, cloudlike caps, which lay at a distance of 4′ to 6′ above the large prominence on the eastern limb, being evidently closely connected with its eruptive nature. These rings were also photographed at Sfax by the Astronomer Royal. Such phenomena were never before photographed, though Lockyer reports having seen something similar in 1870. No trace of an intra-Mercurial planet could be found. The shadow-bands were clearly seen, being about 50 cms long and 4 to 5 cms broad.

A Russian party, in charge of Professor Hansky of the Pulkowa Observatory, occupied a position on the Mediterranean coast near Valencia. They found the coronal light strongly polarised, the bands in the polariscope being much stronger when tangential to the Sun's limb than when radial. There seemed to be a rotation of the plane of polarisation of about 2.5°, which may possibly be ascribed to a magnetic field about the Sun. Another conclusion reached, was that the corona varies in form, brightness and spectrum, with the sun-spot period. The shadow bands were not very well defined. They were of a brownish color and moved with a velocity of 2 to 3 metres a second, the motion however being apparently oscillatory and not translatory. According to other observations in the neighborhood the bands were from 5 to 7 cms. wide and 10 to 15 cms. apart and displaced from north-west to south-east. At Soria in Spain the observations of the bands were as follows: breadth of bands, 2 cms.; from one to another, 6 cms.; velocity 30 metres per minute. These numbers are given by Dr. M. Rosa de Luna of Madrid. It would appear that we have still much to learn of this extraordinary phenomenon.

At Catania, in Sicily, observations of prominences were made during the entire day on which the eclipse occurred. At this observatory it was noted that the maximum effect of solar radiation, corresponded to the minimum potential of atmospheric electricity.

The new Observatory of the Ebro, (under the control of the Jesuit Order,) is located near Tortosa, which was within the zone of totality. The principal work of this institution is the study of the relations existing between solar activity and terrestrial phenomena, its equipment for this object being admirable. In a handsome publication, edited by Father R. Cirera, are given some excellent photographs of the corona and protuberances, and also the magnetic records during the day of the eclipse, as well as those just before and after. Decided deviations from the normal curves are shown in the three elements.

During the Christmas week, I attended the meeting of the Astronomical and Astrophysical Society of America, held in New York, and one of the papers presented was an interesting account of the spectrum of the "flash" taken by Dr. S. A. Mitchell, of Columbia University, who was a member of the U.S. Naval Observatory party in central Spain. Dr. Mitchell has not completed his measurement of the lines of the spectrum, but his work is sufficiently advanced to show that his negatives are exceptionally perfect ones, and that the "flash" spectrum corresponds exactly to the normal solar spectrum. The view expressed at the meeting was, that this work would practically exhaust the subject. Dr. Mitchell is a Canadian and a graduate of Queen's University.

The next total eclipse of the sun will occur on Jan. 14, 1907, the path of totality being across central Asia. It will be best seen at Andishan, north-east of Samarkand, where lived the celebrated Ulugh Beigh, who catalogued the stars at the middle of the fifteenth century. It is on a railway 170 miles south-east of Tashkent where there is an observatory, from which has been issued a map of Turkestan, showing the path of the moon's shadow. The prospects for a clear sky are not very good, but three expeditions—from Pulkowa, Hamburg and the Bureau des Longitudes—are going to observe it. The duration of totality is but two minutes, and I hope the sky will be clearer than it was when the Canadian expedition visited North West River, Labrador.

The next following total eclipse will be on Jan. 3, 1908, but unfortunately its path will be chiefly across the waters of the South Pacific Ocean. Two of the most accessible stations are, Hull I. and Flint I., now the properties of the Lever Co. of Port Sunlight, England.

Janssen and Lockyer found a method for observing the solar prominences without waiting for an eclipse, and many efforts have been made to photograph the corona in ordinary daylight, but without success. Messrs. Millochau and Stefanik, of the Meudon Observatory, however, propose to study the spectrum of the corona from the summit of Mt. Blanc. Their experiments have demonstrated the feasibility of observing the distinctive coronal line in the green (λ 5303) when the atmosphere is sufficiently pure and suitable, screens are employed.

Professor Hansky of the Pulkowa Observatory has made some observations on the granulations of the solar surface has long been a question, whether the granules alter their forms or positions with the time. In the astrographic telescope of the Pulkowa Observatory, the image of the Sun at the primary focus has a diameter of 3 cms., and by using an achromatic concave lens, this was enlarged to 54 cms. Then the negatives were intensified and enlarged to such a scale that the solar disc would be 6 metres. On comparing photographs of the same portion of the disc, taken with an interval of 25 seconds between them, it was seen that the granules had undergone little change of form, but relative movements and changes in brightness could be detected. With an interval of 1 minute, great changes took place, and after 3 minutes they could hardly be recognised. The granules vary in diameter from about 670 kilometres to 2000 kilometres. Professor Hansky hopes to find the relation of the granules to the spots, faculae and other solar features.

A new determination of the magnitude of the Sun considered as a star, has been made by Ceraski, of Moscow. By comparing the Sun with Venus during the day, and then Venus with Polaris, Procyon and Sirius at night, he obtained very accordant results, the mean of which gives the Sun a magnitude of –26.59.

The temperature of the Sun is another physical quantity of great interest, and a new approximate value has recently been found by M. Henri Moissan. who is noted for his work with the electric furnace. The metal titanium is plentiful in the Sun, and Moissan having succeeded in volatilising it in his furnace at a temperature of about 3500°C., he concluded that the temperature of the Sun where this substance is volatilised must be about the same as this. He concludes, that the solar temperature is somewhere between Wilson's estimate of 6590°C. and that of Violle, of 2000 to 3000°C., the probability being that the latter is nearer the truth. (4000°C. = 7212° Fahr.)

In a paper published in 1904, Professor Langley expressed the view that the total solar radiation received by the earth may vary considerably in comparatively short periods. Summarising results obtained since 1902, Mr. C. G. Abbot, who is in charge of the Astrophysical Observatory of the Smithsonian Institution, concludes that this view is confirmed and that a study of the solar radiation will contribute to the solution of the problem of forecasting climate. In connection with this subject, the Solar Commission which met at Innsbruck in 1905, suggested that for the purpose of comparison with solar phenomena, the meteorological observations should be, monthly means of pressure, temperature and rainfall; and that observations of the transparency of the air be made by noting the visibility of distant and high mountains, and by photometrical observations of Polaris.

The Moon

During the lunar eclipse of Feb. 8, 1906, some very interesting observations on the bright spot surrounding the crater Linné were made by Messrs. Barnard, Stebbins, R. H. Frost and others, and the results are quite accordant. The diameter of the bright spot began to increase as Linné passed into the earth's shadow and to decrease rapidly on the return of sunlight to that portion of the Moon's surface.

Prof. W. H. Pickering considers that as this phenomenon has been reported as seen by six independent observers, it may be looked upon as confirmed or accepted as real. He ascribes the increase to the disposition of hoar-frost or something analogous to it, caused by the drop in temperature consequent on the opaque earth screening the Sun's rays.

The ninth part of the great Paris Atlas of the Moon has been published, and in it is a discussion of several theories regarding the production of the features of the Moon's surface.

Another interesting publication on the Moon, is that of Prof. W. H. Pickering, in which he compares the Lunar features with those of Hawaii. In 1905 Professor Pickering visited the Hawaiian Islands and studied carefully the crater formations found there. In great detail these are compared with the Moon's surface, and the evidence adduced, strengthens the conclusion that the surface markings of the moon are of volcanic origin.

It may be mentioned also, that the Greenwich Observatory still continues its great work on the Moon, the researches of Mr. P. H. Cowell deserving especial mention.

The Planets

Mr. W. F. Denning continues his close watch on Jupiter. Between Mar. 24 and May 4, the period of rotation of the Great Red Spot and its hollow was 9h 55m 40.6s, which agreed well with the predicted value, but on August 9, he found the period shortened, it being for the interval, May 4 to August 8, only 9h 55m 33.8s. This increase of velocity is greater than any previously observed. These results were confirmed by Rev. T. E. R. Phillips. Mr. Denning has also determined the period of rotation of several spots on the equatorial side of the southern belt, from observations ranging from 1898 to 1906. In 1880-3 the period was from 18 to 27 seconds shorter than in 1905-6, the rate at this latter time being several seconds slower than in previous years.

At Flammarion's observatory at Juvisy it was observed that a great change had taken place in the visibility of the northern equatorial band. Since 1903 this band had been continually diminishing, and on April 10, 1906, it was almost invisible, but on July 17, after Jupiter's conjunction with the Sun, the band was completely re-formed.

An account of painstaking and excellent work on Mars, is given in volume three of the Annals of Lowell Observatory, and in Mr. Lowell's book on Mars and its Canals. Both volumes are very handsomely issued, and the latter, being a popular, though still scientific account of the long and patient labors of the Director and his able assistants in the observatory at Flagstaff, Arizona, will certainly be widely read. The work is extremely interesting and the author does not hesitate to state his views as to the presence of vegetation and of life on the planet.

Some interesting developments have taken place in the discovery of small planets. Rev. J. H. Metcalf, of Taunton, Mass., described a new method for discovering these minute bodies. It is an adaptation of the method used in photographing·comets, and consists in moving the plate regularly with a speed equal to that of the average asteroid. If one is present, even though very faint, it will impress a circular image on the plate while the stars show trails. Mr. Metcalf in this way discovered an asteroid on March 22 and a comet on Nov. 14, 1906.

A recently discovered minor planet, denoted by the symbol TG, proves to be of exceptional interest. The orbits of these bodies are almost invariably contained between the orbits of Mars and Jupiter, but the mean distance of TG is slightly beyond Jupiter's orbit. On the other hand the planet Eros, discovered in 1898, has its perihelion distance within the orbit of Mars.

Up to June 21, 1906, the entire number of these bodies discovered was 601, about three per month being the rate at which they are found.

The Stars

The cultivation of that immense field, the stellar universe, proceeds with undiminished energy and valuable harvests are being reaped by workers at many observatories.

The Royal Observatory at Greenwich well holds its own. A new working catalogue of stars of the ninth magnitude and brighter, situated between declinations + 24° and + 32° is now complete. It includes over 12,000 stars, the places of which have all been accurately brought up to 1910. The work on the Astrographic Catalogue undertaken at Greenwich is also nearly done, and when complete about 178,000 stars will have been accurately charted.

From the Radcliffe Observatory at Oxford comes a new catalogue of 1772 stars, prepared by Professor Rambaut. It is considered a model of accuracy and thoroughness. The microscopic defects in the mounting of the instrument, in the graduated circles and in·other parts of the equipment are hunted down with unending patience, and the result is a catalogue which has received the highest praise.

At the Astronomical Laboratory at Groningen, in charge of Professor Kapteyn, many laborious calculations of great value to the working astronomer, are being made and published. At this place the study of the faint stars is being energetically carried forward, and these efforts are being ably supported by the work at the Harvard College Observatory. By both photometric and photographic methods, many valuable results are being obtained.

A very important addition to the photometry of the stars is contained in vol. 16 of the Publications of the Astrophysical Observatory at Potsdam, recently issued. The north celestial hemisphere was divided into four zones for convenience in working, and this volume contains the fourth and last zone. It includes all stars of magnitude 7.5 or brighter, and the results obtained show a satisfactory accordance with those in the Bonn, Harvard and Oxford photometries.

The number of stars usually supposed to be visible in the largest telescopes and on the best photographs is about 100,000,000. Mr. J. E. Gore has recently counted the stars on the prints given in Dr. Roberts' stellar photographs. He found that the average number of stars per square degree was 4137 in the Milky Way, 1782 near the Milky Way and 408 in the more distant regions. Combining these results with the areas of the regions considered, he obtained as the grand total of visible stars 64,184,757; though, if we include clusters and nebulae this number will be somewhat increased. Mr. Gore therefore considers 100,000,000 an upper limit.

The activity shown in discovering new variable stars is so great that it is hard to keep account of all. Max Wolf, of Heidelberg, announces the discovery of 55 new variables m the region about γ Sagittae, and 7 in Orion. Miss Leavitt, of the Harvard Observatory has found 58 new ones in Carina. At the Lick and other observatories additional variables have been found. In Circular No. 112 of the Harvard College Observatory, Professor Pickering publishes a plea for the organised observations of long-period variables, work especially suited for amateur observers. To facilitate this work, catalogues and charts are being published, and will be placed in the hands of those willing and able to use them. Professor Bailey, of the same Observatory, proposes a co-operative plan for the construction of a variable star Durchmusterung. I might remark that one of our members, Mr. J. Miller Barr, of St. Catharines, has made a decided success of this work. Not only has he successfully observed the changes in stars already, discovered, but, he has found new ones.

One of the most interesting of variable stars is β Lyrae, discovered in 1784 by John Goodricke of York, a deaf-mute, scarcely 20 years of age. It has a double minimum, one being much more pronounced than the other, and its period is given as 12d 22h, but the period appears to be increasing though not uniformly. The change is at a diminishing rate. A cause for this extraordinary effect is suggested by Dr. A. W. Roberts in the Observatory, his view being, that in this star we have a binary system in which the component stars are slowly receding from each other under tidal forces, in accordance with Darwin's theory, regarding the evolution of planetary and stellar systems. On the other hand Professor Schaeberle accounts for the result on the principle of the repulsion due to light. He suggests, that at a certain period of the system, the decrease in mass by repulsion from one body was so rapid, as to cause an increase in the periodic time of any other body belonging to the system. If now a portion of this ejected mass afterward returns to the parent body, the increase in period would be at a diminishing rate.

There has also been a plentiful harvest of double stars. Aitken, of the Lick, publishes 350 new ones, Rev. T. E. Espin gives 42, and Burnham of the Yerkes has completed his monumental catalogue of double stars, to which he has devoted so much of his life. It will be issued by the Carnegie Institution and will undoubtedly be the standard work on the subject for many years. Prof. E. Doolittle of the Flower Observatory, University of Pennsylvania, has published measures of 1066 double and multiple stars. Another very important event in this department is the publication of a great memoir by Mr. T. Lewis, of the Greenwich Observatory, on W. Struve's double stars. It gives the complete observations made on 3000 pairs from the time of their discovery to the present time, computes the orbits when possible and criticises the orbits computed by others.

Much work has also been done on the measurement of radial velocities, for which the Lick, Yerkes and Potsdam observatories are especially famous. I may say too, that this line of work is being assiduously carried on at our own observatory at Ottawa, and results will soon be forthcoming in a ·form suitable for publication. Attention is also directed to the excellent work done by Mr. Slipher at the Lowell Observatory on the radial velocity of ten standard stars. It is found, that at this observatory on account of the great altitude and prevailing transparency of the atmosphere, results can be secured in about one-half the time required at the Yerkes Observatory.

The largest and finest nebula in the sky is believed to be that in Orion, but Professor Barnard has discovered photographically a large nebula in Scorpio comparable in size and complexity to the one just mentioned. Professor Barnard thinks that the branching, straggling character of this and similar nebulae tends to discredit the accepted form of the nebular theory of stellar evolution.

The Zodiacal Light

The Zodiacal Light has always been an enigma, and information regarding it is much to be desired. During the years 1899-1901 Mr. Maxwell Hall, of Montego Bay, Jamaica, made some interesting and suggestive observations. He determined the breadth of the light and its boundaries at different distances from the Sun, and on reducing his observations he obtained evidence tending to show that the light is parallel to the invariable plane of the Solar System, a result confirmed by some others. He concludes, that the Zodiacal Light is caused by reflection of sunlight from masses of meteoric matter still contained in the invariable plane, which may be considered the original plane of the Solar System. In this case, the phenomenon is astronomical in origin and should be seen better and more frequently at stations in high latitudes.

Professor Barnard has also paid some attention to the subject and concludes that the light extends at least 65° north and south of the Sun.

Meteors and Comets

Two magnificent fireballs are reported by Mr. Denning. One was seen on Jan. 27 at 8.33 p.m., above the North Sea, disappearing near Wainfleet. Its brightness was equal to that of the full moon. Its height was from 59 to 45 miles. The length of observed path was approximately 42 miles and the velocity about 24 miles a second. Its trail was visible for 5 minutes. Another was seen on Dec. 30, 1905, in Scotland and the northern counties of England. The height of the meteor at the points of observation was from 27 to 67 miles, its length 72 miles, and velocity 15 miles a second. In this case the trail was visible for 12 or 13 minutes.

One of the most remarkable of meteoric phenomena, however, is that described by Capt. C. B. Anderson of the Steamer African Prince, who says : "On the evening of Oct. 17, I was on the bridge with the second officer, when suddenly the dark night was light as day, and an immense meteor shot comparatively slowly at first, (because the direction was so perpendicular to our position,) then more rapidly towards the earth. The train of light was an immense broad electric-colored band, gradually turning to orange, and then the color of molten metal.

When the meteor came into the denser atmosphere close to the earth, it appeared, as nearly as it is possible to describe it, like a molten mass of metal being poured out. It entered the water with a hissing noise, close to the ship."

During the year eight comets were observed, though none visible to the naked eye. Comet 1906a, was discovered by Brooks, of Geneva, N.Y., on Jan. 26; 1906b, by Kopff of the Königstuhl Observatory, Heidelberg, on March 3; 1906c, by Ross, of Melbourne, March 18; 1906e, also by Kopff, Aug. 22; 1906g, by Thiele, at Copenhagen, Nov. 10; 1906h, by Metcalf, at Taunton, Mass., Nov. 14. Comet 1906d, was Finlay's comet, the period of which is 6.56 years, "re-discovered on July 16 by Kopff; and 1906f, was Holmes' Comet, of period 6.87 years, originally discovered on Nov. 2, 1892, but re-discovered on its second return by Wolf, at the Königstuhl Observatory, on Aug. 28. Naked-eye comets are somewhat rare. Halley's Comet, which has a period of about 76 years, should be observable with a telescope at the end of 1909, and during the latter half of March 1910 will likely be seen with the naked eye.

Geodetic Measurements

The observations to determine the precise manner in which the latitude varies are being continued at about a dozen observatories, some of them established by international agreement, specially for the purpose. At the recent meeting of the Astronomical and Astrophysical Society of America, a paper was presented by Prof. C. L. Doolittle, of the Flower Observatory, University of Pennsylvania, in which, in addition to the regular variation having a period of 428 days, one of approximately six years appeared to be indicated.

An important work for any country to undertake, is the measurement of an arc on the earth's surface, and several nations have an honorable record of such labor. At present one of the greatest undertakings of the kind, is that of measuring an arc of the 30th Meridian, extending from Cape Colony to Egypt, and it is satisfactory to learn that the end of this splendid international work is almost in sight.

In Canada the determination of the longitude of various stations and the delimitation of the U.S. boundary is being continually pushed forward.

Improvements in Equipment

As we should expect, the world will never be satisfied with its present astronomical equipment, but greater engines of research are ever in process of evolution.

At Hamburg, Germany, the senate and council have voted Mk. 1,000,000 ($250,000) towards the erection and equipment of a new observatory. When completed it will possess a meridian circle of 18 cm. (7 in.) aperture; a refractor of 60 cm. (23 in.) aperture; a double photographic telescope; and a reflector of diameter 1 metre.

Look for Part 2 in the next issue of the Journal

Skyward

For the Love of Comets and Pegasus

by David Levy, Kingston & Montréal Centre

When David Rossetter and I began our observing session at the Tucson Amateur Astronomy Association's Chiricahua Astronomy Complex on the evening of 2023 August 5, we did not expect that we would be treated to an evening of cosmic history. That was the night we glimpsed Comet Pons–Brooks, a comet with an orbit that, like Halley's Comet, takes almost a human lifetime to orbit the Sun. I might have spotted it the night before, but on this night David and I saw the same thing: a spot of haze in the darkness. It was a faint misty cloud that bears the names of two of the most famous comet discoverers in all history—a spot of haze with quite a story to tell.

Comet Pons–Brooks was first identified by Jean-Louis Pons, the great French comet hunter, during the summer of 1812. In the late summer of 1883, on its subsequent pass around the Sun, it was rediscovered by another famous comet hunter, William Robert Brooks.

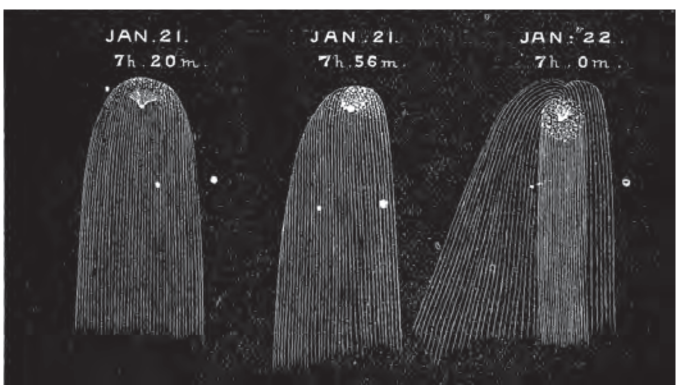

Figure 1 — Three sketches of the Comet Pons–Brooks during its January 1884 apparition by Herbert Couper Wilson. Besides his obvious ability in sketching, Wilson sighted canals on Mars and was one of the few who agreed with Percival Lowell's arguments about these alleged features.

I first encountered Brooks in a *Sky & Telescope* article I read in the second issue I received, at age 14, in April 1963. As I digested the story, I learned how Brooks might have politely entertained a visitor to his observatory, and how that visitor eventually learned that Brooks was one of the world's most famous comet discoverers. As I relished these words, I foresaw myself, someday, also as a hunter of comets. Not a discoverer, because that would be hard. But as a hunter, that's easy.

Those ideas stayed with me until 1965 December 17, when I began my program of searching for comets. Since then, my own life has been punctuated by several sparks of cometary light, as each new comet added brightness to the field of my telescope. I joined a group of people linked not by nation, nor by continent, but by being citizens of the world united by a love of comets.

Emboldened by the offer by Hulbert Harrington Warner of an award of $200 for each comet discovered, Brooks managed to find three comets within five weeks of each other on 1886 April 17, April 30, and May 22. He must have known how his colleague Edward Emerson Barnard built his "comet house" partly out of funds also earned from Warner's award. (The Warner prize has survived through history. The Astronomical Society of the Pacific offered its Donohoe Comet Medal for a time, and later Roger Tuthill gave a plaque, and now there exists the Edgar Wilson Award, which is sponsored by the Central Bureau for Astronomical Telegrams [CBAT] of the International Astronomical Union.)

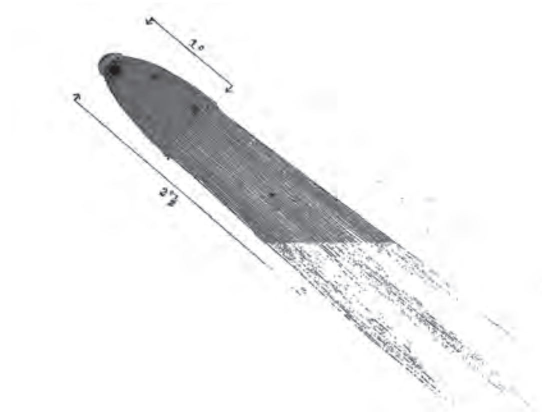

Figure 2 — This sketch, from 1843, was done by Edward Emerson Barnard, one of the foremost visual observers who ever lived.

Like all serious comet hunters, Brooks was far more interested in discovering comets than in the money he could earn from these finds. In later years, his success as a comet hunter earned him a professorship in astronomy at Hobart College in Geneva, New York. With Brian Marsden's 1979 Catalog of Cometary Orbits as a guide, we can surmise that Brooks discovered a minimum of 22 comets in his lifetime.

Despite this remarkable accomplishment, Brooks is only the second most prolific comet finder in world history. The winning ticket goes to Jean-Louis Pons himself, who was the first "discoverer" of Comet Pons–Brooks. Truly, Pons was also not the first. This comet might have been observed by Chinese astronomers in the late summer of 245 CE, then definitely by the Chinese in 1385, and in 1457 by Paolo del Pozzo Toscanelli. Today, Pons is considered to have discovered about 30 comets. Over the decades, I observed a second Pons periodic comet, Pons–Gambart in January 2013.

By the way, Pons had a most humble and trusting nature, and in his younger years he was ridiculed by astronomers who should have known better.

These days, it is almost impossible for an individual to discover more than half a dozen comets. My total is 23, but as CBAT director Dan Green (possibly correctly) stated, "He discovered 9 comets and lucked out on 11 more," before graciously adding Comet Shoemaker–Levy 9 to my total.

Pons and Brooks shared a passion for telescopes and the fleeting comets they could detect parading about the sky. I like to imagine that finding new comets was secondary to their pure enjoyment of the night sky, its treasures, and the secrets that it infrequently shared with those people who truly lived, and live, for its precious hours of darkness.

Pegasus

As a youngster growing up in Montréal in the early 1950s, I was impressed by the seeming simplicity of Montréal's weather. It appeared to me as though there were just two kinds of weather: In wintertime, a grey sky, and in summertime, a blue sky. I wasn't completely wrong about this. In 1961, while trying to run a small astronomy club for young people, I counted an unbroken string of cloudy Friday nights that lasted for months. And sure enough, when the weather began to moderate the following spring, we were treated to, at last, a clear night.

As I grew older, my thoughts turned to finding a different locale where the sky would be clear more often. In September 1979, I packed my bags and telescopes and headed for the American southwest. I was rewarded immediately. My first season here—the autumn of 1979—was punctuated by a virtually unbroken string of more than 50 clear nights in a row.

There was a specific reason for my wanting clearer nights. In the fall of 1965, I was planning a search program for comets, and it began on December 17 that year, just before midnight. I used the largest telescope I had at the time: the 8-inch reflector named Pegasus. Less than a year later, Miss Isabel K. Williamson, director of observations of The Royal Astronomical Society of Canada's Montréal Centre, wrote this in the November 1966 issue of the Centre's newsletter *Skyward*: "The increase in the number of observations over the previous year can be attributed to David Levy who has made the search for and observation of comets and novae his main astronomical project. In addition to patrolling assigned areas, he has made a total of 360 observations of the dome, the twilight horizon, and the sky in the Sun's vicinity, and on 33 nights spent a total of 48 hours at the eyepiece of his telescope, sweeping the sky for comets."

Miss Williamson's words from all those years ago remain among the highest compliment I have received from anyone.

Figure 3 — Pegasus, the first telescope the author used for comet hunting.

And I still use Pegasus for some of my comet hunting, including the evening of 1987 October 11, when I used it to find my third comet, 1987 T1. In fact, to celebrate the completion of this article, I went outdoors and used Pegasus for a short comet search this very evening.

I may have been right about my childhood weather forecast. Southern Arizona offers many more clear nights than one can appreciate from the frequently cloudy sky over Montréal. And from the Chiricahua Astronomy Complex, a two-hour drive southeast of my Vail, Arizona, home, observers are treated to one of the darkest sky locations in the world. It is well worth loading Pegasus into a van and using it at that wonderful CAC dark site. Whether I am down there or right here, placing my eye at the eyepiece of this beloved telescope warms my heart and pierces my soul. ✶

David H. Levy is arguably one of the most enthusiastic and famous amateur astronomers of our time. Although he has never taken a class in astronomy, he has written more than three dozen books, has written for three astronomy magazines, and has appeared on television programs featured on the Discovery *and* Science *channels. Among David's accomplishments are 23 comet discoveries, the most famous being Shoemaker-Levy 9 that collided with Jupiter in 1994, a few hundred shared asteroid discoveries, an Emmy for the documentary* Three Minutes to Impact, *five honorary doctorates in science, and a Ph.D. that combines astronomy and English Literature. Currently, he is the editor of the web magazine* Sky's Up!, *has a monthly column, "Skyward," in the local* Vail Voice *paper and in other publications. David continues to hunt for comets and asteroids, and he lectures worldwide. David was President of the National Sharing the Sky Foundation, which tries to inspire people young and old to enjoy the night sky.*

CFHT Chronicles

Stars!

by Mary Beth Laychak, Director of Strategic Communications, Canada-France-Hawaii Telescope (mary@cfht.hawaii.edu)

Last issue was all about MegaCam and our imaging work. This time around we are taking a look at the work of our high-resolution spectrograph Echelle Spectropolarimetric Device for the Observation of Stars (ESPaDOnS).

Death-defying Planet

The Jupiter-like planet 8 UMi b, officially named Halla, orbits the red-giant star Baekdu (8 UMi) at only half the distance separating Earth and the Sun. Using two Maunakea Observatories on Hawai'i Island—W.M. Keck Observatory and CFHT—a team of astronomers led by Marc Hon, a NASA Hubble Fellow at the University of Hawai'i's Institute for Astronomy (IfA), has discovered that Halla persists despite the normally perilous evolution of Baekdu. Using observations of Baekdu's stellar oscillations from NASA's *Transiting Exoplanet Survey Satellite* (TESS), they found that the star is burning helium in its core, signaling that it had already expanded enormously into a red-giant star once before.

The star would have inflated up to 1.5 times the planet's orbital distance—engulfing the planet in the process—before shrinking to its current size at only one-tenth of that distance. The paper was published in the June issue of the journal *Nature*.

"Planetary engulfment has catastrophic consequences for either the planet or the star itself—or both. The fact that Halla has managed to persist in the immediate vicinity of a giant star that would have otherwise engulfed it highlights the planet as an extraordinary survivor," said Hon, the lead author of the study.

The planet Halla was discovered in 2015 by a team of astronomers from Korea using the radial-velocity method, which measures the periodic movement of a star due to the gravitational tug of the orbiting planet. Following the discovery that the star must at one time have been larger than the planet's orbit, the IfA team conducted additional observations from 2021–2022 using Keck Observatory's High-Resolution Echelle Spectrometer (HIRES) and CFHT's ESPaDOnS instrument. These new data confirmed the planet's 93-day, nearly circular orbit had remained stable for over a decade and that the radial-velocity changes must be due to a planet.

"Together, these observations confirmed the existence of the planet, leaving us with the compelling question of how the planet actually survived," said IfA astronomer Daniel Huber, second author of the study. "The observations from multiple telescopes on Maunakea was critical in this process."

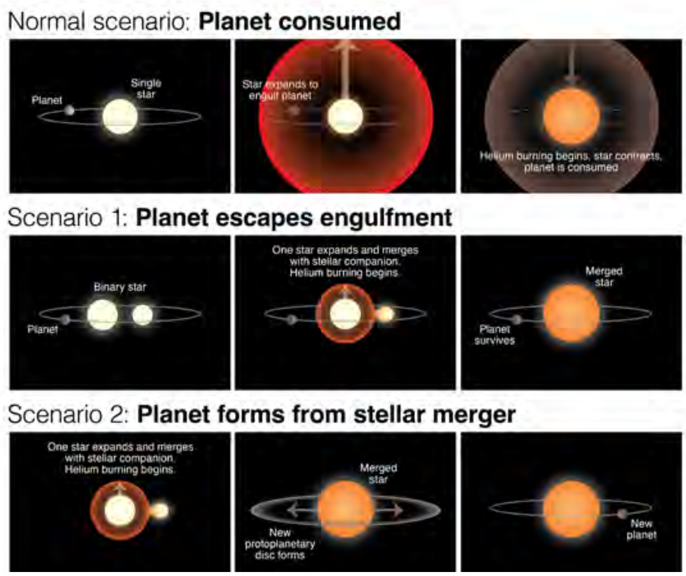

Figure 1 — Evolutionary pathways for the 8 UMi system. (Top) Had the planet 8 UMi b orbited a single star closely, the star's expansion would have destroyed the planet. (Middle and bottom) The merger of two stars provides two scenarios that may have led to the planet's survival around a core-helium-burning star as observed today. Image credit: Brooks G. Bays, Jr, SOEST/University of Hawai'i

At a distance of 0.46 astronomical units (au, or the Earth-Sun distance) to its star, the planet Halla resembles "warm" or "hot" Jupiter-like planets that are thought to have started on larger orbits before migrating inward close to their stars. However, in the face of a rapidly evolving host star, such an origin becomes an extremely unlikely survival pathway for planet Halla.

Another conjecture for the planet's survival is that it never faced the danger of engulfment. Similar to the famous planet Tatooine from *Star Wars*, which orbits two suns, the team believes the host star Baekdu may have originally been two stars. A merger of these two stars may have prevented any one of them from expanding sufficiently large enough to engulf the planet.

A third possibility is that Halla is a relative newborn—that the violent collision between the two stars produced a gas cloud from which the planet formed. In other words, the planet Halla may be a recently born "second generation" planet.

"Most stars are in binary systems, but we don't yet fully grasp how planets may form around them. Therefore, it's plausible that more planets may actually exist around highly evolved stars thanks to binary interactions," explained Hon.

As the first known close-in planet around a core-helium burning star, the planet Halla shows that exoplanet discoveries may still surprise us by appearing around stars where they are least expected. The ultimate fate of exoplanets is not yet certain, but the union between stellar and planetary sciences will continue to shed light on whether death-by-star is a fate truly shared across all planets residing near their suns.

Co-authors on the study include Nicholas Rui and Jim Fuller from Caltech, Dimitri Veras from the University of Warwick, a multinational group of researchers hailing from Italy, Denmark, Turkey, and Australia, as well as astronomers affiliated with the California Planet Search group. Additional co-authors on the study include IfA graduate students Jingwen Zhang and Casey Brinkman, IfA postdoctoral fellows Daniel Hey and Joel Ong, and UH IfA alumni Ashley Chontos, Zachary Claytor, Jamie Tayar, and Lauren Weiss.

Magnetic Stars

A team of researchers led by Tomer Shenar at the University of Amsterdam found a highly unusual star that has the most powerful magnetic field ever found in a massive star. The star, HD 45166, may one day become one of the most magnetic objects in the Universe: a type of neutron star known as a magnetar. This finding marks the discovery of a new type of astronomical object—a massive magnetic helium star—and sheds light on the origin of mysterious magnetars.

Neutron stars, the compact remains of massive stars that explode as a supernova, are made of the densest matter in the Universe. Some neutron stars, known as magnetars, also claim the record for the strongest magnetic fields of any object. How magnetars—which are a mere 15 kilometres across—form and produce such colossal magnetic fields remains a mystery.

New observations by a team of astronomers may shed important light on the origin of these magnetic powerhouses. The team used various telescopes around the globe, including CFHT's ESPaDOnS, to identify this new type of object. Massive helium stars have very high surface temperatures, strong stellar winds, high abundances of heavy elements, and much less hydrogen than typically found in other stars. Prior to the team's announcement, massive magnetic helium stars were not on astronomers' radar.

Despite more than a century of observations by astronomers, little was known about the true nature of HD 45166, beyond the fact that it is rich in helium, somewhat more massive than our Sun, and part of a binary system.

Having studied similar helium-rich stars before, Shenar was intrigued by the unique characteristics of HD 45166, which is located 3000 light-years away. He suspected that magnetic fields could explain what he was seeing.

"This star became a bit of an obsession of mine," said Shenar. "I remember having a 'Eureka!' moment while reading the literature: 'What if the star is magnetic?'"

Shenar and his collaborators set out to test this hypothesis by taking new observations of this star system with the instrument ESPaDOnS installed at CFHT. The observations were taken using the spectropolarimetric mode of the instrument, which enables astronomers to measure the magnetic field of stars. Spectropolarimeters, like ESPaDOnS, are relatively uncommon instruments.

These observations revealed that HD 45166 has a phenomenally powerful magnetic field, about 43,000 gauss. For comparison, the magnetic field of the Sun is 1–2 gauss, and its sunspots reach up to 3,000 gauss.

Figure 2 — Artist's impression shows HD 45166, a massive star recently discovered to have a powerful magnetic field of 43,000 gauss, the strongest magnetic field ever found in a massive star. Intense winds of particles blowing away from the star are trapped by this magnetic field, enshrouding the star in a gaseous shell, as illustrated here. credit: ESO/L. Calçada.

In addition, by studying how HD 45166 interacts with its companion star, the team was able to make precise estimates of its mass and age, leading the team to speculate that, unlike other helium stars that eventually evolve from a red supergiant, this particular one was likely created by the merger of a pair of intermediate-mass stars.

After taking a look at the data, Shenar reached out to co-author and stellar magnetic field expert Gregg Wade, from the Royal Military College of Canada, and asked him to examine the data.

"Gregg looked at the data and replied, 'Well my friend, whatever this thing is, it's definitely magnetic,'" said Shenar. "It's exciting to discover a new type of astronomical object, especially when it's hiding in plain sight all along."

In a few million years, HD 45166 will explode as a very bright, but not particularly energetic, supernova. During this explosion, its core will contract, trapping and concentrating the star's already daunting magnetic field lines. The result will be a neutron star with a magnetic field of around 100 trillion gauss—the most powerful type of magnet in the Universe. Prior to the team's discovery, astronomers believed the most likely magnetar formation scenarios involved stars much more massive than HD 45166.

"Magnetars are rare and mysterious objects, so the team's discovery of the first massive magnetic helium star that will later become a magnetar enhances our understanding of their formation," said Nadine Manset, CFHT's director of science operations and ESPaDOnS instrument scientist. "ESPaDOnS is an ideal instrument for measuring the magnetic fields of stars and it is always rewarding to see it unveil new magnetic secrets of stars."

CFHT is located on Maunakea, land of the Kānaka Maoli people, and a mountain of considerable cultural, natural, and ecological significance to the Native Hawaiian people. ✶

Mary Beth Laychak has loved astronomy and space since following the missions of Star Trek's Enterprise. She is the Canada-France-Hawaii Telescope Director of Strategic Communications; the CFHT is located on the summit of Maunakea on the Big Island of Hawaii.

Dish on the Cosmos

The Ammonia Megastorms of Saturn

by Erik Rosolowsky, University of Alberta (rosolowsky@ualberta.ca)

Planets are some of the most prominent objects in our sky, and their slowly wandering motions have made them a source of interest for millennia. We usually study planets in visible light, where their colours and patterns tell us about their composition and properties. In particular, the gas giants show a range of colours and patterns, all related to the gasses in their atmosphere and their intense weather. The bands and zones on Jupiter highlight the patterns of gas flows in the atmospheres of the planet, which stand in strong contrast with lower-contrast colours in the other three gas giants. Saturn is the closest in mass and distance to the Sun to Jupiter, yet it has a blander appearance in the optical without the strong red banding of its larger sibling. When viewed in radio wavelengths, however, the faint banding seen in the optical light becomes far more prominent, showing bright changes in radio colours across the surface. Recently, astronomers have used these radio observations to study the long-term evolution of massive storms in Saturn's upper atmosphere to learn about weather on these large planets.

Gas giants like Saturn are composed almost entirely of hydrogen and helium gas, mimicking the concentration of elements across the Universe. The next most-abundant elements are carbon, oxygen, and nitrogen, and these three elements tell us how they combine with hydrogen to make the simplest possible molecules. Carbon forms stable atoms with hydrogen as methane (CH_4), oxygen forms stable molecules with hydrogen to make water (H_2O), and nitrogen combines with hydrogen to make ammonia (NH_3). Sunlight can then

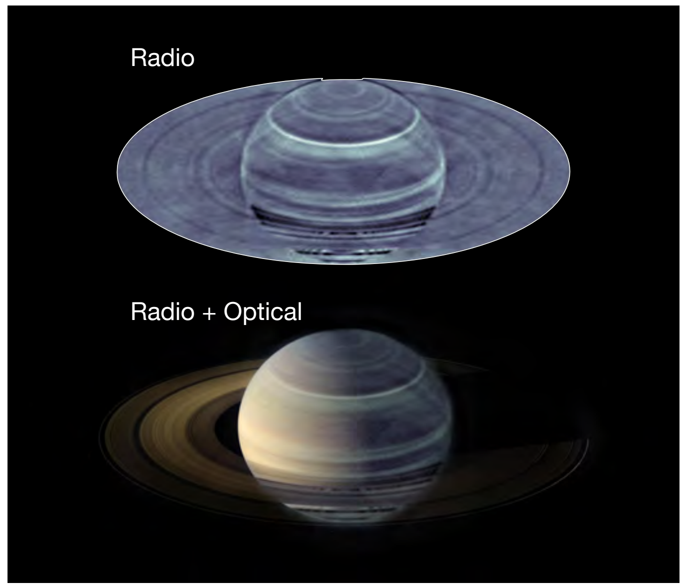

Figure 1 — (Top) A radio image of Saturn made with the Very Large Array in radio light with a wavelength of 1.3 cm; (Bottom) Composite image of Saturn in radio plus optical imaging from the Cassini *mission. Image credit: Credit: S. Dagnello (NRAO/AUI/NSF), I. de Pater et al (Berkeley)*

catalyze reactions between these basic molecules to make more-complicated molecules, which is especially true for Jupiter as the closest gas giant to the Sun.

The primary colours of the planets are set by the balance of methane, water, and ammonia in their atmospheres. All three of these molecules are transparent in gas form, but they can condense into droplets of liquid and form clouds, but the temperature of this condensation varies with the molecule. Methane condenses at the lowest temperatures, followed by ammonia, followed by water. The condensation temperatures of clouds set the colours of the planets. For example, Neptune and Uranus are relatively cold, and these low temperatures cause methane molecules to cool out into a vapour and form clouds in the upper atmospheres. Methane vapour absorbs red light readily, so these planets appear blue. In contrast, Saturn is closer to the Sun and warmer, so the methane in the atmosphere remains in gas phase, and we see farther down through the atmosphere to an ammonia layer where the clouds reflect the yellow colour of light. Jupiter shows the same ammonia clouds, but the red bands of colour show up because the violent weather on Jupiter dredges up sulphur-bearing molecules into the upper atmosphere that reflect red light prominently. Finally, if gas giants were even warmer and the condensation of the ammonia molecules was also prevented, then we would see down into the layers where the water molecules form, and the gas giants would appear white like the clouds in our own atmosphere.

These planet-covering cloud decks prevent us from seeing deep into these gas giants in the optical light where the molecules absorb and reflect light easily. In contrast, in radio waves, these clouds do not absorb or re-emit much light. The optical light that we see from planets is the reflected radiation from the Sun, but in the radio waves, the light we see is made by the planet itself. This radiation is the same type of light that the Sun is generating, but since the planets are substantially colder than the Sun, we see it as much longer wavelengths of light like the infrared or the radio. Brighter regions correspond to warmer parts of the atmosphere and fainter regions are colder. Just like we can observe planets in different colours of light in the optical, we can also observe them in different colours of light in the radio, corresponding to different wavelengths of radio waves. In the planetary atmosphere, the different wavelengths of light are coming from different depths in the atmosphere. Long-wavelength radiation comes from deeper inside the planet, so the combination of the brightness of the light and the different wavelengths mean that radio light can be combined to map out the temperatures in three dimensions in the planet.

Recently a group of astronomers have used the Very Large Array to make a high-resolution map of the light coming from Saturn. The radio map of Saturn is shown in Figure 1, as well as the optical+radio map of the planet. This map just shows a single wavelength of radio light, but it reveals a strongly striped appearance to the planet. The bands in radio light appear coincident with some of the bands visible in the optical image. The bright regions correspond to warm regions in the upper atmosphere and darker regions are colder. Then, the researchers used maps like these at different wavelengths of light to map out the temperature profile at different depths.

The final innovation in this research comes from combining the radio observations with a model of how the ammonia clouds form in the atmosphere. Ammonia in Saturn plays the same role that water and carbon dioxide play in Earth's atmosphere as a greenhouse gas. The ammonia regulates the flow of radiation from the interior of the planet out into space, much like water and CO_2 shape the flow of radiation on Earth. The research team found that radiation was flowing out in some regions faster than expected, consistent with there being less ammonia in a layer of the atmosphere than the model suggests. They connected their observations to a peculiar phenomenon in Saturn's atmosphere. Every 10 to 30 years, Saturn experiences a "megastorm," which brings up a large bubble of ammonia from the interior of the planet. They believe that this storm has saturated the atmosphere leading to an excess of ammonia raining back down into the interior, "drying out" some levels in Saturn's upper atmosphere by removing ammonia from them. The pattern fits well: different historical storms on the planet could be connected to different ammonia-poor regions giving some strength to the model.

Overall, these new observations of Saturn highlight how radio light can probe the atmospheres of planets in ways that complement our usual optical perspectives. These observations continue to be exciting, since the atmospheres and storms of the planets change over the years, making it possible to watch how the weather on different planets evolve. This study ultimately helps us understand atmospheres in general and Earth's atmosphere in particular. ✶

Read more: www.science.org/doi/10.1126/sciadv.adg9419

Erik Rosolowsky is a professor of physics at the University of Alberta where he researches how star formation influences nearby galaxies. He completes this work using radio and millimetre-wave telescopes, computer simulations, and dangerous amounts of coffee.

John Percy's Universe

Becoming an Astronomer

by John R. Percy, FRASC
(john.percy@utoronto.ca)

I am occasionally asked, at my public talks, about how one becomes an astronomer—or how I did. I have already discussed how the training of astronomers in Canada has evolved over the last century or two (Percy 2015), and the wide range of non-astronomical careers that are available to astronomy graduates (Percy 2018). Here, I shall describe the routes to astronomer-hood—direct and less-direct—and the barriers that some aspiring astronomers face, and that should be lowered however possible.

The Direct Route

In high school, develop an interest in and a talent for science and math. In university, enroll in an astronomy program, or a physics and math program with some astronomy courses. Get some research experience, either as part of your winter course work, or in the summer. Ideally, get some teaching and outreach experience as well, both to enhance your resumé, and to strengthen and share your passion for astronomy. And do well!

In your senior year, apply to one or more graduate programs in astronomy; your undergraduate instructors can give you advice on this. If you are accepted, you may start out in a Masters (M.Sc.) program, or in a direct-entry Ph.D. program. You will take some graduate courses, start one or more research projects, and probably take a comprehensive or general exam to test your overall understanding of astronomy. Past that hurdle, you will start (or continue) a research project that will become your doctoral thesis. Also, get some more training and experience in teaching! Participate in some of your department's outreach programs. Complete, write, and defend your thesis in front of a committee that will consist of four or five experts in your field. Then you will become Dr. Astronomer!

But wait! There are always a few dozen "editorial corrections" to your thesis that are requested by the exam committee. That takes another month. And your graduation does not become official until convocation where, in your cap and gown, you will get appropriately hooded by the university president or whoever.

Then, apply for post doctoral fellowships ("postdocs"). They will give you two to three years more research experience. Finally, apply for positions in university, government, or other professional astronomy settings. In universities, most faculty positions are in the "research stream." Your duties will be 40 percent research, 40 percent teaching, and 20 percent everything else. By the way, I find it bizarre that you get so many years of preparation for your research duties, and little or none for your teaching! For those who prefer teaching to research, there are now also positions in the "teaching stream" in which your duties are 80 percent teaching, and 20 percent everything else.

After about seven years, you will be considered for "tenure" i.e. permanent employment. This will be based on the quantity and quality of your research and teaching. You should receive lots of advice and preparation for this, from your department, your university, or your faculty association or union. If you pass this filter, and most do, you are all set. You may subsequently branch out into administration, in your department, university, or professional associations, as I did, or you may simply continue to do your research and teaching well. If you go into administration, you get little or no training.

These days, the steps to astronomer-hood almost always take place at different universities, often in different countries. For some, that's a big plus, but not for others. There may be the "two-body" problem, for instance: if you have a partner, they may not easily find employment in the same place as you. That's a problem that you have to deal with in your own way.

Of course, you can bail out of the system at any point. Then be sure to read my column about alternate careers for astronomers! There is no shame in this; we need astronomy-trained people in industry, business, government, politics, education, journalism, etc.

The Less-Direct Route

Then there are more indirect routes. In my own case, as an undergraduate astronomy student, I delved into biophysics (Percy 2020). After my Master's degree, I spent a year at teachers' college, and a year as a high-school teacher, before being enticed back into astronomy. But my interest in education has remained. And those two non-standard years have been invaluable.

My colleague Gwen Eadie spent a year as a professional figure skater, before rejoining the astronomer pipeline, and becoming an award-winning faculty member in Astronomy and Statistics. Skating is still an important part of her life.

My former undergraduate research student Inese Ivans worked as a tradesperson for several years before starting undergraduate and graduate studies in astronomy, receiving a Ph.D., then winning a prestigious Hubble Postdoctoral Fellowship, and going on to a faculty position at the University of Utah.

Jayanne English obtained an undergraduate degree in art and design from the OCAD University in Toronto before embarking on the standard route to astronomer. After her

Ph.D., she worked on the multi-award-winning Hubble Heritage Project, which produced stunning, aesthetically impactful Hubble images that preserved their scientific integrity. She then became a professor in Physics and Astronomy at the University of Manitoba. Earlier this year, she was appointed a Member of the Order of Canada "for her innovative work at the crossroads of science and art, and for making astronomy accessible to all." Congratulations, Jayanne!

There are many other examples. So, if you have other passions besides astronomy, you don't necessarily have to give up one or the other. They may be mutually supportive. Besides, you need more than astronomy in your life—encompassing as it may be.

The Rugged Route

There are young people, however, who may dream of becoming an astronomer, but the odds are stacked against them. Their families may insist that they pursue a more predictable and lucrative career, such as law or medicine. They may be refugees or other immigrants with limited language skills, in a sub-standard school, with limited extracurricular activities. They may belong to groups, such as Black or Indigenous, which have faced discrimination and a lack of role models, in addition to other challenges. Women are still under-represented in some areas of STEM, as are LGBTQ+ and disabled people. It also doesn't help if you are the first in your family to go to university.

Some young people may be among the embarrassingly large number of Canadians who live in poverty or near-poverty. The cost of a university education can be astronomical, and this can be insurmountable for many. One solution would be to make university education less expensive, or even free, as is the case in some countries, but the university system in Canada is already under financial stress. It certainly is in Ontario. Universities could give preferential admission and support to applicants from under-served communities, but this is already controversial in the U.S. Several universities, including mine, and most recently Cambridge University, have created bridging or transitional-year programs to give such disadvantaged students an opportunity to prove themselves.

There are also an increasing number of programs aimed at under-served students. University of Toronto astronomy students, for instance, partner with *Visions of Science Network for Learning* [1], which has traditionally encouraged and supported Black students, and *Pueblo Science* [2], which serves Indigenous youth, among others. Perhaps RASC Centres could also direct some of their outreach to young people in these under-served communities. There are also some scholarships specifically aimed at these students; my wife and I have endowed one at University College, our *alma mater.*

The Amateur Route

It costs nothing to be an amateur astronomer; "the stars belong to everyone." And there are no qualifications needed. There are many good books in our free public libraries, including Nicole Mortillaro's annual guide to the night sky, *The Night Sky Almanac*. The resources on the internet are almost infinite; for instance, I can recommend the University of Toronto's *Cosmos from your Couch* series, available on YouTube [3]. RASC Centres and universities like mine provide star parties and other public events. As you get more knowledge and experience, you may find yourself volunteering at these events, and passing along your passion for astronomy. You could even become a "citizen scientist" by participating in research projects with professional astronomers such as me.

I have enjoyed every minute of my career in astronomy. I get to push back our understanding of the Universe, just a little bit. I get to help train the undergraduate and graduate students who will be the next generation of astronomers. I get to share my love of astronomy with thousands of other students, with the public, and with you the reader.

But I have been very fortunate. I was born in England in the depths of WWII. My birth father, in the RAF, was killed in the war. At the end of the war, my mother married a Canadian soldier, and that's why I ended up here in Toronto in 1946. We started in the semi-slums of Cabbagetown, then moved to the "sticks" of Downsview. But I had excellent schools and teachers throughout, thanks to you the taxpayers. In university, I had scholarships, thanks to an earlier generation of donors. And I had the support of my family, for whom education was always a very high priority.

So, let's make sure that both astronomy and education continue to be appealing and accessible to everyone in Canada! ✶

Endnotes

1 *Visions of Science Network for Learning:* https://vosnl.org
2 *Pueblo Science*: https://puebloscience.org
3 *Cosmos from your Couch*: https://ow.ly/EIto50PGOs0

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John Percy FRASC is a very active Professor Emeritus in Astronomy & Astrophysics, and Science Education, at the University of Toronto. He is a former President (1978–80) and Honorary President (2013–17) of the RASC.

Imager's Corner

More Layering

by Blair MacDonald, Halifax Centre
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This edition's column continues our look at some layering techniques, demonstrating at a layer-based technique for preserving colour when stretching an image.

As most astrophotographers quickly find out, brightening our images comes at a cost. Sometimes it is an increase in noise, other times it is bleaching of the image colour. Most times, colour can be restored with some careful saturation increases, but this can lead to colour noise in the resulting image. There are stretches, such as the arcsinh stretch that preserves much of the colour, but these may not be suitable for the final stretches in your processing workflow. Some packages allow you to stretch just the luminance channel, at least on some functions, but the function list is usually limited. It turns out that there is a simple layer combination that preserves much of the colour in an image using almost any arbitrary stretch and produces the same result as a luminance stretch.

First let's look at an image with lots of blue and red such as this one of WR134 (Figure 1). While a little dark, the colour is obvious.

Figure 1 — Initial colourful, but dark, image of WR134

There are several different stretches we could use here, but we'll apply simple histogram equalization to the image. The result shows a lot of colour loss, especially in the reds, although it brightens the image significantly (Figure 2).

Looking at a larger view (Figure 3), the colour loss has left the shot with an ugly salmon colour instead of a more vibrant red.

Now let's look at a layered technique for applying the exact same stretch and the resulting effect the approach has on the colour of the final image. First we extract the luminance from the original image of Figure 1 to make a grayscale image that we will use for one of the layers (Figure 4).

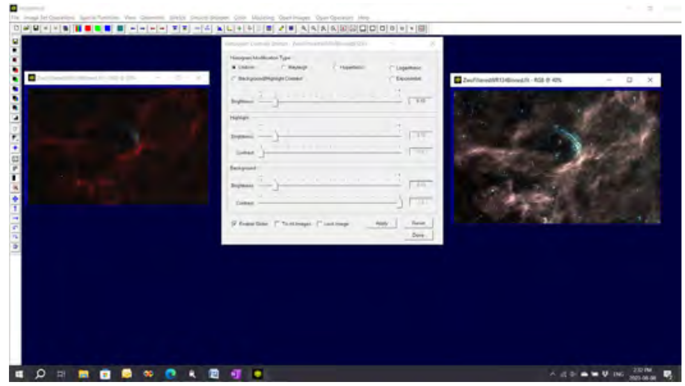


Figure 2 —The image after histogram equalization. Note the colour loss in the red parts of the nebula.

Figure 3 — A larger view clearly shows the impact of the simple histogram equalization stretch on the colour.

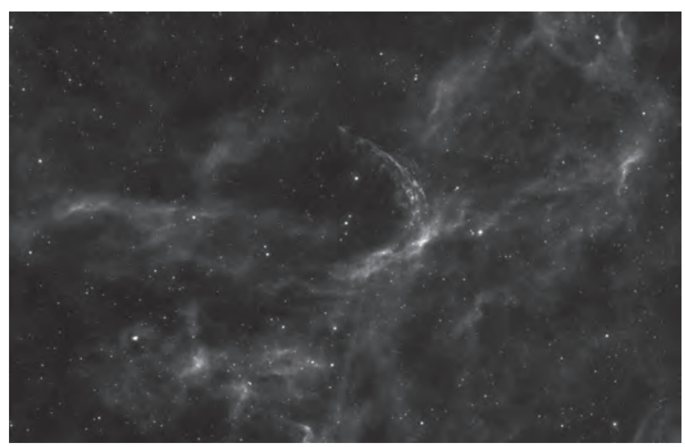


Figure 4 — Extracted luminance from the data of Figure 1

Next duplicate this luminance layer and invert it to get the following negative image. We will refer to this as the divide layer (Figure 5).

Apply the stretch (histogram equalization in this case) to the non-inverted, luminance layer (Figure 6).

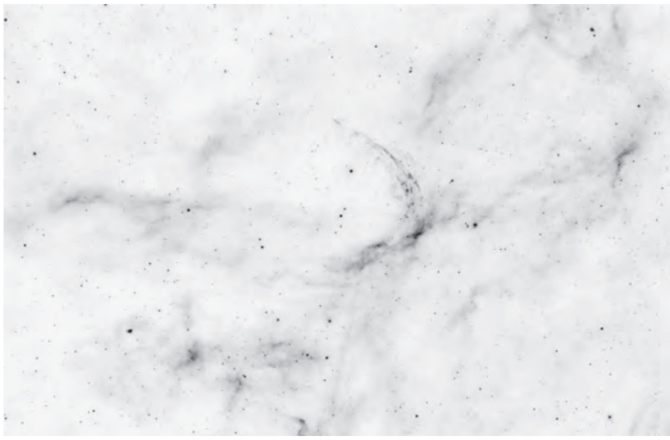


Figure 5 — Inverted luminance divide layer

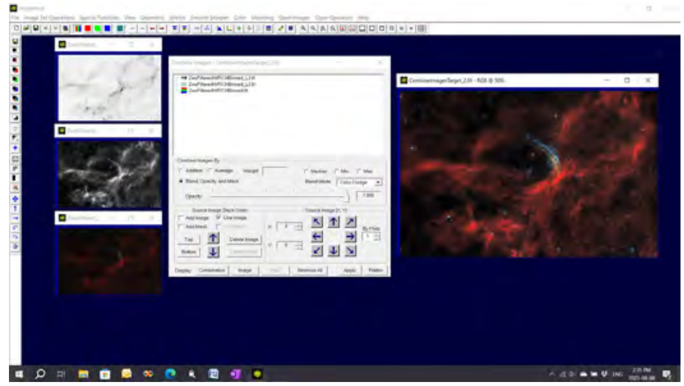


Figure 7 — Image stack. The stack order is shown with the images on the left. The top layer blend mode is set to colour dodge while the second layer is set to multiply. The bottom layer blend mode is left at the default of normal.

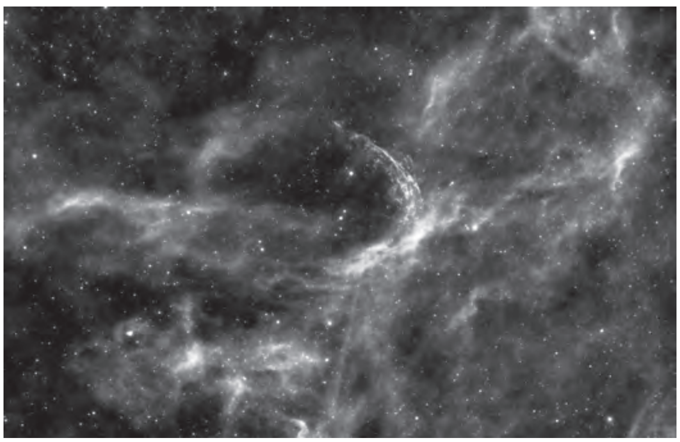


Figure 6 — Luminance layer with the histogram equalization applied.

Finally, make a layer stack with the original image from Figure 1 at the bottom, the luminance image as the next layer up and the divide layer data on top. Set the blend mode of the luminance data to multiply and set the blend mode of the divide layer to colour dodge. By setting the blend to colour dodge and using inverted data, you are effectively dividing by the original unstretched luminance data. I like this approach as some software packages don't handle pixel values of zero well if you set the blend mode to divide. Figure 7 shows the image stack setup.

The resulting image has all the brightening of the histogram equalization applied while retaining most of the original colour as shown in Figure 8.

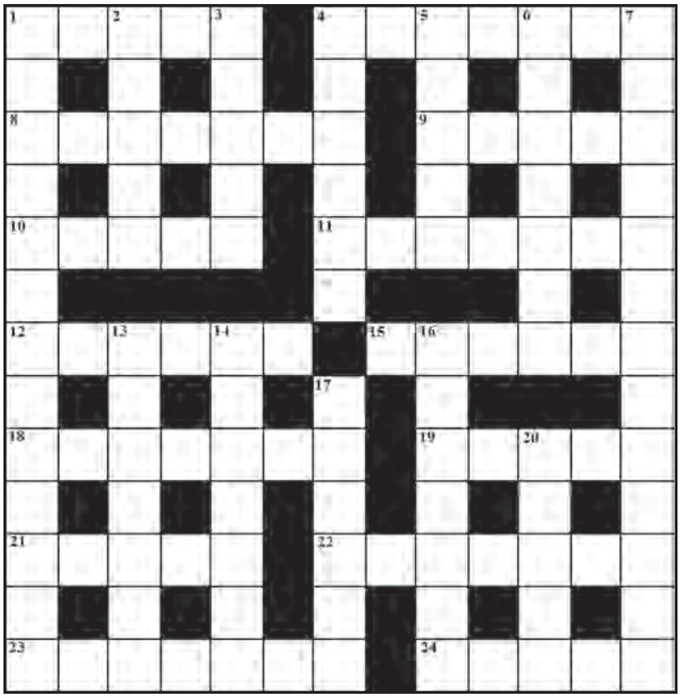
Remember, this column is based on your questions, so keep them coming. You can send them to me at b.macdonald@ns.sympatico.ca. Please put "IC" as the first two letters in the topic so my email filters will sort the questions. ✶

Figure 8 — Final image after the full layered, colour-preserving stretch is applied.

Blair MacDonald is an electrical technologist running a research group at an Atlantic Canadian company specializing in digital signal processing and electrical design. He's been an RASC member for 20 years, and has been interested in astrophotography and image processing for about 15 years.

Astrocryptic

by Curt Nason



ACROSS

1. Dancing about a prom with a dish in Coonabarabran (5)
4. Effect of brush or solar cycle on cosmic rays (7)
8. Photosphere feature from lunar disturbance in gravitational energy (7)
9. Space station had no part of three constellations (5)
10. Outreach activity seen as timeless at the horizon (5)
11. Energetic equilibrium from candy I'm distributing (7)
12. I am ready, I hear, to move from asteroid danger (6)
15. Span of light across a sunspot (6)
18. A leaf swirls around copper features of the Sun (7)
19. Ukrainian physicist was an early Big Banger (5)
21. The editor's task is to correct me in the end (5)
22. Good paper for sketching sunspots or Lin nude (7)
23. Sped around in a track around Neptune (7)
24. Talked of a radial feature in Saturn's rings (5)

DOWN

1. Attractive area to study the source of sunspots (8,5)
2. Solar feature by the Riviera, perhaps (5)
3. Supervision recommended for young solar observers instead, ultimately (5)
4. Particle counterparts appear if LEDs are scattered (6)
5. Aries led an effect on photon wavelength through scattering (5)
6. Nude man turned like many a numbered asteroid (7)
7. Observer chewed her legs badly on the solar filter (8,5)
13. His cells deflected polarized light, rotating poles around Cape Kennedy (7)
14. Physicist linked meteors to comets as a church boy back in Germany (7)
16. German gun returned to us by the little king (7)
17. Oddly unable to see the Owl with binoculars (6)
20. Sal was a co-star at Griffith Observatory (5)

Answers to previous puzzle

Across: **1** HYPATIA (an(I)ag); **5** ROMAN (2 def); **8** LUNAR (anag-DI); **9** ROBOTIC (2 def); **10** NIOBIUM (2 def); **11** NONCE (N+anag); **12** SEAGER (anag); **13** TARTER (2 def); **17** REBER (R+anag); **20** ALGENIB (anag); **22** ELTANIN (el+tan+in); **23** EULER (E+anag); **24** THEBE (T+Hebe); **25** NASMYTH (NAS+myth)

Down: **1** HELEN (2def); **2** PANDORA (Pan+Dora); **3** TURBINE (T(anag)E)); **4** ABRAMS (AB+anag); **5** RUBIN (anag); 6 METON (Me+ton); **7** NUCLEAR (anag); **12** SARGENT (an(E)ag); **14** ANGLERS (2 def); **15** TINSLEY (anag); **16** CANNON (2 def); **18** BETHE (anag); **19** RANGE (2 def); **21** BIRTH (Birt+H)

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Compiled by James Edgar

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Great Images

by Klaus Brasch

Klaus Brasch imaged a favourite deep-sky object, the Lagoon Nebula (Messier 8) in Sagittarius. He used a Celestron C-11 SCT, equipped with a ƒ/7 focal reducer and coma corrector to get the widest possible view. The final image is a composite of 5 × 3-minute exposures at ISO 5000 through IDAS LPS P1 and V4 filters, combined in Registar and processed as HD in Photoshop CS6.

Journal

Eclipses can be hard to image as they are extremely weather dependent. Shelley Jackson almost didn't set up for the 2023 October 14, annular eclipse (partial in Ontario where she is located), but the clouds broke up and she took a chance. She managed to capture the partial eclipse from her observatory using an Askar V at 80 mm with flattener FL 495-mm and a Mylar filter over the objective with a 50-mm guide scope, ZWO 120 mono guide camera, on a Sky-Watcher EQ6-R pro mount and a ZWO ASI183MM CMOS camera.