The Journal of The Royal Astronomical Society of Canada

Journal

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PROMOTING
ASTRONOMY
IN CANADA

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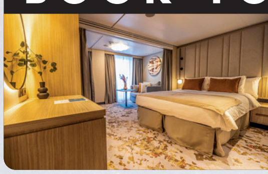

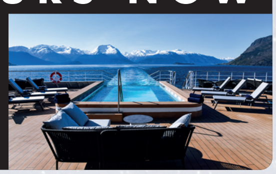

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Royal Astronomical Society of Canada
Société Royale d'Astronomie du Canada

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Great Images / Superbes images

This incredible image of the Horsehead Nebula and Flame Nebula was taken by Rob Lyons using a Sky-Watcher Quattro 150p with an ƒ/3. He used an ASI2600MC Pro One Shot Colour camera and a variety of filters to combat the city light pollution and the pesky moonlight. He also used the Optolong Quad Enhance and Antlia Quad Band light pollution filters to collect RGB data. Finally, he also used the Altair Astro 4nm Hα/OIII and SII/OIII filters to collect narrowband data, assigning the hydrogen and sulphur data to red, and the oxygen data to both blue and green to try to keep a more natural look to the image. He says, "Miraculously, I managed to get seven clear nights in January! It allowed me to collect 23 hours of data and made processing the image much easier than previous years. A little trick I did for this image was to replace the RGB stars with the narrowband stars. This kept the halos on Alnitak on the other bright stars in check."

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

Reflections at the End of my Term as RASC President

by Michael Watson, President
Michael.Watson@gowlingwlg.com

When I joined the Toronto Centre of the RASC at the end of my last year of high school in 1970, I could scarcely have imagined that in a few years I would be involved in the governance of the Society, much less that I would become its President 53 years later.

As I near the end of my second and last year as RASC President, I have been reflecting on my more than half century of membership in our national astronomy club, the ups and downs that the Society has experienced over that period of time, the financial condition of the RASC just a few years ago, and what the Board of Directors, working with the National Council and the Executive Director, Jenna Hinds, has managed to accomplish over the last few years.

When I became a member, the RASC had 18 Centres, compared with 30 now, and the total membership was 2,502, compared with about 4,300 as of April 2025. Financially, in 1970 the RASC was a much smaller organization than it is today. A review of the annual report from that year (available in the RASC online archives) shows that total revenues in 1970 were not quite $48,800, and assets amounted to a little less than $53,000. By comparison, in 2024 the Society's total revenues (not including gains on investments during the year) were about $593,000, and assets exceeded $2 million. The RASC is a larger and more broad-based organization now than it was 50 years ago.

Many members—myself included—would probably prefer to forget what can only be called the financial crisis that we found ourselves in at the end of 2022. As was recounted in the report of the President and the Treasurer in the Annual Report 2022, the combined effect of the pandemic, the financial collapse of the Society's subsidiary *SkyNews*, out-of-control expenditures, and lack of proper internal financial oversight, resulted in an operational loss of $692,000 in that year. This, combined with a required write-off of the Society's $292,308 investment in *SkyNews*, led to a staggering total loss for 2022 of close to $1 million. These numbers are well known to every member of the Society who has followed the club's financial situation over the past few years.

Much has been reported to the National Council and much has been written both in the ensuing Annual Report and in my columns since I became President, about the steps that the Board, the National Council, and National Office staff together have done to return the RASC to a position of financial equilibrium in the almost two and a half years since that bleak time. Apart from reducing the number of National Office staff to the bare minimum of three that is required to perform all of the services to which members and the Centres expect and have become accustomed, we also finally brought an end to the money-losing *SkyNews* operation, sold the Society's robotic telescope, and—spearheaded by Executive Director Jenna Hinds—engaged in a ruthless cost-trimming and efficiency drive in the Society's operations.

I am not writing this as any form of self-congratulation to me and my fellow Board members; we should have been much more attentive to the Society's finances than we were. And I had been on the Board for several years, was Second Vice-President in 2022 while this was happening, and properly deserve criticism for allowing matters to deteriorate to the point where they quite properly became the focus of both concern and criticism of the leadership. No, the point that I am trying to make is that, with the good will and cooperation of and dedicated work by all of those in leadership positions in the Society, there has been a significant turnaround in which we can all take some satisfaction.

Looking a little further back, since I passed most people's retirement age several years ago—even though I still practise and teach law full time—I have wondered how my age when holding the position of RASC President compares with my predecessors. So I went back to the Society's records of its Presidents starting in 1890 (which can be found online here: www.rasc.ca/past-officers). I have been preceded by 67 Presidents, the youngest of whom when becoming President were Frank Hogg, born in 1904, and John Percy, born in 1941. They both became President at 37 years of age, in 1942 and 1978, respectively. By contrast, I was born in 1952 and became President at age 71. The only other person who was older than I am when he was President was Larrett W. Smith, who was also a lawyer by profession. He was born in 1820 and served as the President of the Toronto Astronomical Society—the predecessor to the RASC—for a one-year term in 1895 when he was 75 years of age. Mr. Smith was born in England and served as Co-Vice Chancellor of the University of Toronto. As reported by Peter Broughton in his work *Looking Up: A History of the Royal Astronomical Society of Canada*, "Infirmities of old age prevented him from chairing more than a couple of meetings during his Presidency in the Society." Fortunately for me, physical infirmity seems not to have afflicted me during my term as President, so I have been able to chair some 20 meetings of the Board of Directors in the last almost two years!

Moving on from Mr. Smith and me, of the remaining 65 Presidents for whom I could find years of birth, ten were in their 60s when they took office, 23 were in their 50s, 26 in their 40s and the remaining four in their 30s. The average age of RASC Presidents when they take office is about 52. So I am the oldest RASC President in more than one and a quarter centuries.

Finally: After taking many years off from when I was last on the National Council as Treasurer from 1998 until 2004, I came onto the Board of Directors in 2017 at the suggestion of my long-time friend, former RASC President and Executive Director, and current member of the Board of Directors, Randy Attwood. In the eight years since that time, I have been fortunate to have worked with and under the guidance of Presidents Colin Haig, Chris Gainor, Robyn Foret, and Charles Ennis, as well of course as numerous talented and hard-working directors. I am grateful to all of them for their guidance, inspiration, and friendship.

Although I will shortly be stepping down as President, I still have two years left in my term as a director of the Society, and I look forward to continuing to work with the talented and dedicated volunteers who keep the good ship RASC on a steady course into the future. It has been such a privilege to have been the President for the last two years of the astronomy club that we all cherish, and I thank all members of the Society, and especially my fellow directors, for the wonderful opportunity to have served you and to have served with you.

Quo Ducit Urania,

Michael, FRASC ✶

The Royal Astronomical Society of Canada is dedicated to the advancement of astronomy and its related sciences; the Journal *espouses the scientific method, and supports dissemination of information, discoveries, and theories based on that well-tested method.*

News Notes / En manchette

Compiled by Jay Anderson

Dark energy gets a shade darker

In mid-March, science news feeds reported the startling announcement that dark energy may be fading away in an expanding Universe. That news came from the Dark Energy Spectroscopic Instrument (DESI), which sits on a four-metre telescope at the Kitt Peak National Observatory in Arizona.

DESI consists of 5,000 fibre-optic "pipes" that can be automatically positioned to intercept the light of individual galaxies several times each night, feeding the information to a large bank of spectrographs for analysis. It's an efficient design: on one record night, DESI recorded the spectra of nearly 200,000 galaxies. The spectral information revealed the recession speed of the galaxies, allowing their relative distances to be estimated. To get the absolute distances, the recession measurements had to be calibrated against something else.

That something else was density ripples (or bubbles)—baryonic acoustic oscillations or BAOs—in the early Universe that were frozen in place about 350,000 years after the Big Bang when the Universe cooled. The BAOs are faintly visible in the current distribution of galaxies as a series of overlapping spheres roughly a billion light years across—the time that the BAOs had to travel before freezing. DESI's galaxy maps can tease out these frozen ripples, measuring the apparent size of the ripples at different eons after the Big Bang.

From May 2021 to June 2022, the robotic fibres gobbled up photons arriving at Earth from different eras of cosmic history. The DESI researchers transformed that data into the most detailed cosmic map ever made. It features the precise locations of about 6 million galaxies as they existed between roughly 2 and 12 billion years ago. When the DESI data were blended with other cosmological datasets—the cosmic microwave background (CMB), three redshift-supernova maps, and measurements of weak gravitational lensing—some odd characteristics became apparent. This led to March's announcement that the initial results showed signs that dark energy may be weakening over time, a conclusion that would require a revaluation of how the Universe evolved.

"What we are seeing is deeply intriguing," said Alexie Leauthaud-Harnett, co-spokesperson for DESI and a professor at UC Santa Cruz. "It is exciting to think that we may be on the cusp of a major discovery about dark energy and the fundamental nature of our Universe."

Taken alone, DESI's data are consistent with the standard model of the Universe: Lambda CDM (ΛCDM), where CDM is cold dark matter and Lambda (Λ) represents the simplest case of dark energy, where it acts as a cosmological constant. However, when paired with the other surveys, the early indications that the impact of dark energy may be weakening over time suggested that models other than ΛCDM may be a better fit. "We're guided by Occam's razor, and the simplest explanation for what we see is shifting," said Will Percival, co-spokesperson for DESI and a professor at the University of Waterloo. "It's looking more and more like we may need to modify our standard model of cosmology to make these different datasets make sense together—and evolving dark energy seems promising."

So far, the preference for an evolving dark energy has not risen to "5 sigma," the gold standard in physics that represents the threshold for a secure discovery. However, in different combinations of DESI data with the CMB, weak lensing, and supernovae datasets, sigma ranged from 2.8 to 4.2. (A 3-sigma event has a 0.3 percent chance of being a statistical fluke.) To guard against unconscious biases, the analysis was "blinded," a technique that hides results from the scientists until they are revealed at the conclusion of analysis.

According to Einstein's general theory of relativity, any matter or energy can drive cosmic expansion. But as space expands, all the familiar kinds of matter and energy become less dense as they spread out in a roomier Universe. As their densities fall, the expansion of the Universe should slow down, not speed up. One substance that does not become diluted with the expansion of space, however, is space itself. If the vacuum has an energy of its own, then as more vacuum (and therefore more energy) is created, the expansion will speed up. It was the discovery of the accelerating expansion of the Universe that revealed the presence of a tiny amount of energy associated with the vacuum of space—dark energy.

While researchers find these numbers tantalizing, they also warn against reading too much into the higher values as statistical significances depend on subtle assumptions in the data analysis. DESI researchers expect that their next map will

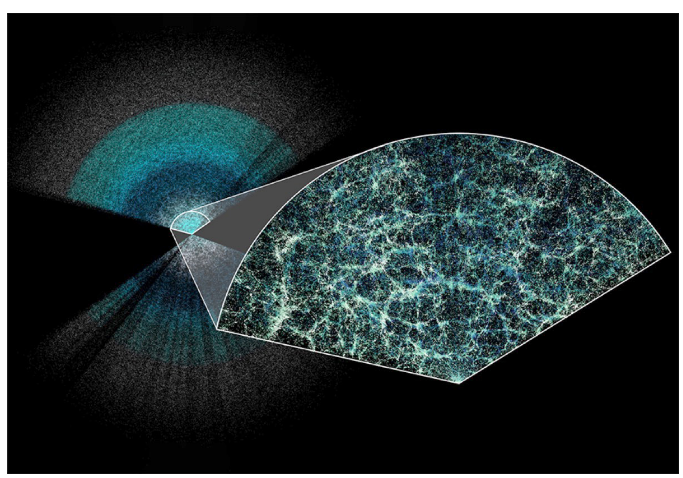


Figure 1 — The Dark Energy Spectroscopic Instrument (DESI) has made the largest 3-D map of our Universe to date. Credit: Claire Lamman/DESI collaboration

contain nearly twice as many galaxies as the map unveiled in March.

If dark energy is weakening, it can't be a cosmological constant. Instead, it may be the same sort of field that many cosmologists think sparked a moment of exponential expansion during the Universe's birth. This kind of field could fill space with an amount of energy that looks constant at first—like the cosmological constant—but eventually starts to slip over time.

"The idea that dark energy is varying is very natural," said Paul Steinhardt, a cosmologist at Princeton University. Otherwise, he continued, "it would be the only form of energy we know which is absolutely constant in space and time."

But that variability would bring about a profound paradigm shift: We would not be living in a vacuum, which is defined as the lowest-energy state of the Universe. Instead, we would inhabit an energized state that's slowly sliding toward a true vacuum. "We're used to thinking that we're living in the vacuum," Steinhardt said, "but no one promised you that."

"It may be the first real clue we have gotten about the nature of dark energy in 25 years," Adam Reiss, a physicist at Johns Hopkins University who shared the 2011 Nobel Prize in Physics, told *The New York Times*. "This result is very interesting and we should take it seriously. Otherwise why else do we do these experiments?"

String theorists have a share in the new results. With their proposal that everything boils down to the vibration of strings, they can weave together universes with different numbers of dimensions and all manner of exotic particles and forces. But they can't easily construct a universe that permanently maintains a stable positive energy, as our Universe has seemed to. Instead, in string theory, the energy must either gently fall over the course of billions of years or violently drop to zero or a negative value. "Essentially, all string theorists believe that it's one or the other. We do not know which one," said Cumrun Vafa of Harvard University.

Observational evidence for a gradual decline of dark energy would be a boon for the gentle-fall scenario. "That would be amazing. It would be the most important discovery since the discovery of dark energy itself," Vafa said.

Composed in part with material provided by the Lawrence Berkeley National Laboratory.

Where do meteorites come from?

In a March review paper in the journal *Meteoritics & Planetary Science*, Peter Jenniskens of the SETI Institute and NASA Ames Research Center and Hadrien A. R. Devillepoix of Curtin University traced the orbit of 75 observed meteorite falls to several previously unidentified source regions in the asteroid belt.

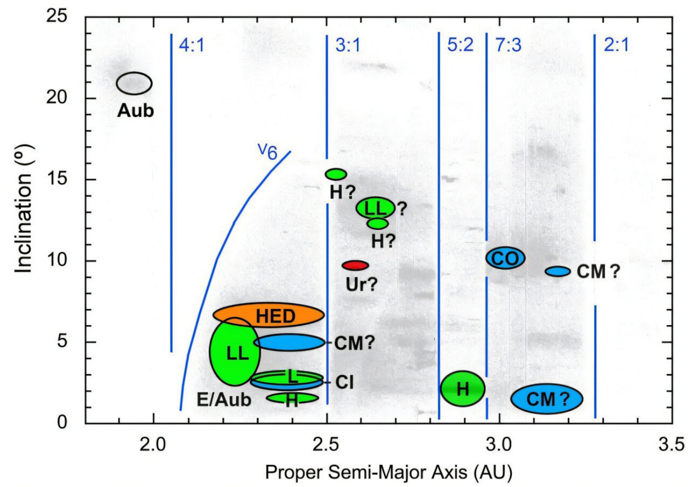


Figure 2 — Geologic map of the asteroid belt. Ovals identify the asteroid families from which the meteorites originate and letters mark the corresponding meteorite type. The horizontal axis ranges from short orbits moving just inside the asteroid belt (left) to longer orbits just outside (right). The vertical axis shows how much the asteroid orbits are tilted relative to the plane of the planets. Blue lines are the delivery resonances. Credit: Jenniskens & Devillepoix (2025) Meteoritics & Planetary Science.

"This has been a decade-long detective story, with each recorded meteorite fall providing a new clue," said Jenniskens. "We now have the first outlines of a geologic map of the asteroid belt."

Ten years ago, Jenniskens teamed up with astronomer Hadrien Devillepoix of Curtin University and colleagues in Australia to build a network of all-sky cameras in California and Nevada that can capture and track the bright light of meteorites as they hit the Earth's atmosphere. Many institutes and citizen scientists have participated in this effort over the years.

"Others built similar networks spread around the globe, which together form the Global Fireball Observatory," said Devillepoix. "Over the years, we have tracked the path of 17 recovered meteorite falls.'

Many more fireballs were tracked by doorbell and dashcam video cameras from citizen scientists around the globe and by other dedicated networks. Overall, about 13 meteorite falls are reported each year.

"Altogether, this quest has yielded 75 laboratory-classified meteorites with an impact orbit tracked by video and photographic cameras," said Jenniskens. "That proves to be enough to start seeing some patterns in the direction from which the meteorites approach Earth."

Most meteorites originate from the asteroid belt, a region between Mars and Jupiter where over a million asteroids larger than one kilometre circle the Sun. Those rocks originate from a small number of larger asteroids that broke up during collisions, the debris fields of which litter the region. Even today, asteroids still collide to create debris fields within these asteroid families, called clusters.

After the initial collision, asteroid fragments are affected primarily by the gravitational pull of Jupiter and, to a lesser extent, by the Yarkovsky effect. The Yarkovsky effect is a small acceleration imparted to the asteroid or meteorite that is caused by the heating of its surface by the Sun and subsequent emission of infrared radiation as the heated surface rotates into shadow. The emitted thermal radiation acts as a micro-thruster, gradually changing the orbit of the body over millennia. The Yarkovsky effect is sufficient to perturb metre-sized objects into resonance orbits with Jupiter in a couple of million years.

Resonance orbits are those that have a regular return period to Jupiter's neighbourhood—for instance, returning to Jupiter's influence every four orbits when Jupiter arrives after 3 orbits. These resonances can have many whole-number values (i.e. 7:3, 5:2, 4:1) depending on the orbit of the meteorite. Once resonance has been established, the meteorites can be quickly directed toward the inner Solar System and the Earth. The redirection is about 300 times more efficient for bodies in the inner asteroid belt than for those in orbits closer to Jupiter.

"We now see that 12 of the iron-rich ordinary chondrite meteorites (H chondrites) originated from a debris field called 'Koronis,' which is located low in the pristine main belt," said Jenniskens. "These meteorites arrived from low-inclined orbits with orbital periods consistent with this debris field."

Astronomers can measure how long ago these rocks were dug up from below the asteroid's surface by measuring the level of radioactive elements created by exposure to cosmic rays. This cosmic-ray exposure age of the meteorites proves to match the dynamical age of some of the asteroid debris fields. Scientists determine the dynamical age of debris fields by measuring how far asteroids of different sizes have spread over time.

"By measuring the cosmic ray exposure age of meteorites, we can determine that three of these 12 meteorites originated from the Karin cluster in Koronis, which has a dynamical age of 5.8 million years, and two came from the Koronis2 cluster, with a dynamical age of 10–15 million years," said Jenniskens. "One other meteorite may well measure the age of the Koronis3 cluster: about 83 million years."

Jenniskens and Devillepoix also found a group of H-chondrites on steep orbits that appear to originate from the Nele asteroid family in the central main belt, which has a dynamical age of about 6 million years. The nearby 3:1 mean-motion resonance with Jupiter can pump up the inclinations to those observed. A third group of H chondrites that have an exposure age of about 35 million years originated from the inner main belt.

"In our opinion, these H chondrites originated from the Massalia asteroid family low in the inner main belt because that family has a cluster of about that same dynamical age," said Jenniskens. "The asteroid that created that cluster, asteroid (20) Massalia, is an H chondrite type parent body."

Jenniskens and Devillepoix find that low iron (L chondrite) and very low iron (LL chondrite) meteorites come to us primarily from the inner main belt. Scientists have long linked the LL chondrites to the Flora asteroid family on the inner side of the asteroid belt, and they have confirmed that connection.

"We propose that the L chondrites originated from the Hertha asteroid family, located just above the Massalia family," said Jenniskens. "Asteroid Hertha doesn't look anything like its debris. Hertha is covered by dark rocks that were shock-blackened, indicative of an unusually violent collision. The L chondrites experienced a very violent origin 468 million years ago when these meteorites showered Earth in such numbers that they can be found in the geologic record."

Knowing from what debris field in the asteroid belt our meteorites originate is important for planetary defense efforts against Near Earth Asteroids. An approaching asteroid's orbit can provide clues to its origin in the asteroid belt in the same way as meteorite orbits.

"Near-Earth Asteroids do not arrive in the same orbits as meteorites, because it takes longer for these to evolve to Earth," said Jenniskens. "But they do come from some of the same asteroid families." However, not all assignments are certain.

"We are proud of how far we have come, but there is a long way to go," said Jenniskens. "Like the first cartographers who traced the outline of Australia, our map reveals a continent of discoveries still ahead when more meteorite falls are recorded."

What's coming next? Asteroids directly match meteorites when observed in space before impacting Earth and ARE then recovered. Jenniskens guided the recovery of the first such small asteroid in 2008, called asteroid 2008 TC3, and we are about to see a lot more, thanks to new astronomical facilities coming online.

Barnard's Star planets confirmed

In November last year, a research team led by Jonay González Hernández, an astrophysicist at the Instituto de Astrofísica de Canarias in Tenerife, Spain, announced the discovery of a planet in orbit around Barnard's Star, the fourth closest star to Earth. The planet was detected by the back-and-forth radial-velocity wobbles that it causes in the spectral lines of the star, which revealed a 3.15 day orbital period. The announcement also noted the suspected presence of three other planets around the star, visible as smaller oscillations superimposed on

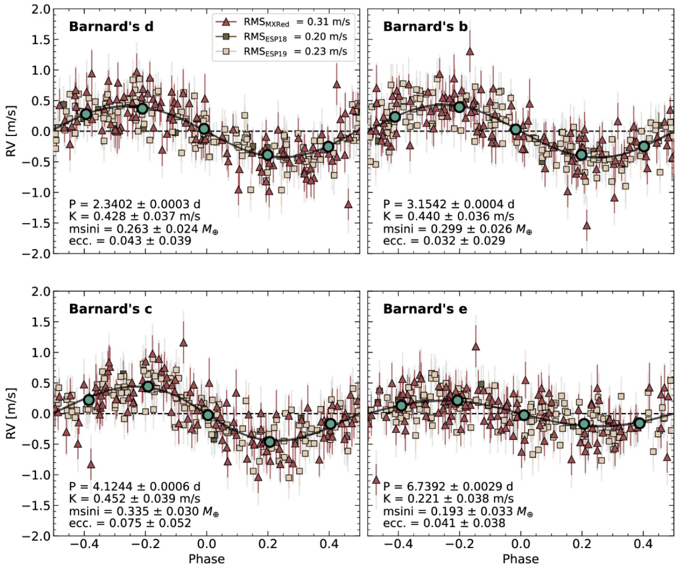


Figure 3 — Phase-folded plots for planets Barnard b, c, d, and e, based on joint fit between MAROON-X Red channel and ESPRESSO radial velocities. Image: Ritvik Basant et al 2025 ApJL 982 L1

the larger, but below the level at which they could be conclusively identified.

Barnard's Star is a single M-type red dwarf star in Ophiuchus that is notable for having the largest stellar motion across the sky, 10.3 arcseconds per year., Barnard's Star also seems to be one of the oldest stars in the Milky Way (7–10 Gy), a conclusion drawn from its very slow rotation (130 days) and low levels of activity. At a distance of 5.93 ly, it's a small 13th-magnitude star, about 20 percent of the size of our Sun and hosting a temperature of around 3,200 K.

In March of this year, a second team of European and American researchers confirmed the original discovery and also two of the three possible planets originally proposed by the González Hernández group. The fourth planet also seems to have been detected, but again at a level that does not allow statistical confirmation. Detection of the tiny Doppler-shift wobbles in the stellar spectrum requires extreme precision and can only be accomplished with specialized instruments on large telescopes. In this case, the team used MAROON-X (M-dwarf Advanced Radial velocity Observer Of Neighboring eXoplanets) on the 8-metre Gemini North telescope in Hawai'i. MAROON-X was able to reach a resolution of 13 cm/s in its analysis of the spectral Doppler shift (the Earth imposes a 9 cm/s wobble on the Sun).

In order to detect the planets, the MAROON research team first had to measure and remove the radial-velocity signature caused by the rotation period (~142 days) and periodic activity of the star itself. Once this was done, the remaining signal was processed by successively removing the signals of the individual planets and modelling the resulting spectrum to tease out the characteristics of those remaining. Finally, the new results were combined with those of the earlier DESI measurements. The combined dataset clearly showed the presence of three planets (labelled b, c, and d) and increased the likelihood of the fourth (e).

"It's a really exciting find—Barnard's Star is our cosmic neighbour, and yet we know so little about it," said Ritvik Basant, Ph.D. student at the University of Chicago and first author on the new study. "It's signaling a breakthrough with the precision of these new instruments from previous generations."

In order, the confirmed planets were found to have orbital periods of 3.15, 4.12, and 2.34 days while e was best fitted with a 6.74-day orbit. Minimum masses of the four ranged from 0.19 to 0.34 $M_\oplus$. Their distances from Barnard's Star range from 0.019 to 0.038 au. They're probably rocky planets, with bare-rock surfaces blasted by their star's radiation. They'll be too hot to hold liquid water, and any atmosphere is likely to have been stripped away. Nevertheless, the find is a new benchmark for discovering smaller planets around nearby stars. The team was able to rule out, with a fair degree of certainty, the existence of other planets in the habitable zone around Barnard's Star.

For a century, astronomers have been studying Barnard's Star in hopes of finding planets around it. First discovered by E. E. Barnard at Yerkes Observatory in 1916, it is the nearest system with only one star. The absolute nearest star system to us, Proxima Centauri, has three stars circling each other, which changes the dynamics of planet formation and orbits.

Barnard's Star has been called the "great white whale" for planet hunters; several times over the past century, groups have announced evidence that suggested planets around Barnard's Star, only for them to be later disproved. But these latest findings, independently confirmed in two different studies by the different instruments ESPRESSO and MAROON-X, mean a much larger degree of confidence than any previous result.

"We observed at different times of night on different days. They're in Chile; we're in Hawaii. Our teams didn't coordinate with each other at all," Basant said. "That gives us a lot of assurance that these aren't phantoms in the data."

"We worked on this data really intensely at the end of December, and I was thinking about it all the time," Bean said. "It was like, suddenly we know something that no one else does about the Universe. We just couldn't wait to get this secret out.

"A lot of what we do can be incremental, and it's sometimes hard to see the bigger picture," he said. "But we found something that humanity will hopefully know forever. That sense of discovery is incredible."

Composed in part with material provided by the University of Chicago

Martian mystery rock

Last March, the Perseverance Science Team, monitoring their rover on Mars, were astonished by the image of a strange rock composed of hundreds of millimetre-sized spheres… and the team are now working hard to understand their origin.

Early in the month, the Perseverance rover arrived at Broom Point, situated at the lower slopes of the Witch Hazel Hill area, on the Jezero crater rim. Here, a series of light- and dark-toned bands were visible from orbit, and just last week the rover successfully abraded and sampled one of the light-toned beds. It was from this sampling workspace where Perseverance spied a very strange texture in a nearby rock.

The rock, named "St. Pauls Bay" by the team, appeared to be comprised of hundreds of millimetre-sized, dark gray spheres. Some of these occurred as more elongated, elliptical shapes, while others possessed angular edges, perhaps representing broken spherule fragments. Some spheres even possessed tiny pinholes! What quirk of geology could produce these strange shapes?

This isn't the first time strange spheres have been spotted on Mars. In 2004, the Opportunity rover spotted so-called "Martian Blueberries" at Meridiani Planum, and since then, the Curiosity rover has observed spherules in the rocks of Yellowknife Bay at Gale crater. Just last year, Perseverance itself also spied popcorn-like textures in sedimentary rocks exposed in the Jezero crater inlet channel, Neretva Vallis.

In each of these cases, the spherules were interpreted as concretions (minerals that come out of solution) that were formed by interaction with acidic, salty, groundwater circulating through pore spaces in the rock over two geological epochs. Not all spherules form this way, however. They also form on Earth by rapid cooling of molten rock droplets formed in a volcanic eruption, for instance, or by the condensation of rock vaporized by a meteorite impact (tektites). Martian blueberries are known to be rich in hematite (iron oxide), but the exact proportion is unknown, though expected to be high. The blueberries are actually gray, but adopt a bluish tinge when set against the rusty Martian soil.

Each of these formation mechanisms would have vastly different implications for the evolution of these rocks, so the Perseverance team is working hard to determine their context and origin. St. Pauls Bay, however, was float rock—a term used by geologists to describe something that is not in-place.

The team are now working to link the spherule-rich texture observed at St. Pauls Bay to the wider stratigraphy at Witch Hazel Hill, and initial observations have provided tantalizing indications that it could be linked to one of the dark-toned layers identified by the team from orbit. Placing these features in geologic context will be critical for understanding their origin and determining their significance for the geological history of the Jezero crater rim and beyond! ✶

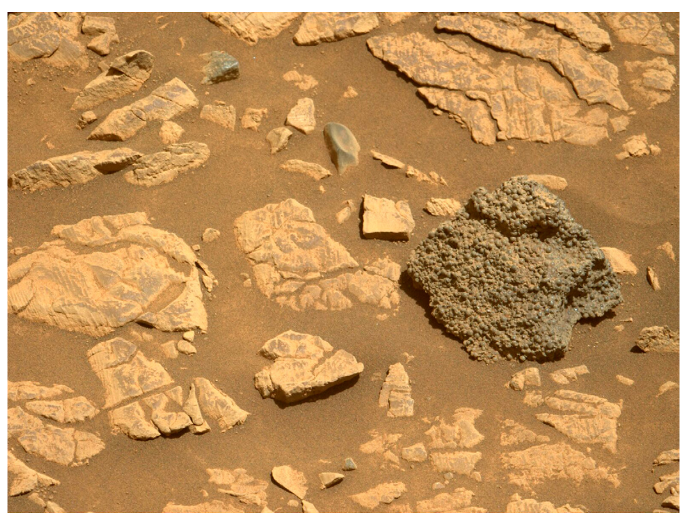


Figure 4 — NASA's Mars Perseverance rover acquired this image of the "St. Pauls Bay" target (the dark-toned float block in the right of the view) using its Left Mastcam-Z camera. Credit: NASA/JPL-Caltech/ASU

Feature Article / Article de Fond

From Backyard Telescopes to Scientific Discovery: The Role of Citizen Science in Modern Astronomy

by Ian Doktor

Astronomy provides unique opportunities for students and amateur astronomers to make meaningful contributions to our understanding of the Universe. (Christian et al., 2012). Through citizen science initiatives such as Zooniverse Projects and professional-amateur collaborations led by organizations such as the American Association of Variable Star Observers (AAVSO), amateur astronomers play a critical role in gathering and analyzing astronomical data (see Eisner et al., 2021). These initiatives not only allow amateur scientists to develop new skills and improve their astronomy knowledge, but they also serve a valuable purpose in a discipline that is often overwhelmed by the amount of data collected.

Among the many ways non-professional astronomers can make contributions, differential photometry stands out as a particularly impactful area. These impacts can come in the form of observations of variable stars or through the analysis and submission of data for professional astronomers to use. The purpose of this article is to equip amateur astronomers with the necessary background, tools, and resources necessary for gathering, reducing, and analyzing photometric data. By outlining an accessible approach to differential photometry, this article aims to empower citizen scientists to make meaningful contributions to modern astronomy research such as exoplanet transit observations, binary star timing, and cataclysmic star outburst monitoring.

Prerequisite Skills

Differential photometry involves measuring changes in the brightness of a star over time. The time scales of variable stars can differ significantly: SX Phoenicis stars, for instance, exhibit variations in brightness that occur over minutes to hours, while longer-period variable stars or exoplanets may require months or years to observe. The imaging skills required are similar to deep-sky astrophotography, so amateur astronomers interested in starting photometric studies should begin by mastering the basics of astrophotography. To gather scientifically useful data astronomers should be proficient in several important skills:

1. The operation of equatorial mounts.
2. Finding and tracking stars for long periods of time.
3. Using cameras to capture multiple, short-exposure images (typically ≤ 120 s, depending on the target brightness).

Beyond acquiring images for data analysis, the reduction and processing of images also requires skills and techniques commonly used by astrophotographers, including:

1. Alignment and stacking of images.
2. Dark frame, flat frame, and bias corrections.

With these skills and readily available amateur equipment, citizen scientists can begin participating in photometric studies. While this paper deals with introductory differential photometry techniques, a more comprehensive guide is available in the AAVSO DSLR observing manual (2014).

Required Equipment

For bright variable stars, such as Betelgeuse, photometric measurements can be conducted with a simple tripod-mounted DSLR camera. However, observing fainter targets requires more sophisticated equipment. The essential tools required for photometric studies include:

1. Tracking Mount – Required for long exposures to prevent star images from trailing.
2. Telescope – An 80-mm achromatic refractor suffices for moderately bright targets, but larger apertures may be needed to observe fainter variable stars.
3. Camera – A DSLR camera will work for bright stars with large changes in brightness, but a cooled CCD or CMOS camera provides higher precision and sensitivity.

Differential Photometry

Differential photometry measures changes in a star's brightness by comparing it to a non-variable reference star. The target star is compared to a non-variable star with a known brightness. This method involves selecting:

1. The variable star (the target whose changes in brightness are being measured).
2. A comparison star (a non-variable star with known, stable brightness).
3. A check star (a second non-variable star used to confirm the stability of the comparison star).
4. By analyzing how much brighter or dimmer the target star is than the non-variable star, astronomers can determine how the brightness of the target star changes over time. The next section will explore the role of these three stars in more detail.

Selecting a Target Star

The first step in amateur photometry is selecting a suitable variable star to observe. There are several high-quality resources that can be used, such as the AAVSO International Variable Star Index (www.aavso.org/vsx/) which contains data for more than two million variable stars. With millions of potential variable stars, it is useful to have criteria before choosing a star to study. Important considerations for amateur astronomers are the target star brightness, and period of the variable star. Stars fainter than 13.5 can make poor targets since they will be difficult to observe with the equipment available to most amateur astronomers. Another important consideration is the change in brightness (or transit depth in the case of transiting exoplanets). Most amateur observations will be limited to transit depths greater than 25 millimagnitudes. (For many variable stars of interest to amateur astronomers this limit is rarely reached; the main exceptions will be exoplanet transits or some cataclysmic variable stars.) If the change in brightness is less than this threshold, the detectors available to amateur astronomers may lack the necessary precision to detect it. Although shorter-period stars allow for a larger number of observations, long-period stars may still be worthwhile photometric targets. For example, the flare star *T Coronae Borealis* has a period that spans decades yet remains an important object of study for amateur astronomers.

Selecting a Variable Star

Variable stars come in many types, including pulsating, eclipsing, and cataclysmic variable stars. An important initial step is to choose a variable star to observe as part of the photometry project. The AAVSO Variable Star Index contains many beginner-friendly targets. Below are five suggested examples:

Beta Persei (Algol) – Algol is one of the most famous variable stars and has been observed since antiquity. As a naked-eye eclipsing binary, it changes from a magnitude of 2.1 to 3.4 over a period of 2.87 days. As a result, it is a well-studied eclipsing binary star and an excellent choice for introductory photometry. The variable star consists of two stars that orbit a common centre of mass along our line of sight. As a result, this eclipsing binary star system experiences periodic dimming and brightening, as one of the stars moves in front of the other. The period is 2.87 days, and the partial eclipse lasts approximately 10 hours. Because it is one of the brightest variable stars in the sky, it is possible to make photometric measurements of Algol with a tripod-mounted DSLR. However, because the eclipse lasts for close to 10 hours, it may be necessary to make measurements on subsequent nights.

W Ursa Majoris – Located in the circumpolar constellation Ursa Major, W Ursa Majoris (W UMa) is a contact binary—a class of stars is now named after it. In these systems, two stars orbit so closely that the outer envelopes of the stars are in contact, creating a tight dumbbell-like object, shown in Figure 1.

This system has a maximum brightness of 7.75 and during the primary eclipse it drops to 8.48. The secondary eclipse has a smaller change in brightness, dropping to 8.38 and is still easily detectable with DSLR or CCD equipment. A full orbit of the system takes eight hours, and as a result, a significant portion of a full cycle can be observed in a single evening.

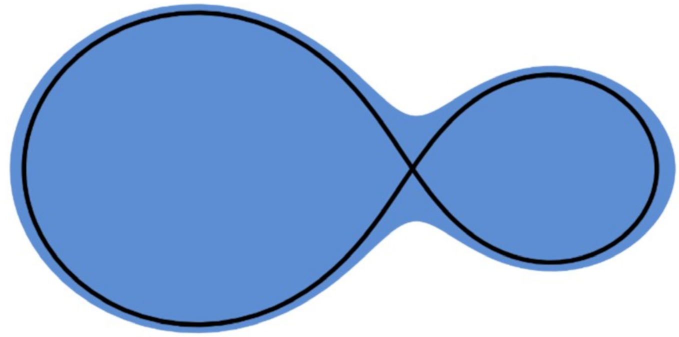


Figure 1: Schematic diagram of a W Ursae Majoris variable star. Credit: en.wikipedia.org/wiki/W_Ursae_Majoris_variable

Lambda Tauri – λ Tauri was the third eclipsing binary star system to be discovered. As an eclipsing binary star like Algol, this system consists of two stars that vary in brightness from +3.37 to +3.91 over 3.95 days. However, unlike W UMa, the longer period makes complete observations more challenging.

BL Camelopardalis – BL Camelopardalis belongs to a class of variable stars known as SX Phoenicis. Unlike the previous variable stars, these are not eclipsing variable stars but rather pulsating stars. The period of pulsation of SX Phoenicis stars is under two hours, with BL Camelopardalis having a period of 0.039 days or 56.2 minutes. Coupled with its circumpolar location in Camelopardalis, this is an ideal star for introductory photometry in northern latitudes because it is visible throughout the year and multiple pulsations can be observed in a single evening. However, the star is relatively dim and exhibits a fairly small change in brightness, changing from 12.92 to 13.25. As a result, good observations require a moderately sized telescope.

Delta Cephei – δ Cephei was one of the first variable stars identified in modern times and is the prototype Cepheid variable star. Like BL Cam, this is a pulsating star, and it varies in brightness from 3.48 to 4.37, making it an easy target for a 200-mm lens on a DSLR camera or a small telescope. Because it has a period of 5.37 days, observing a full cycle in a single observing session is challenging. However, combining observations over several nights can provide sufficient data to create a full light curve.

The chart below summarizes the key information from these variable stars for quick reference.

Procedure

Differential photometry follows a relatively straightforward process: capture a sequence of images, calibrate those images,

Variable Star Name	Right Ascension	Declination	Magnitude Range	Period
β Persei	03h 08m 10.13s	+40º 57′ 20.33	2.1 – 3.4	2.86 days
W Ursa Majoris	09h 43m 45.47s	+55º 57′ 09.07	7.75 – 8.48	8h 0m 33s
λ Tauri	04h 00m 40.82s	+12º 29′ 25.23	3.37 – 3.97	3.95 days
BL Camelopardalis	03h 42m 54.67s	+63º 13′ 27.60	12.92 – 13.25	56.3 min
δ Cephei	22h 29m 10.26s	+58º 24′ 54.71	3.48 – 4.37	5.37 days

Table 1 – Variable Star Quick Reference Guide

and then analyze the calibrated images to determine variations in brightness. There are several free and accessible software packages that can be used to carry out the photometric analysis, including IRIS, C-Munipack, or vPHOT. Despite the availability of high-quality analysis software, image acquisition remains fundamental to photometry; no amount of image processing or analysis can turn bad data into good data.

1. Image Acquisition

As discussed in the introduction, this article is designed for amateur astronomers already familiar with astrophotography. While calibrating images with dark, flat, and bias calibration frames is a crucial step in obtaining high quality data, this process will not be discussed in detail here.

The first task in image acquisition is obviously to locate and frame the target star. Once this is complete there are several important considerations:

- Exposure Time – There is no universal exposure setting to use. Much like astrophotography, this depends on the optical system (telescope, lens, and camera). It is important to ensure the star is properly exposed—overexposed images are not useful for analysis.
- Focus – Achieving the sharpest focus will yield the best photometric results. A focusing mask or computer assisted focusing can aid in this.
- Number of Images – The purpose of photometry is to measure the change in brightness of a star over time. As a result, it is important to take images over an extended period. In the case of SX Pheonicis stars like BL Cam, this can be done over the course of a few hours with a few hundred images in one night. Stars with longer periods, such as Algol or δ Cephei, may require data collection that spans several days or weeks.

2. Data Reduction and Analysis

Data reduction of photometric images is similar to the process used for astrophotography and the same software can be used (these include Nebulosity, MaximDL, and others). For the most accurate results, each image should be individually corrected using dark, flat, and bias frames. Unlike astrophotography, stacking is rarely used in photometry as it removes the time-dependent variable that is needed for analysis.

Software packages such as C-Munipack (Muniwin for short) and IRIS allow users to perform photometric analysis. Both Muniwin and IRIS are freely available for download using the links below:

Muniwin: cmunipack.sourceforge.net/

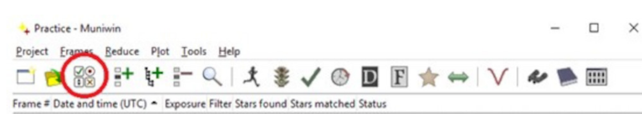
IRIS: www.astrosurf.com/buil/iris-software.html

Muniwin offers users an interface that is intuitive and comes with comprehensive documentation and has been used by professional astronomers when analyzing photometric data of variable stars (Pakštienė, 2019). It is capable of both data reduction (dark, flat, and bias subtraction) as well as data analysis. The next section will describe how to use Muniwin to complete basic photometric analysis.

Muniwin Tutorial

1. Open the Muniwin Program and select *New Project.*

2. Choose a name for the project and then click on the *Project Settings* icon.

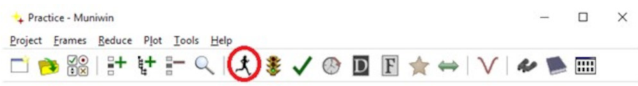


If Muniwin encounters issues when analyzing data, it may be necessary to adjust the parameters under the *settings* tab and use a different algorithm. Key parameters include properties like the *star detection threshold*, *matching algorithms*, and *photometry aperture.* For images with many stars (more than 100 for example) the *dense star field* algorithm is often the best choice. An incorrect algorithm will not allow enough stars to be matched by C-Munipack to continue with the data reduction.

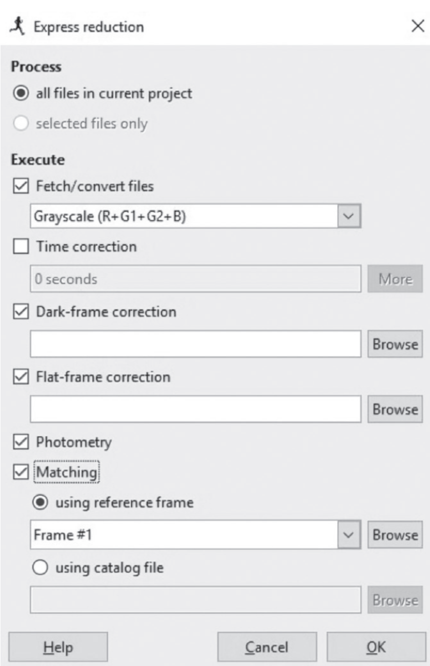
3. Add your image files.

It is possible to add images selecting individual files or by adding all files in a folder.

4. Select the Express Reduction to add dark and flat frames.



To begin data analysis, the Express Reduction option is the simplest method available. After beginning this step, the user will be prompted to add the dark and flat frames as well as complete the matching (alignment) and photometry.



Muniwin only supports a single dark and a single flat frame file per project. To ensure accurate calibration, it is necessary to create a master dark or flat frame using the option in the project settings. To proceed with photometry and matching, ensure the boxes in Figure 5 are selected. Click OK to begin reduction. At this point, Muniwin will apply dark/flat corrections, align images, and extract photometric data (Figure 5 shows the settings menu).

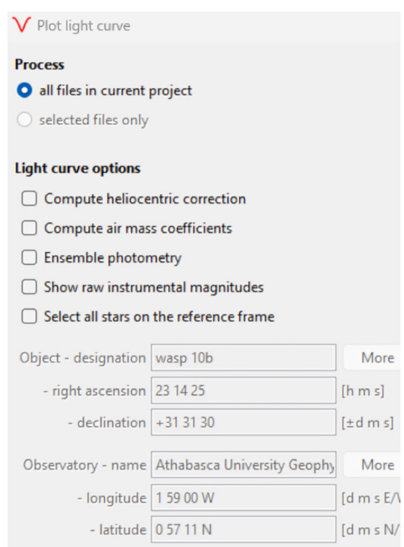
It is possible to run each of the steps (converting files, dark/flat reduction, alignment, or photometry) individually using the buttons to the right of the express reduction; if a problem with the express reduction is encountered, it may be useful to work

through each process in a step-by-step fashion to determine what the issue was.

5. Click on the Light Curve icon to begin data analysis and create a light curve for the variable star. Note, if the light curve icon is greyed out that means one of the previous steps was not properly completed.

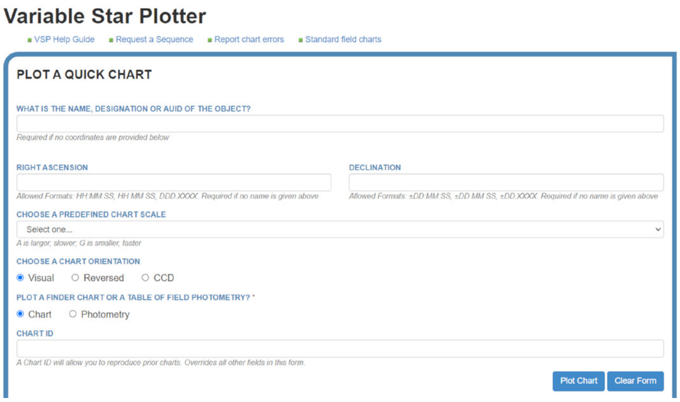
Before Muniwin can create a light curve, a variable and comparison star must be identified. The comparison star should be a non-variable star and resources such as the AAVSO Variable Star Plotter (www.aavso.org/apps/vsp/) can assist in identifying suitable non-variable stars. Muniwin will determine the difference in intensity (hence the term differential photometry) of the two stars and convert it to a stellar magnitude. It is also helpful to identify a third star to use as a check against the comparison star. This can ensure that any changes in the variable star/check star are not artifacts of the image acquisition or processing, and that the comparison star is not a variable star itself.

Once the Light Curve icon is selected, a new window will open, shown in Figure 8.

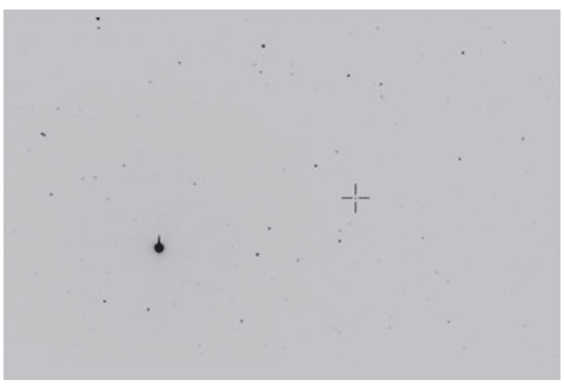


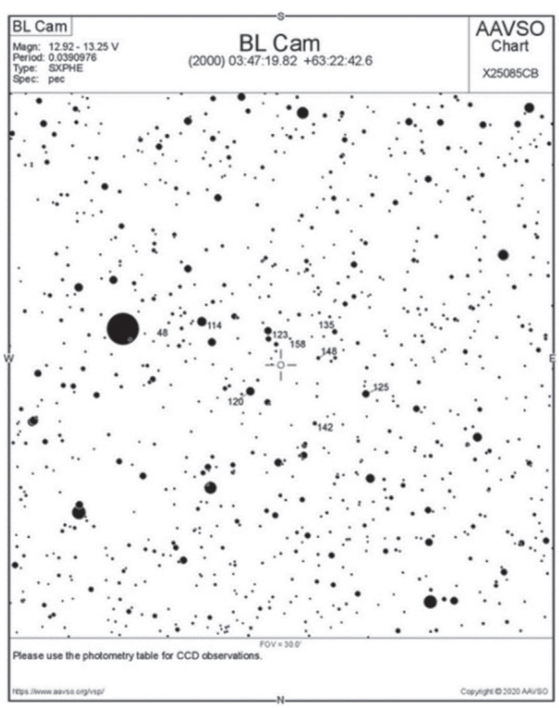
For simple light curves, the options in this tab are not required. Click on "Apply" to begin selecting the variable, comparison, and check stars. By including the imaging location and the star's right ascension and declination, Muniwin can compute both a heliocentric correction and account for changes in brightness due to atmosphere extinction.

Once you click "Apply," the starfield will be displayed. It is important to know which star is the variable star. This can be done by plate solving, which calibrates stars in an image with those from a catalogue. Several online tools can aid in this process, including the AAVSO Variable Star Plotter (apps.aavso.org/vsp/) shown in figure 9 or Astrometry.net (nova.astrometry.net/). Generating a star chart is straightforward. You can search for a chart by catalogue name or by RA and DEC and select star charts of various fields of view options.

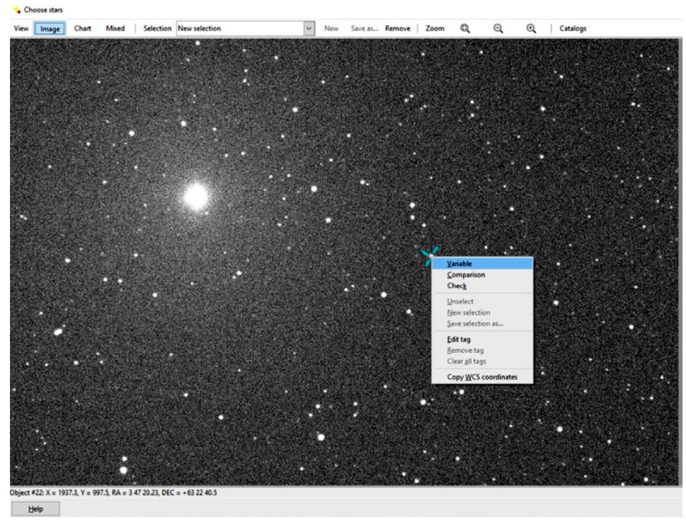


Below is an image of the starfield around the variable star BL Cam alongside the star chart from the Variable Star Plotter. Note that the fields of view are slightly different, and the image is rotated about 90°. Identifying the variable star by comparing it to the star chart is essential to the rest of the analysis. On the AAVSO star chart, the numbers represent the magnitudes of known non-variable stars without a decimal place, for example 123 refers to a star with magnitude 12.3. Since these stars are confirmed to be non-variable stars, they are ideal stars to use for comparison and check stars.



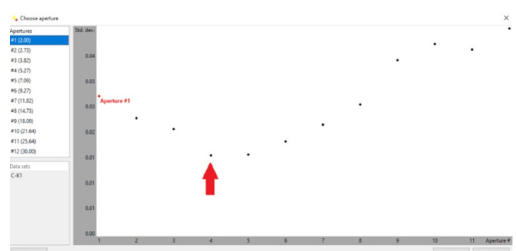


After identifying the variable, check, and comparison stars, return to Muniwin, and find those stars in the image. Next, click on each star and Muniwin will prompt you to identify them as variable, comparison, or check stars.

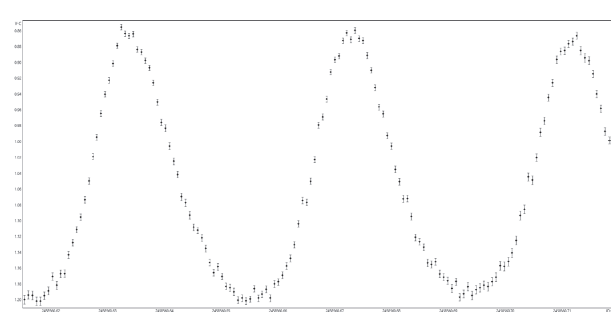


After identifying the three stars you want to use, click "OK" to proceed to select an aperture for the photometric analysis.

In Muniwin, the aperture refers to the size of a circle the program uses to measure the star's intensity. It will vary depending on many factors, such as the stars being analyzed, the camera used, and the length of exposure. However, understanding all the details is not necessary for introductory photometry. Instead, when prompted, select the aperture with the lowest standard deviation (the lowest value of the graph). In the example below the best aperture to select would be 4 or 5.



After selecting an aperture setting, click on OK and your light curve will be generated. It is possible to adjust the aperture used by selecting from the aperture drop-down menu on the light curve. Note that changing the aperture setting will alter the size of the error bars and likely affect the light curve.



6. Publication

Light curve data can be added to various professional databases, depending on the quality and type of variable star. Most variable star observations can be submitted to the AAVSO through their WebObs application (www.aavso.org/webobs); this will require you to register with the AAVSO for an observer code.

Exoplanet transit observations can be contributed to the Exoplanet Transit Database (var2.astro.vz/ETD/) after signing up for a free account. Adding your variable-star observations to these databases provides a useful contribution to the ongoing study of variable stars and exoplanet research.

Conclusion

Differential photometry offers astronomy students and citizen scientists a valuable opportunity to contribute to professional research in astronomy. With simple equipment and easily accessible tools, amateurs can analyze photometric data, which can address the observational needs of professional astronomers. This includes tasks such as observing exoplanet transits or studying variable and binary stars, offering amateurs meaningful ways to contribute to professional research, which are both extensive and impactful. Amateur astronomers play a crucial role in modern research by contributing real data to professional databases. Whether monitoring exoplanet transits or tracking variable stars, their work has a lasting impact on astronomical science. By using the methodologies in this article, amateur astronomers can begin a rewarding journey that enriches both personal exploration and the broader scientific community. ✶

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Wilkinson Memorial Observatory Redux: A 26 Year Update

by Joan Hodgins (306295hodgins@gmail.com);
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Theodore Venema Ph.D. (tvenema@sasktel.net)

An article about the Wilkinson Memorial Observatory (WMO), located just outside the town of Eastend in SW Saskatchewan, appeared in the *Journal* of The Royal Astronomical Society of Canada, written by R.A. Clark some years ago back in 1998. Here's a link to that issue: www.rasc.ca/sites/default/files/publications/JRASC-1998-12.pdf. *(Article is reprinted at the end of this article.)*

The recorded history of the area here around Eastend, located in the SW corner of the province, does not go back all that far in years. In fact, the earliest grave in the town cemetery dates back to only 1914, the same year Eastend was incorporated as a town. Still however, happenings in the area—around and shortly before that time—include a wealth of wild west stuff like the Red Coat Trail, the original Northwest Mounted Police, Commissioner Walsh, Chief Sitting Bull from the battle of Little Big Horn, etc.

Alan Dyer, a well-known astrophotographer, recently visited the local Eastend history museum in the summer of 2024. He saw an old 20-cm (8 inch) telescope and inquired about it. He suggested to one of the museum volunteers that an article about the story behind it should be submitted to the RASC *Journal*. A quick Google search on WMO revealed that an article had already been written in 1998, about Jack Wilkinson, a machinist/blacksmith/welder, who was an immigrant to Canada in 1927. He found good work in Eastend, plying his trade repairing equipment for the local farmers & ranchers. Around 1947, he developed a keen interest in astronomy. Using his wits and ordering in specialized pieces, he assembled hand-ground mirrors, lenses, and eyepieces for his own telescopes.

He first built a 10-cm refractor, then a 15-cm reflector, and then finally a 20-cm reflector. The sheer weight of this behemoth required lots of ingenuity to build a mount that could enable the telescope to rotate and track the night sky. Lots of effort and muscle was also required to move it out to places where the public could take a look through it. In 1950, Jack built an observatory to house his 20-cm telescope. People were fairly blown away, however, by seeing things they may have only read about in books. The telescope was eventually given a new permanent home on the roof at the local public school. The observatory there consisted of a five-metre diameter platform on four 3-metre-tall concrete legs. A science teacher, one Bob Bandurka, was the main schoolteacher who dealt with it there. Jack Wilkinson passed away in 1953, but his work had kindled an interest in others in the area that remains to this day. An astronomy club was formed. In 1993, the observatory and telescope were moved to the top of one of the hills south of Eastend, on land donated by one Elaine Andreas. At the same time, the Eastend Community Tourism Authority donated a Celestron Schmidt-Cassegrain 28-cm (11-inch) telescope to replace the original 20-cm telescope, which was moved to the local Eastend Historical museum.

Southwest Saskatchewan has three dark-sky preserves: Cypress Hills Inter-Provincial Park, Grasslands National Park, and Old Man on His Back Prairie & Heritage Conservation area. Located near all these locations, the small town of Eastend is well suited to be the place of an observatory, as it sits 1000 metres above sea level. On the hills, the WMO itself is another 125 metres higher, which is close to the elevation of Calgary! One person mentioned in the 1998 article, Wade Selvig from the town of Shaunavon, some 33 kilometres away from Eastend, continues to be an active member of the local Astronomy Club. In late spring, summer, and early fall, tours of the sky at the WMO are still given to the public. Joan Hodgins, our current Astronomy Club president, has always said the purpose is to make astronomy available to anyone. Jack Wilkinson's son, Jack Wilkinson Jr., resides in Eastend. He is a retired science and math teacher and has long been a member of the local astronomy club. A short meeting was arranged with Joan Hodgins and Jack Wilkinson Jr., regarding the suggestion given by Alan Dyer who was fascinated by the old 20-cm telescope at the museum. It didn't take long to decide to submit an update!

Today, nearly three decades later on, some things have changed, and some things have remained largely the same. The population of Eastend has declined by about 100 souls from the 752 mentioned in the 1998 article. There is however, a new hustle/bustle happening here. In 1991, the world's largest Tyrannosaurus Rex (Scotty) was discovered in the nearby hills; a life-sized replica of the fossil itself is housed in the TRex Discovery Centre Museum. A tourist train initiative has begun, cafés have opened, and a yearly music festival (Big Flat Folk Festival) is taking place each July (www.townofeastend.com/). A wave of expats from B.C. has recently been moving in. Well, why not? Housing here is far cheaper! The white-domed WMO looks much the same, with the same Celestron C11 telescope within it. The tracking system operates by solar energy. The opening of the door for the telescope to view the night sky, as well as the rotation of the dome, are still done by hand. The astronomy club is in the process of considering ways to improve the ease of opening the main door and rotating the dome. The focus knob of the telescope needs work, and the Eastend Astronomy Club is considering a telescope replacement, as the Celestron telescope is now well over 30 years old. Night-sky tours continue to be offered by and through the astronomy club. We have now added to our arsenal a Lunt Solar telescope, a 1980's vintage 4-inch (100-mm) Bausch & Lomb Criterion 4000 Schmidt-Cassegrain telescope, as well as a Meade Lightbridge 5-inch (125-mm) reflector telescope. New, younger members are joining the astronomy club. Like the grasses and cactus that cover the surrounding hills, we survive, and we thrive! ✶

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The Wilkinson Memorial Observatory

by R. A. Clark, Windsor Centre

The town of Eastend is in southwestern Saskatchewan, near the borders of Alberta and Montana. The population numbers seven hundred and fifty-two. It nestles in a wide coulee that was carved by an ancestor of the Frenchman River. The stream winds peacefully southward through the prairie wheat lands. To the west, the Cypress Hills shelter the town from the infamous prairie winds. These picturesque hills were once home to the mighty Tyrannosaurus Rex dinosaur, but are now a place where gentle white-faced cattle, mule deer, and antelope graze.

Eastenders live in unique but quiet isolation. The nearest large community is Swift Current, almost one hundred kilometres to the north. They are a community-minded people. They have created resources that are unsurpassed by many larger towns. There are five churches, a high school, an arena, a curling rink, a nine-hole golf course, a 14-bed hospital, and a café where most of the community's business deals are consummated. They have plans for a million dollar museum to display the complete skeleton of a Tyrannosaurus Rex that was recently discovered in a nearby canyon wall—and on a hill, just south of town, they have an astronomical observatory that would be the envy of most educational institutions having an astronomy program. It is called the Wilkinson Memorial Observatory.

In 1927 when a young blacksmith named Wilkinson immigrated to Canada, Eastend was already a bustling cow town. The ranchers and the wheat farmers needed someone who was good with a forge and who could repair their specialized equipment. Jack Wilkinson's smithy business boomed and soon he had expanded into a machine shop, using his own handcrafted tools. Jack had a lively curiosity about almost everything. His need to know and to discover extended to the stars that shone so brightly from the clear skies of Saskatchewan. Mostly from mail-order sources, he began to assemble information about astronomy and optics.

His first telescope was an ambitious 10-cm refractor, made from scrap tubing and welded in his own shop. Lenses were ground and polished with his own hands. Eyepieces were constructed as needed, from brass cylinders turned on his shop

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Pen & Pixel

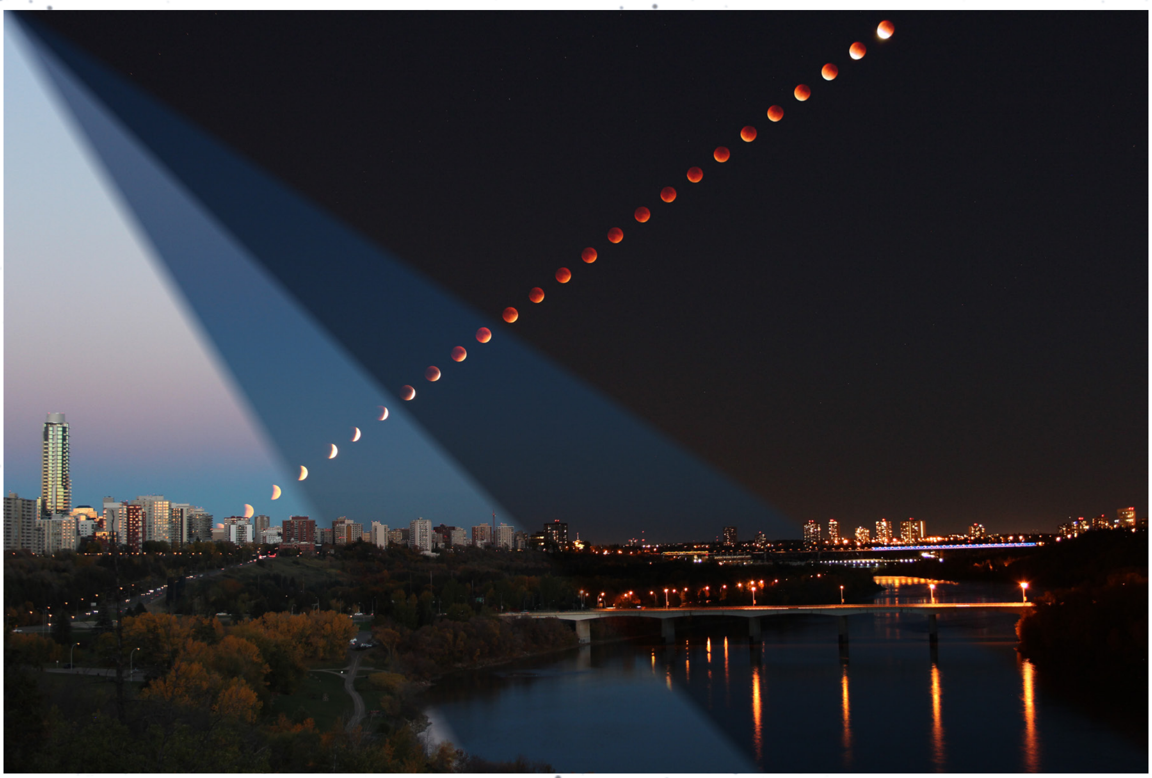

Figure 1 — Luca Vanzella of the Edmonton Centre writes: "This lunar eclipse moonrise was just before sunset, and the end of totality was in a dark sky, hence significant changes in lighting as the eclipse progressed. I wanted to capture the changing colour of the Moon and the changing colours of the sky and foreground." Full story here: https://www.flickr.com/photos/53851348@N05/22694496750/

Details: 2015 September 27, 19:27 – 21:32 MDT from St. George's Crescent, Edmonton, Alberta

Canon EOS REBEL T3i — Moon: 1/25 – 2 sec, f/5.6, 30 mm, ISO 800.

Figure 2 — Andrea Girones imaged the March 29 solar eclipse from Alma, New Brunswick, "a coastal village near the Fundy National Park at 6:30 am to set up in the fierce -11 C windchill.

With cloud approaching from the west, we managed to have an incredible clear view to the east at dawn and witnessed this lovely event. Thankfully it was low tide ('You did check the tides before we left?" asked my concerned husband')." The final image is a blend of an unfiltered foreground shot before the sun rose, and composited with filtered images of the sun once it rose. Assembled in Photoshop. She used a Nikon Z8 at 300Mm on a fixed tripod at ISO 100 f/13 with various exposure times.

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What's Up in the Sky?

June/July 2025

Compiled by James Edgar

June Skies

The Moon begins the month as a waxing crescent, just 1.4 degrees from Mars and 1.7 degrees south of the bright star, Regulus, in the constellation Leo, The Lion. Five days later, Spica in Virgo is occulted for viewers in the Southern Hemisphere; for northerners, it's a mere 0.5 degrees away from the Moon. On the 10th, another occultation occurs but not for North America, when the Moon is 0.3 degrees from Antares, the bright red star in Scorpius, The Scorpion. Did you know that Ares is the Greek god of war – same as the Roman god Mars, so Antares mean "the opposite of Mars." The Moon is full on the 11th. For people with good telescopes who like a challenge, try to pick out Pluto among the distant stars – its motion gives it away. For a few days ahead of June 14, it will gradually move to meet up with the Moon, an occultation in the area around Australia and East Asia. Pluto will be retrograding, that is appearing to move westward. Saturn and Neptune are both in the constellation Pisces, The Fish, and the Moon meets up with them on the evening of the 18th. On the 22nd, The Moon is among the stars of the Pleiades in Taurus, The Bull. The Moon is new on the 25th, and its thin sliver joins up with Mercury in the western sky on the 26th. The month ends like it began, with the waxing crescent Moon on the 29th just 1.5 degrees south of Regulus, and 0.2 degrees north of Mars.

Mercury gradually appears in the west on the second week of June, though favouring observers in the Southern Hemisphere. The speedy planet is joined by the Moon on the 26th.

Venus reaches its greatest elongation west on the 1st, and ever so slowly begins to round in its orbit away from Earth. People wanting to see the bright planet will need to rise very early, like 3:30 or 4 a.m. as it comes up just before the Sun in the east.

Mars, as indicated above, is in Leo, paired up twice in the month with Regulus, the "kingly star." It is a multiple star system, with four other component stars. The very large star spins on its axis every 16 hours – compare that to our Sun's leisurely rotation rate of 27 days – Regulus is very egg shaped because of that rapid rotation!

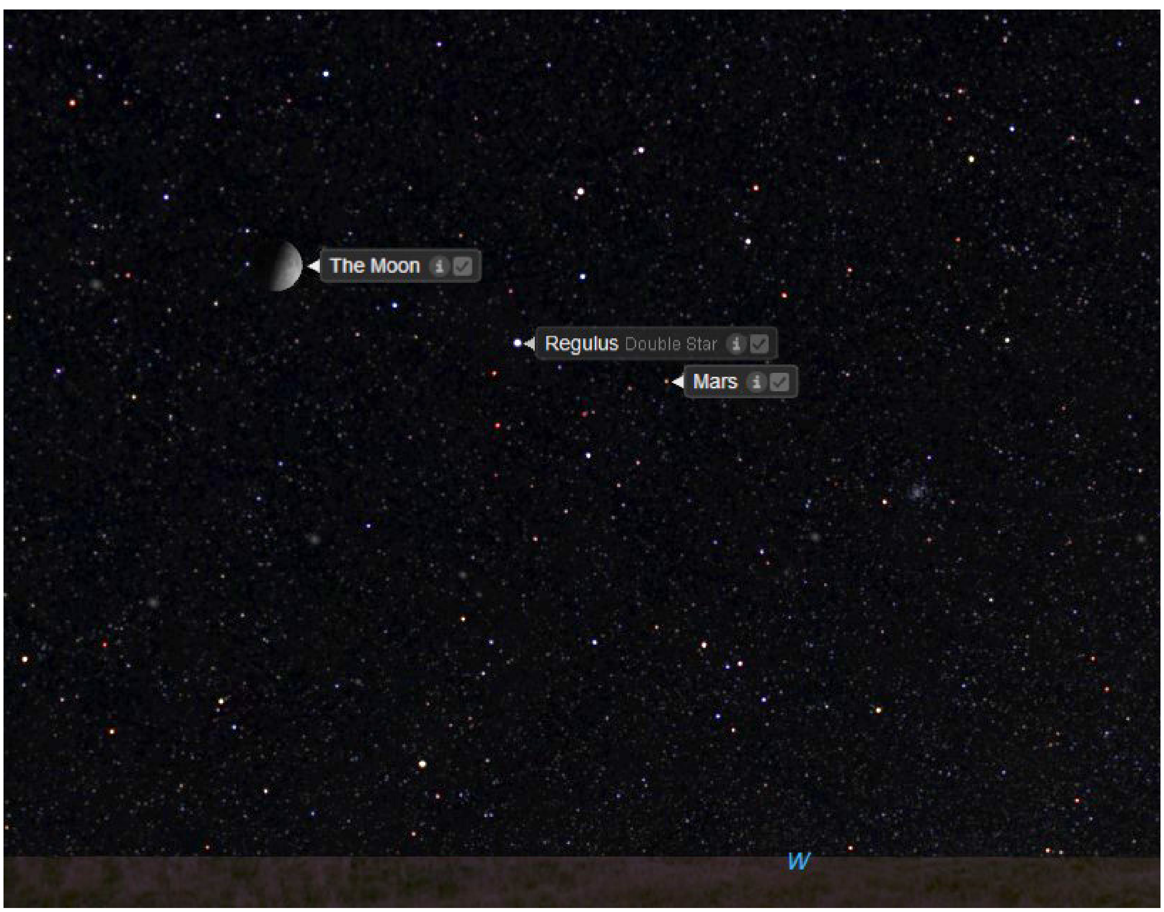
Jupiter is behind the Sun and not visible.

Saturn rises shortly after midnight, remaining visible over a short timeframe before sunrise.

Uranus gradually distances from the Sun in the early morning.

Neptune is like Saturn above, as they both occupy the same part of the sky. The two planets are in conjunction on the 29th, only 1 degree apart. However, Saturn is about 500 times brighter than the distant Neptune, so the blue-green gas giant is nearly impossible to see.

June 20 is the summer solstice– the days begin to shorten.



June 2 sees Regulus split the Moon-Mars pair shortly after sunset.

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The Sky June/July 2025

Compiled by James Edgar with cartography by Glenn LeDrew

Celestial Calendar (bold=impressive or rare)

Jun. 1 Venus at greatest elongation west (46°)

Jun. 1 Mars 1.4° south of waxing crescent Moon

Jun. 1 Regulus 1.7° south of waxing crescent Moon

Jun. 2 Moon at first quarter

Jun. 6 Spica 0.5° north of waxing gibbous Moon

Jun. 7 Moon at apogee (405,553 km)

Jun. 8 Mercury 2° north of Jupiter

Jun. 10 Antares 0.3° north of nearly full Moon

Jun. 11 full Moon at 3:44 a.m. EDT

Jun. 17 Mars 0.8° north of Regulus

Jun. 18 Moon at last quarter

Jun. 19 Saturn 3° south of last-quarter Moon

Jun. 19 Neptune 2° S of last-quarter Moon

Jun. 20 summer solstice at 10:42 p.m. EDT

Jun. 23 Moon 0.6° north of Pleiades (M45)

Jun. 23 Moon at perigee (363,178 km)

Jun. 25 new Moon at 6:32 a.m. (lunation 1268)

Jun. 27 Mercury 3° south of thin crescent Moon

Jun. 29 Saturn 1.0° south of Neptune

Jun. 29 Regulus 1.5° south of crescent Moon

Jun. 30 Mars 0.2° south of Moon

Jul. 2 Moon at first quarter

Jul. 3 Mercury 1.5° south of Beehive (M44)

Jul. 3 Earth at aphelion (152,087,376 km)

Jul. 3 Spica 0.8° north of Moon

Jul. 3 Venus 2° south of Uranus

Jul. 4 Moon at apogee (404,627 km)

Jul. 7 Antares 0.4° north of nearly full Moon

Jul. 10 full Moon at 4:37 p.m. EDT

Jul. 16 Neptune 3° south of waning crescent Moon

Jul. 16 Saturn 4° south of waning crescent Moon

Jul. 17 Moon at last quarter

Jul. 20 Moon 0.8° north of Pleiades (M45)

Jul. 20 Moon at perigee (368,041 km)

Jul. 24 new Moon at 3:11 p.m.

Jul. 26 Regulus 1.3° south of thin crescent Moon

Jul. 28 Mars 1.3° north of waxing crescent Moon

Jul. 29 south delta-Aquariid meteors peak

Jul. 31 Spica 1.0° north of waxing crescent Moon

Planets at a Glance

	DATE	MAGNITUDE	DIAMETER (″)	CONSTELLATION	VISIBILITY
Mercury	Jun. 1		5.1	Taurus	—
	Jul. 1	–0.2	7.6	Cancer	Evening
Venus	Jun. 1	–4.4	23.9	Pisces	Morning
	Jul. 1	–4.2	17.8	Taurus	Morning
Mars	Jun. 1	1.3	5.5	Leo	Evening
	Jul. 1	1.5	4.9	Leo	Evening
Jupiter	Jun. 1	—	32.4	Taurus	—
	Jul. 1	—	32.0	Taurus	—
Saturn	Jun. 1	1.1	16.8	Pisces	Morning
	Jul. 1	1.0	17.7	Pisces	Morning
Uranus	Jun. 1	—	3.4	Taurus	—
	Jul. 1	5.8	3.5	Taurus	Morning
Neptune	Jun. 1	7.9	2.3	Pisces	Morning
	Jul. 1	7.9	2.3	Pisces	Morning


NORTH
PERSEUS
Double Cluster
CASSIOPEIA
LACERTA
Capella
AURIGA
NW
CAMELOPARDALIS
CEPHEUS
Deneb
Northern Cross
URSA MINOR
Polaris
Little Dipper
LYNX
Castor
GEMINI
Pollux
CYGNUS
VULPECULA
DRACO
Vega
LYRA
URSA MAJOR
M44
Big Dipper
HERCULES
CANES VENATICI
LEO MINOR
CANCER
WEST
Regulus
LEO
BOÖTES
CORONA BOREALIS
Arcturus
COMA BERENICES
SERPENS CAPUT
OPHIUCHUS
HYDRA
VIRGO
Spica
CORVUS
CRATER
LIBRA
SCORPIUS
Antares
SW
LUPUS
CENTAURUS
SOUTH

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July Skies

The Moon is at first quarter at the beginning of July. On the 3rd, it is among the stars of Virgo, The Maiden. The Moon occults objects four times in the month, none of which are visible from North America. The first one is on the 3rd, when Spica is 0.8 degrees north of the Moon. The 2nd occultation is on the 7th, when the Moon is at waxing gibbous phase and Antares is 0.4 degrees north. However, the Moon overpowers even the bright Antares, so probably a non-event. The Moon is full on the 10th. Sometimes the Moon is south of the ecliptic, and other times during the month, it's north of that imaginary line that represents the plane of the planets' orbits. When the Moon appears to cross the ecliptic, it's called a node, and ascending node this month is on the 15th. Neptune, and the Saturn, on the 16th, are 3 and 4 degrees south of the Moon, respectively. By the 20th, the Pleiades (M45) and the waning crescent Moon share the spotlight. New Moon is on the 24th. On the 26th, Regulus is 1.3 degrees south; on the 28th Mars is 1.3 degrees north; on the 30th Spica is 1 degree north. All three events are occultations, but not visible from the Northern Hemisphere.

Mercury continues to delight Southern Hemisphere observers – not so much in the north. It swings out in its orbit, reaching greatest elongation east on the 5th and thereafter closes in on inferior conjunction by month-end.

Venus remains a bright beacon in the morning sky before sunrise, but gradually fading as July progresses. The waning crescent Moon passes by on the 20th/21st.

Mars is visible for a short while after sunset, still among the stars of Leo, The Lion. The thin waxing-crescent Moon passes by on the 28th.

Jupiter struggles to be seen in the early morning twilight after mid-month. While the gas giant was behind the Sun, it moved into the Gemini constellation, where it will remain for the rest of the year. The waning-crescent Moon passes 5 degrees to the north on the 23rd.

Saturn is in a good position for observing, rising in the east near midnight. On the 14th, it appears to be motionless, then begins retrograding against the background stars. The Moon is 4 degrees north on the 16th.

Uranus rises very early in the east, ascending into the morning twilight sky.

Neptune is near Saturn, and like the Ringed Planet, the distant planet appears to stop moving, then reverses direction to retrograde for the remainder of the year.

On July 29, the south delta Aquariid meteors peak in the evening.✶

Early in the eastern morning sky, July 2 has Uranus and Venus in the stars of Taurus, with Saturn away off in Pisces.

Continued from page 112

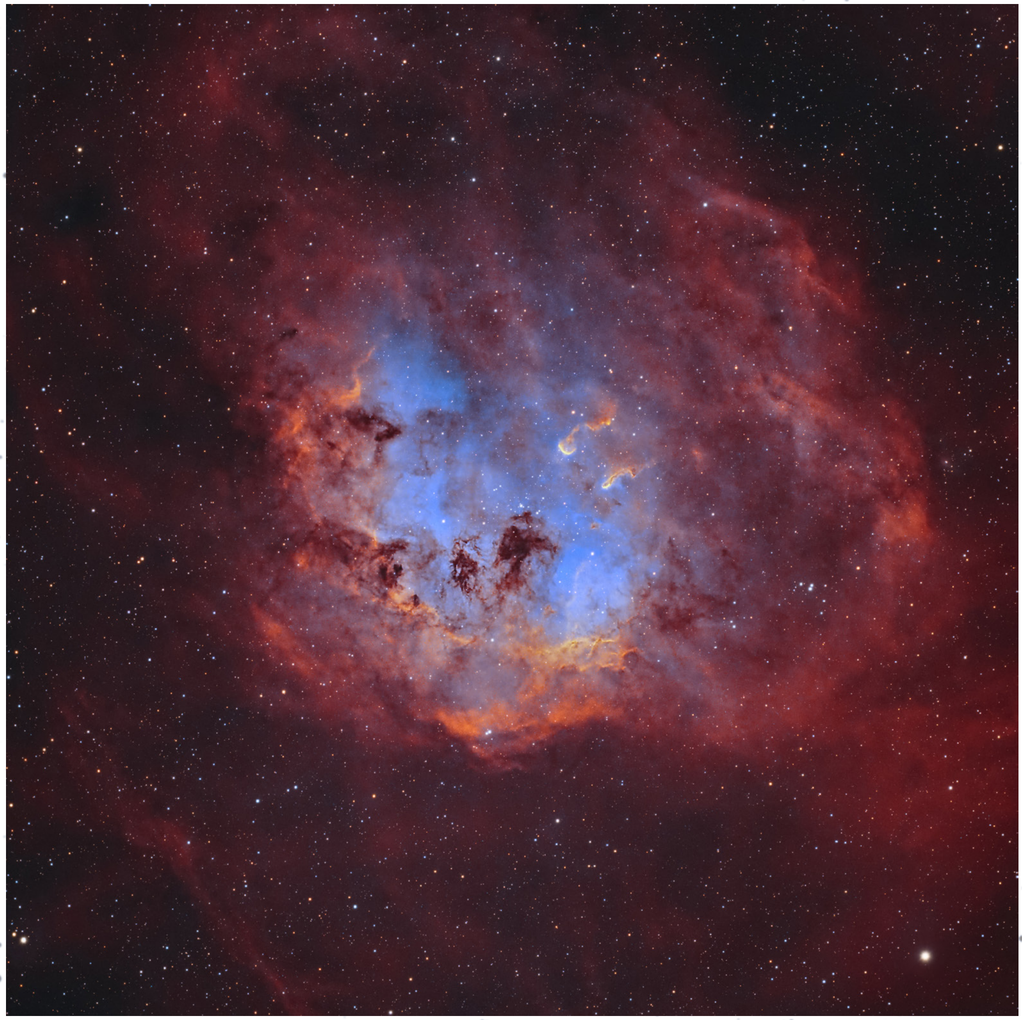

Figure 3 — Mark Germani imaged the Tadpole Nebula (IC410), an area of emission nebulosity surrounding NGC 1893, an open cluster of stars in Auriga. He says, "The titular tadpoles are about 10 light years in length, and are thought to be areas of star formation, their distinctive shape caused by erosion from stellar winds and radiation." He collected eight hours of narrowband data with a OSC camera and an Hα, an OIII filter, as well as one hour of RGB data with a light-pollution filter for the stars. He chose a blend of HOO and Foraxx palettes. He used an Astro-Tech AT92 on an iOptron CEM26 mount, and a ZWO ASI533MC Pro. He also used an Optolong L-eXtreme 2" and Optolong L-Pro 2" filters. Total integration: 9h 15m

Figure 4 — As Scott Johnstone says, "M42 is one of the best jewels of the winter night sky. It's such a big, bright, beautiful nebula that it's often the first target for beginner astrophotographers yet it's so complex and dynamic that it can be a real challenge for the most seasoned imager. With this image I wanted to keep the nebula and its colours looking as natural as possible and still pull the wispy veil away from the core just enough to get a glimpse into the heart of a star factory. I was excited to see that I was able to resolve the Trapezium so clearly as well." He used a Sky-Watcher Quattro 150p with a 0.86x coma corrector at f/3.4 on a Sky-Watcher HEQ5-p mount with a ZWO ASI533MC-p camera at –10 degrees with an Antlia Quad Band filter. 78x180 sec and 60x10 sec lights 20 darks, 20 flats, 20 dark flats. Stacked and processed in PixInsight with finishing touches in Photoshop.

Continued from page 111

lathe. Next came a 15-cm reflector. The grinding of the mirror took the Wilkinson family one whole winter. A testing jig was designed and built to test the parabolic accuracy of the mirror. The town's pharmacist supplied the coating for the mirror, and the jeweler assisted with the application.

In order to provide a rigid mounting for the telescope, the Wilkinson machine shop truly came into its own. Many of the components came from a World War II Anson training aircraft that had crashed nearby. To track the stars according to the Earth's rotation, an equatorial mount was designed and constructed by the community blacksmith.

A 20-cm telescope was next with a mount so heavy that it sat at the back of the shop. When the stargazers of Eastend wanted a viewing session, they had to have enough strong men to roll the telescope onto the sidewalk with steel rollers. From there they gathered to observe the craters of the Moon, the rings of Saturn, star clusters, and nebulae. A whole new dimension had been opened for the citizens of this small agricultural town.

A new and permanent site was needed. As with his previous efforts, Jack Wilkinson designed a circular building with a rotating dome. By trial and error and with the help of many friends, the observatory was built on the roof of the high school.

Jack Wilkinson died in 1953, but the interest that he had awakened in the town lived on. A club was formed, with membership shares that would pay for the care and the improvement of the observatory. The structure was moved to a hill, on land donated by a local rancher. A Celestron C11 was purchased, and the little town could boast that they had an observatory with one of the largest telescopes in western Canada. They called their observatory the Wilkinson Memorial Observatory.

Times have changed for small prairie towns. Many young people have moved away and others have found new interests. The Wilkinson Observatory now sits alone, awaiting an eager face to press against the eyepiece. Occasionally classroom tours arrive during daylight hours. The students are able to look for sunspots or to try reading the signs on the Shaunovon grain elevators, 30 kilometres away. Wade Selvig of Shaunovon and Richard Drockner of Maple Creek make the long drive as frequently as possible. Jim Young of the Saskatoon Centre visits to help with the maintenance and to give advice.

My sister Beryl resides at Eastend, and so on a visit during the past summer I inquired at the town hall about a tour of the observatory. In true western hospitality the reply came, "Yes, you may. We'll send the key over and you may use it as long as you wish."

Figure 1 – The Wilkinson Memorial Observatory at Eastend, Saskatchewan.

It was Kendal McCuaig, the local Plumbing and Heating contractor, who brought the key. Generously he offered to drive to the observatory to ensure that all was in good working order. The road took us along the "Red Coat Trail," the original route of the Northwest Mounted Police when they were establishing forts for the protection of Canada's southern border. It was on the same trail that Commissioner Walsh rode out to meet Chief Sitting Bull. The Chief and his Sioux army had retreated into Canada after the battle of the Little Big Horn. Walsh and a few of his officers intended to remind the Chief that he was now in Canada and must respect Canadian laws. The Chief agreed and he kept his word.

Kendal and I entered the observatory, and I was amazed by the spacious installation. A well-maintained C11, resting on its steel mount, was anchored in concrete. Its electronic drive is powered by solar panels. There is a fine assortment of eyepieces and filters, a solar filter, and a modest but adequate library of star charts and astronomy books. The dome moved easily with a generous opening slide. Under the sparkling skies of southern Saskatchewan and with no Moon, that night was going to be a wonderful experience for me.

My sister, her family, and some neighbours all expressed interest in joining me for a star party. Alas, as evening came, clouds rolled in and the rain began to fall. It rained all that night, the next day, and the next night. The following day I had to make a run for Regina to catch my flight home.

The happy part of this story is that the area had been suffering from a drought. The farmers and the ranchers were beginning to have concern for their crops and their cattle. There was great rejoicing in Eastend as the life-giving rain fell on my star party. As for me, I can only hope that the Wilkinson Observatory will be found by more of the curious with the same hunger for knowledge as that of the young blacksmith. His spirit lives in Eastend and on that lonely spot in the Cypress Hills. ✶

Mostly Variable Stars

Novae and Supernovae

by Hilding Neilson
(hneilson@mun.ca)

It's an exciting time time for stellar astronomers. Instead of staring and patiently waiting for Betelgeuse to explode as a supernova, we are busy waiting and watching for a nova to erupt from T Coronae Borealis (T CrB). This system is composed of a white dwarf star and a low-mass red giant star that accretes onto a disk surrounding the white dwarf star. As more material accretes on the disk, it gets hotter and more dense, which continues until some part of the disk is hot enough and dense enough to fuse hydrogen in a thermonuclear runaway that creates a bright flash, as illustrated in Figure 1. For T CrB, this means the system goes from a brightness of about magnitude 10 to as bright as magnitude 2.5, as was measured in February 1946 (Sanford, 1949).

But, T CrB is pretty special for such a rare phenomenon. T CrB is classified as a recurrent nova with observations suggesting a period of about 80 years. Since the last time the system went nova was in 1946 and the time before that was in 1866, then we are about due for another light show. Unfortunately, we have only two instances where we see the nova, though Schaefer (2023) suggested that the nova may have been observed in 1787 and even in 1217. But, watching and waiting for this expected nova (assuming T CrB hasn't already exploded by the time you read this) is a big deal for astronomers.

This particular event will allow astronomers and enthusiasts to explore an uncommon event and learn more about mass transfer from one star to another. We know of many different kinds of novae from classical events that are usually the same as T CrB but not known to repeat. Most novae seem to be classical, but there are also a few that appear to fuse helium in their explosion instead of hydrogen because there is no hydrogen seen in the spectrum of the nova (Rosenbush, 2008).

Perhaps, the best reason to study the recurrent nova T CrB is to probe the connections and transitions from being a regular nova to being a Type Ia supernova. A Type la supernova occurs when a white dwarf reaches the Chandrasekhar limit of about 1.4 solar masses, in which the star is too massive and dense to maintain degeneracy pressure. In this case, the white dwarf isn't bad, but the pressure is caused by electron degeneracy where every electron is bound to atoms in the most compact form and cannot be squeezed more. When that happens, the white dwarf explodes in a thermonuclear runaway and creates one of the brightest light shows in the Universe. These supernovae can be related to "regular" novae in a

Figure 1 — An artist illustration of a binary system in which a white dwarf is feeding on material stripped from a companion red-giant star. (Image credit: NASA/Goddard Space Flight Center)

straightforward way: a system that undergoes nova flashes may continue to accrete material on the surface of the white dwarf until it reaches that Chandrasekhar limit and then explode. Of course, it is also believed that Type Ia supernovae occur when two white-dwarf stars merge. But, Soraisam & Gilfanov (2015) tested whether novae are progenitors to supernovae by measuring and comparing the occurrence rates of novae and Type Ia supernovae from simulations of galaxy populations and showed that the hypothesis is reasonable. More recently, Hillman et al. (2025) modelled the rare helium nova systems to see under what conditions they might explode as a supernova instead. They found that that the amount of material the white dwarf can accrete before any explosion depends both on the mass of the white dwarf and on the rate of mass accretion, more explicitly if the mass accretion rate is small, $<10^{-8}$ solar masses per year, then the system might explode as a Type Ia supernova. If the accretion rate is greater than that but $<10^{-5}$ solar masses per year, then the system would be a repeating helium nova. So the evolution of a nova and/or supernova depends on the white dwarf and how it responds to accretion.

More directly, T CrB is exciting during the build up for the nova event. Toalá et al. (2024) present recent X-ray observations, along with observations from the American Association of Variable Star Observers, that show an increase in both the mean B- and V-band brightness starting in the latter part of 2015 along with an increase of amplitude in the variability of the light. They also show that the X-ray flux from T CrB is also variable, but by fitting the X-ray flux as a function of wavelength (or in the jargon, hard vs soft X-rays), they measure the disk around T CrB to be about 1 au in radius with an average accretion rate of about 10^{-8} solar masses per year. This accretion rate, though T CrB is not a helium nova, is similar to the models and provides a important probe of the physics of accretion and the evolution channel for classical novae, recurrent novae, and perhaps, Type Ia supernovae.

So, in many ways, studying novae, especially this nearby T CrB, offers astronomers important insights into the evolution of white-dwarf stars as they build up to the Chandrasekhar limit. Novae are also useful as probes, in general of stellar evolution and Type Ia supernovae and how these supernovae are crucial tools for measuring the rate of expansion and acceleration of the Universe. But, perhaps most importantly, when T CrB finally erupts in this once-in-a-lifetime event, it will put on one great light show. ✶

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Skyward

Shakespeare and Time

by David Levy, Kingston & Montréal Centres

William Shakespeare is probably the greatest writer the world has ever seen. Was he capable of writing something poorly, if he really tried? I doubt that. He lived four centuries ago. Born in Stratford, he was successful in London, and he retired and died in Stratford.

Scholars have worked on every possible aspect of Shakespeare for centuries. My doctoral thesis dealt with an aspect the others largely ignored: Shakespeare and the night sky. Not so much science, or astronomy, but the simple majesty of the sky. When he was eight, his father probably showed him Tycho Brahe's brilliant *stella nova*. A new star it was not, but instead a massive old star blowing up. Years later, the star found itself in the opening lines of *Hamlet:*

Last night of all,
When yond same star that's westward from the pole
Had made his course to illume that part of heaven
Where now it burns, Marcellus and myself,
The bell then beating one,—

Many critics have praised Shakespeare's curiosity about nature—trees, flowers, animals —but I think he enjoyed a special and enduring interest in the night sky. The iambic pentameter lines point to where the supernova would have lit up the sky, around 1 a.m. in late autumn.

It is possible that Shakespeare, who as a youth developed interests in all of Nature, forged a particular thirst for the night sky. Thanks to his reference in the opening lines of Hamlet, I think it likely that Tycho's star led to that passion. But this concern did not begin and end with the simple beauty of the night sky. Especially in his later works, he also developed an inquisitiveness about the cosmos itself, and about how time, though carefully measured in seconds on Earth, passes unhurriedly throughout the cosmos, not in seconds or hours but over billions of years. In preparing my Doctoral dissertation at the Hebrew University, I found more than 200 allusions to the night sky in Shakespeare's canon. But in Macbeth alone I counted 59 references to time. Here are two of them:

Time, thou anticipat'st my dread exploits:
The flighty purpose never is o'ertook
Unless the deed go with it. (4.1.144-146.)

Shakespeare portends that the progression of time is not always linear. Macbeth addresses time directly in this passage. Macbeth is continuing his murderous rampage, but time itself knows that the deed itself, to take place in the future, will confirm the bloody purpose. The unity of time and space, which Einstein posited in his special theory of relativity, in 1905, took place 299 years after Macbeth was probably written. In his essay on special relativity, Einstein added the dimension of time to the three dimensions of space, because the observed rate at which time passes for an object depends on the object's velocity relative to the observer. Einstein expanded his thought in general relativity, in which he demonstrated that a gravitational field can slow the passage of time for an object as seen by an observer outside that particular gravitational field.

To me you speak not.
If you can look into the seeds of time,
And say which grain will grow, and which will not,
Speak then to me, who neither beg nor fear
Your favours nor your hate. (1.3.55-61.)

In this passage Shakespeare has Banquo speak directly to time as if it had a personality, even seeds or parents and children. Macbeth is also asking time if it could tell him (like the weird sisters) whether his enterprise would succeed or fail. In the play, his enterprise clearly fails with the three-word rapturous stage direction "Dies. Fleance escapes." (3.3.17)

As the play nears its denouement, Macbeth is informed of the death of his wife. I like to imagine that the speech that follows is divinely inspired, as it is one of the finest scripts ever to touch paper: I quote it here, as it appeared in the First Folio published in 1623. I also take the liberty of adding two words at the end:

She should haue dy'de hereafter;
There would haue beene a time for such a word:
To morrow, and to morrow, and to morrow,
Creepes in this petty pace from day to day,
To the last Syllable of Recorded time:
And all our yesterdayes, haue lighted Fooles
The way to dusty death. Out, out, breefe Candle,
Life's but a walking Shadow, a poore player,
That struts and frets his houre vpon the Stage,
And then is heard no more. It is a Tale
Told by an Ideot, full of sound and fury
Signifying nothing.

[Signifying … everything.]

I am happy that the conclusion I reach here never made it to my dissertation, as I am certain that some scholars would have rejected it. But in this article, where I get to write what I like, I suggest that without being aware of it, Shakespeare anticipated Einstein's theory of general relativity by about three centuries. I also think that the culmination of the playwright's wording points to those final two words that quite possibly might have entered the poet's mind at the time, for surely his mind was aware of the status of that speech.

The next time you go out of doors and look at the evening sky, you may behold two of its features. One is the planets and stars that appear. The other is this collection of ancient words that potentially add a new dimension to our appreciation of the cosmos of which, for just an instant, we belong. ✶

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.*

John Percy's Universe

Damien Lemay—Citizen Scientist Extraordinaireby

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My previous column (Percy 2025) highlighted the work of my University of Toronto colleague Helen Sawyer Hogg, who was Canada's best-known and most beloved astronomer in her time. In addition to her many contributions to public education and outreach, and her leadership in scientific organizations, she had a long-standing research program on variable stars, especially those in globular star clusters (Clement 2024). But you don't have to be a professional astronomer to observe and study variable stars; it's a branch of astronomy in which so-called "amateurs" can make important contributions. The American Association of Variable Star Observers[1], founded in 1911 provides excellent resources and support for this work (Percy 2019).

A stellar example was brought to my attention a few weeks ago by RASC historian Peter Broughton. Long-time RASC member and former RASC National President Damien Lemay was honoured by the AAVSO for contributing over 100,000 CCD (charge-coupled device) observations of variable stars to the AAVSO database for use by researchers! In this column, I highlight this and his many other remarkable contributions to astronomy. You might want to check out his webpage[2].

Damien was born in 1943 on a farm in a village located about 75 km west of Québec City, the 11th of 13 children. There was no high school in the area, so he had to leave home and attend a boarding school at a college for four years, before going off to Laval University for a degree in physics. Clearly, his schoolteachers and family recognized his potential. His physics education led to a lifelong career as a telecommunication systems engineer at Québec Téléphone, in increasingly senior roles that have had a positive impact on both Québec and Canada. He is now retired, and he and his partner have moved to the dark skies a few kilometres outside Rimouski.

Damien developed an interest in astronomy as soon as he could read, when he discovered a weekly astronomy column by Paul-H. Nadeau in a local newspaper. From this, he learned the basics of astronomy, including how and what to observe in the sky. One of his sisters, a schoolteacher, then bought an encyclopaedia, which had more information and better star charts than the newspaper did. This motivated him to borrow his brother's binoculars—his first observing instrument. By the time he was in university, he had his first telescope—a 4.5″ (11.4 cm) Tasco reflector. His largest instrument is now a 24″ (61 cm) reflector, which he assembled from its parts with the help of a friend. He enjoys using this for visual observation.

Then came Sputnik, in 1957, and his interests expanded to include space, rockets, and satellites. He notes that, when groups of older folks got together to passionately discuss this kind of news, he began explaining it to them—and they listened. He claims to have been extremely shy as a boy, but it seems that space and astronomy brought him out of his shell. Thus began his lifelong interest in astronomy outreach and communication, to students, teachers, and the general public.

In college and university, he continued to devour astronomy books. In the summers, he worked at the Québec Observatory on the Plains of Abraham, with Paul-H. Nadeau—the same person whose newspaper articles had inspired him as a boy. His instrumentation has gradually improved with time, as you can see in Figure 1. He acquired a 5.5″ (14 cm) Schmidt camera in 1977 with which, over a seven-year period, he produced a photographic atlas of the sky down to −30°, on 1182 8″x10″ (20 × 25 cm) plates. For this, he was awarded the RASC Chant Medal in 1987. His interest in sky atlases can be traced back to the star charts in Paul-H. Nadeau's newspaper columns in his boyhood. He now has a very large collection of star atlases.

In 1973, he joined the AAVSO and submitted his first variable-star observations in January of that year. Like many who join the AAVSO, he was motivated by the desire to do science, not just to produce pretty pictures. He took up CCD observing of variable stars in 2007 and, since then, has contributed over 100,000 CCD observations to the AAVSO.

Much of this work has been done through the Centre for Backyard Astrophysics[3], an observing program and network of small backyard telescopes coordinated by Professor Joe Patterson, Columbia University. Damien has co-authored over

Figure 1 — Damien Lemay in his observatory, after a night of observing. Source: Damien Lemay.

a dozen research papers on cataclysmic variable stars—novae, dwarf novae, and nova-like stars—published in journals such as the prestigious *Astrophysical Journal*. This is an indication of the value and importance of the work that he does. Indeed, the tens of millions of observations in the AAVSO database are used for research by hundreds of professional astronomers—including me. He has a total of 68 publications in the NASA Astrophysics Data System[4], and dozens of other publications, including three useful and popular booklets: *Guide Pratique de l'Astronomie Amateur* (1978), *Introduction à la Photo Astronomique* (1978) and *Introduction aux Constellations* (1981).

Damien's interests continue to evolve. In 2019, he took up astronomical spectroscopy, thanks to a gift of instrumentation from Patricia and Hilderic Browne. The AAVSO has been coordinating backyard spectroscopy for several years. Many variable stars have highly variable spectra—Gamma Cas variables, for instance. Amateurs can make a useful contribution to astronomy by monitoring such variability, along with the changing brightness.

One might think, in this day of high-tech professional observatories, on the ground and in space, that there is no place in research for amateurs and their backyard telescopes. That's not the case (Percy 2019). International networks of observers like Damien monitor the complex variability of cataclysmic variables and a wide variety of other such stars, often continuously over several days. AAVSO observers accumulate decades of observations of long-period variables such as Mira stars, providing new information on their long-term variability. They still discover eruptions of novae and supernovae, and other unpredictable events in the sky.

I first got to know Damien through his contributions to the RASC. He joined the Québec Centre 60 years ago and has been a member ever since! He organized a joint meeting of the AAVSO, RASC, and FAAQ (Fédération des Astronomes Amateurs du Québec) at Laval University in 1983, and later became National Vice-President and then National President (1990–1992) of the RASC. This was important as it illustrated and confirmed that there was still an important place in the RASC for Québec astronomers. Damien served many other organizations, including the FAAQ. He co-founded the Club d'Astronomie de Rimouski in 1981. He also served as president of the Canadian Committee on Meteorites and Impacts (1997–2000), which is an advisory committee to the Canadian Space Agency. As of 2023, he and his camera are also part of the Global Meteor Network[5]. In all these ways, Damien serves astronomy, and the astronomical community, while appreciating the social aspects of his science.

Earlier, I mentioned his involvement in astronomy outreach from an early age. This now extends to total audiences of up to 1000 a year, including schools, Scout camps, vacation camps, parks, science expos, teachers, students, and seniors' groups. His work with teachers has been especially important and impactful. He served on the Canadian Committee for the International Year of Astronomy 2009 (as did I), whose aim was to bring astronomy to large and diverse populations of Canadians in as many ways as possible. It succeeded brilliantly (Hesser et al. 2010).

Of course, Damien is not the only Canadian amateur astronomer who has made important contributions to the study of variable stars. There is my fellow *JRASC* columnist, David Levy, nova discoverer Warren Morrison, and Chant Medallist Chris Spratt, among many others. They and Damien and others are highlighted in Peter Broughton's (1994) excellent history of the RASC. But today, Damien is a shining example.

I began this column by introducing the term "amateur" astronomers, i.e. those who do not do astronomy as a profession. But the term is misleading, because many so-called amateurs do astronomy at a very high level, as Damien does. The term "citizen scientist" is often used for these people instead. So, congratulations, Damien—citizen scientist extraordinaire.

Acknowledgement. I thank Damien, not just for his contributions to the study of variable stars, and to so many other areas of astronomy, but also for writing much of this column for me. When I told him of my plan to highlight him and his work in *JRASC*, he quickly sent me a four-page *curriculum vitae*, and a five-page addendum on how astronomy has developed as his personal interest, including the evolution and details of his observatories and instrumentation. I hope he will post this on his website! ✶

Endnotes

1. AAVSO: www.aavso.org
2. Damien Lemay: www.astrorimouski.net/membres/damien/astronomie/index.htm
3. Center for Backyard Astrophysics: cbastro.org
4. Astrophysics Data System (ADS): ui.adsabs.harvard.edu
5. Global Meteor Network: globalmeteornetwork.org/weblog/CA/

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Percy FRASC is Professor Emeritus, Astronomy & Astrophysics, and Science Education, University of Toronto, and a former President (1978-80) and Honorary President (2013-17) of the RASC.

Dish on the Cosmos

Radio Pollution in the Satellite Constellation Era

by Pamela Freeman
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Satellite constellations are a hot topic of conversation for astronomers. Since 2019, when the first *Starlink* satellite was launched, the number of satellites in orbit has ballooned. In dark-sky sites, streaks of light polluting the sky have become a common sight. Now, at the beginning of 2025, there are over 11,000 satellites in orbit with the majority of these belonging to SpaceX in its *Starlink* constellation (Figure 1). Plans for hundreds of thousands more satellites from several companies have been filed across the world.

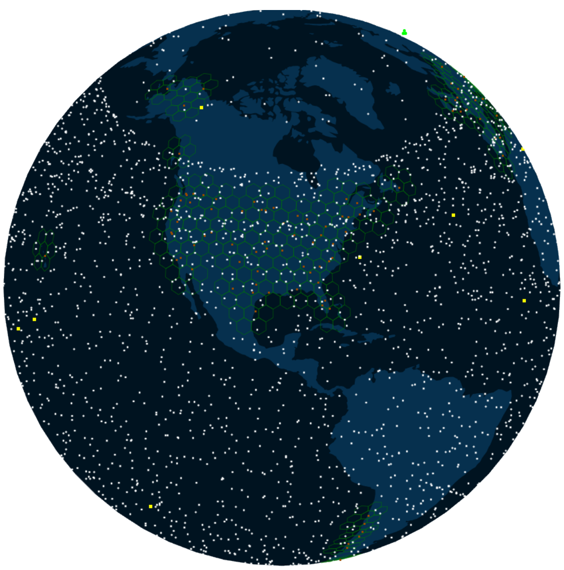

Figure 1 — Starlink *satellites currently in orbit, orbit. Each white dot represents the location of a satellite. Image credit satellitemap.space.*

Satellite constellations provide critical services to underserved, remote communities. They are addressing the digital divide by providing access to information and means of communication in an ever more online world. But their rapid development has raised concerns: the human right to access a pure night sky, the sustainability of space development, and their detrimental effect on astronomical research.

Many of us live in cities where streetlights, billboards, and building lights spill out into the sky and wash out our ability to see anything but the brightest stars. Many of us also live where wi-fi, microwave, mobile phone, and media broadcast signals wash out astronomical radio sources. Now, satellites are a growing cause of light pollution in both the visible and radio parts of the electromagnetic spectrum.

Satellite constellations are seen as bright streaks to someone gazing at the stars. Invisible to us is similar pollution in the radio frequency (RF) spectrum. There are both intentional and unintentional signals emitted towards Earth as satellites provide internet connectivity. There are both intentional and unintentional signals emitted towards Earth as satellites provide internet connectivity. These signals are at frequencies frequently used by radio telescopes and are classified by astronomers as RF pollution—the human-made signals that interfere with (incredibly weak) astronomical signals. Unmitigated, radio astronomers would never be able to detect anything coming from space. Typically, there are two main ways that astronomers protect their observations from pollution: setting up their telescopes in radio-quiet zones and advocating for certain parts of the radio spectrum to only be used in astronomy.

Radio-quiet zones are areas where the use of any RF emitting technology is limited or prohibited. There are necessary items at observatories, like computers, that must be contained in Faraday cages to prevent their signals from interfering with data. Observatories also use natural barriers such as building a telescope high on a mountain or nestled in a valley (like the Dominion Radio Astronomical Observatory in the Okanagan Valley, B.C.). However, these efforts solely focus on ground-based emissions. Space-based emitters, like satellites, have historically been exempt.

The frequency at which astronomers observe is important—some frequencies of light are more interesting to collect. For example, neutral atomic hydrogen emits at 1420 MHz. There is a small frequency range from 1400-1427 MHz that international communities have agreed to protect for radio astronomy by prohibiting use of those frequencies by other technologies. The protected band spans from 1400-1427 MHz, accounting for relatively small shifts in frequency due to objects moving in space—light from stars or galaxies moving away from us is "redshifted," meaning it gets stretched to lower frequencies. Conversely, it is "blueshifted" to higher frequencies if it is moving towards us. The small shifts contained in the protected band allow astronomers to view objects in the Milky Way and in nearby galaxies.

This is a problem for very low-frequency telescopes that search for neutral hydrogen in the distant Universe. The further away the galaxy is, the higher its redshift. For early galaxies, from when the Universe was less than a billion years old, the redshift is so large that astronomers hunt at frequencies around 100 MHz.

Two such telescopes, the LOw Frequency ARray (LOFAR) in Europe and a Square Kilometre Array (SKA) prototype

Figure 2 — A warning sign at the entrance to the Dominion Radio Astrophysical Observatory in British Columbia. The observatory is in a radio-quiet zone, which restricts the use of electronic devices in order to reduce human-made interference in faint astronomical signals.

station in Australia, have detected signals linked to Starlink satellites. The first report from LOFAR came when there were only about 2,100 Starlink satellites in orbit.

At first glance, these telescopes seem to be out of range for satellite communications. *Starlink* transmits data to its ground stations at much higher frequncies, at about 10-12 GHz. What the astronomers detected were unintended signals—electromagnetic radiation leaking out of electronic systems on board the satellites. This unintended emission is not taken into consideration when determining how different devices can use the radio spectrum. While it is weaker than intended emission, it is variable, hard to characterize, and so difficult to remove from astronomical data.

A novel data analysis technique used at the Murchison Widefield Array in Australia might prove useful for removing satellite interference. Astronomers saw an unwanted signal streaking across the sky in their data, and they started sleuthing. It was a rare, but curious, case—they determined it was a television broadcast signal reflected off an airplane into the telescope's view. Typically, astronomers would just discard this data. In this case, they were able to locate the source of interference. It's an important step—if you can find, isolate, and subtract interference then you can save most of your data. This also saves telescope time, astronomer's time, and tax-payer money.

Astronomers have also been working with satellite companies to facilitate a peaceful co-existence. The telescope, run by the National Radio Astronomy Observatory (NRAO), is in a U.S.-regulated radio quiet zone. Scientists and engineers there have worked closely with SpaceX to first determine the impact of *Starlink*'s signals on the Green Bank Telescope and then determine if there was a way for *Starlink* to deliberately avoid the telescope while still providing service to the region. They found there is a way.

NRAO can send the telescope pointing direction and frequency range to the satellites in real time. The satellites can then avoid emitting strong signals that would interfere with the ongoing observations. This avoidance strategy is now in practice, with the NRAO recently announcing that SpaceX can offer internet services to over 99 percent of residents in the radio-quiet zone. This is an announcement unlike any seen before for a radio observatory; while it will undergo a trial period, it truly represents a new era for radio management.This is a promising system, and a resource intensive one. SpaceX is far from the only satellite purveyor, and these kinds of initiatives will need to be more widespread as these constellations grow. There are no set standards or guidelines to direct how satellite companies and observatories should act.

Astronomers are still pushing for satellite regulation, as unintended emission like that seen by LOFAR and the SKA prototype cannot be avoided in the same way. The current solution for unintended satellite emission is to simply not observe in the direction of satellites. This relies on knowing exactly where and when satellites will pass by, and it is an effort that will only become harder as the number of satellites multiplies.

Global collaborations, such as the International Astronomical Union Centre for the Protection of the Dark and Quiet Sky from Satellite Constellation Interference and the United Nations Committee on the Peaceful Uses of Outer Space, are bringing together space experts from many disciplines to tackle these problems. Continued cooperation from satellite companies, scientists, and governments can enable technological development without compromising the heritage of the night sky. ✶

Pamela Freeman recently finished her Ph.D. in astrophysics at the University of Calgary. Specifically, she studies the chemical make-up of star-forming clouds with radio telescopes. Generally, she loves to observe anything and everything about nature.

Blast from the Past!

Compiled by James Edgar
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[This excerpt, which appeared in the RASC *Journal*, is taken from Prof. C.A. Chant's article of 1907, describing work undertaken at the Lick Observatory on Mt. Hamilton, California.

The excerpt was provided by the NASA Astrophysics Data System.]

Observation of Double Stars; Correction to Mr. Espin's Note

In April 1899 Professors R. G. Aitken and W. J. Hussey began a systematic search for new pairs of double stars in that portion of the sky north of declination –22°. During 1899 comparatively little was done, but since then no occasion has been lost in pushing the search. Professor Hussey withdrew from the work on his leaving the observatory in 1905, and since then Professor Aitken has continued the work alone. The great refractor is used on four nights each week for spectrographic work, on Saturday until 10 p.m. for visitors—who come in great numbers—and the other time is devoted to double star observations. In the great catalogue of double stars prepared by Burnham and very recently issued, Burnham gives a list of 1336 discovered by himself. Counting 137 stars just announced in Lick Observatory Bulletin No. 117, Hussey's discoveries amount to 1337. Of these, however, 10 are of southern doubles and have not been properly measured. Professor Aitken has already published more than 1500 new pairs, and has over 100 more ready to publish, and thus he now is decidedly in the lead in this work. His great survey will likely be completed in two years.

Besides this work the measurement of binaries has been kept up-to-date, and Dr. Aitken's card catalogue of these objects is a veritable mine of interesting information.

On account of the great resolving power of the 36-inch telescope—and the keen eye of the observer—many interesting extensions of the labors of other observers have been made. The writer has been given some interesting examples. The star 29 Hydrae was pronounced double by Burnham 20 years ago. It is now found that the principal component, of 6.5 magnitude, is itself a close double; and since all the components have the same proper motion, one can conclude that they form a physical system. Star number 75 in Espin's list in A.N. 3784, with R.A. 15h 15m.9, declination +46° 29′ (1880) is given by its discoverer as double. It is found to be triple. Star b 370 = B.D. +52°·2963 in Burnham's list is given as a binary, being an eighth magnitude star with a ninth magnitude companion. It is now found to be quadruple.

Professor Aitkin informs me that there is a mistake in Rev. T. E. Espin's "Notes on Double Stars" in the last number of the JOURNAL, and I cannot do better than give here a note of correction prepared by Dr. Aitken :

"The Rev. Mr. Espin is usually correct in his statements relating to double stars, but he is mistaken in thinking that the pair B.D. + 29°.1821, near t Cancri is new. It was discovered by me on February 20, 1903, and is included as A553 in the list printed in the Lick Observatory Bulletin No. 50. Possibly a mistake in bringing forward the star place accounts for the failure to recognize the identity of the two pairs, for the correct position for 1900 is R.A. 8h 39m 53s, decl. +29° 22′.

"My measures give 1903.16 70°.4 2″.44, 3 nights, 36-inch. There is no other similar pair in the vicinity."

Beside the work on double stars, micrometric measurements on the comets and satellites too faint for the 12-inch telescope are regularly made with the 36-inch. At present the satellites of Mars and Uranus are being observed. and Kopff's comet 1906 b = 1905 IV has been followed from April 20 to July 3. At the last observation the object was so faint—about the sixteenth magnitude—that when the absence of the Moon allows another observation to be made it will probably be invisible.

The Meridian Circle

The meridian circle belonging to the observatory has an aperture of 6.4 inches, and is one of the fine productions of the Repsolds. It was mounted twenty years ago, and for three quarters of that period has been in active use. It is in charge of Professor R. H. Tucker, who, before joining the observatory staff in 1893, had had much experience in meridian circle work at the Dudley Observatory, Albany, N.Y., and the Cordoba Observatory in the Argentine Republic. A skilful observer may secure good results with an inferior instrument, but the best results can only be obtained with a first class instrument in the hands of an experienced and able observer. This instrument has been investigated in great detail, and the final test, that given by the results obtained in its use, has shown that it is of the highest mechanical design and construction.

There are certain classes of errors that remain constant for one instrument, and the investigation of these can be expected to give data which will be useful for a long period of time, and for the various observers who may use the instrument. The flexure and the division error are included in this class. These have been extensively investigated for the meridian circle. The first is of very small size, certainly less than 10″. The measurement of every division of the graduated circles is a labor too great for any single observer if all his time for a term of years were to be devoted to that alone. The fixed circle of this instrument has been measured completely down to the 10′ divisions; the movable circle down to 3°. Also large numbers of the

2′ divisions have been measured, so that corrections can be applied, either directly for the divisions used, or by interpolation for intermediate divisions. Other classes of instrumental errors are constantly determined, as well as the errors of the investigator, the result perhaps of personal peculiarity in the first place and confirmed by long habit eventually.

The instrument is now being used for work of a fundamental character, in which the greatest refinement of methods is necessary. Few observatories undertake this line of work, but about once in a generation the need becomes somewhat pressing for a revision and adjustment of our fundamental system of star places.

Two volumes of meridian circle measurements have been issued and a third volume is now going through the press. The first volume contains observations of standard stars mainly. The second includes a long list of southern stars, and the stars for Eros which were observed at many other observatories. The present volume, in addition to miscellaneous lists, contains the stars of the Zodiacal Catalogue, which are also to be observed elsewhere. In all about 25,000 observations of star places have been completed and prepared for publication.

The work of this department has naturally included the rating of the fine clocks, of which the observatory has six, including a new Riefler, enclosed in air-tight glass case and wound electrically.

The work at the present time will be a contribution to the knowledge of the positions of the standard stars, just as previous work has contributed to that of the greater mass of less prominent stars. It is hoped to round out consistently a programme that has included a number of detached and a number of closely related schemes.

The Keeler Memorial Volume

James Edward Keeler was appointed director of the observatory in June 1898, and died in August 1900. In the short interval his work with the Crossley Reflector was such a distinguished success that it produced a decided revival in the use of such instruments.

For some time a Memorial Volume has been in preparation, the work being in charge of Professor Perrine, who took over the reflector at the decease of the late director, and completed his programme, of which all but one third had been carried out. The volume, which will be one of the regular publications of the observatory, will contain seventy illustrations, representing the most interesting nebulae and clusters within reach of the instrument at its present latitude. Great difficulty has been experienced in securing proper reproduction of the original negatives, as it is desired to show not only the detail of the denser portions but the fainter parts as well. One fourth of the engraving has been done and the rest will be secured as soon as possible.

The volume will also contain a brief memoir, a reprint of Keeler's well-known paper on the Crossley Reflector and a catalogue of new nebulae discovered on the negatives. On the 103 plates taken 744 new nebulae were found. Each of these plates covers three-fourths of a square degree and as they were well distributed throughout the sky a simple calculation leads to the conclusion that over 500,000 nebulae are within the reach of the Reflector with an exposure of four hours.

Paper photographs, no matter how carefully made, are not suitable for original research, which should be made with glass plates. It is hoped that means will be found to prepare six or eight sets of glass positives of these Crossley photographs of nebulae and star clusters, to be deposited, for the use of investigators, with leading learned societies and institutions throughout the world.

Reference has been made above to alterations made in the optical system of the Reflector. Its mounting was entirely remodelled, according to Dr. Perrine's plans, in 1903. In 1904 Saturn's ninth satellite was photographed and soon after this followed the discovery of Jupiter's sixth and seventh moons.

For some time Dr. Perrine has been investigating the distortions of photographic films, preparatory to undertaking his parallax programme. The discordance between successive photographic plates of an object is many times greater than the errors of measurement. Much of the trouble lies in the structure of the photographic film. If the difficulty can be overcome a great advance in the means of research will be attained.

The above notes, though somewhat extensive, by no means exhaust the activities of the Lick Observatory. Systematic studies of the different classes of variable stars are in progress, an important contribution to this subject by Dr. Albrecht having recently appeared. An investigation is also being made into the Zodiacal Light; while no new object appears in the heavens—such as a nova or a comet—without being promptly attacked. In cases of emergency the entire resources of the observatory are turned to the study of a new phenomenon.

Another matter which strongly impresses the visitor is that the doors of the observatory are never closed, and at almost any hour of the day or night someone can be found busy in observation or investigation. Indeed the energy, enthusiasm and earnestness of purpose of the Director are reflected throughout the entire institution; and the spirit of investigation seems to saturate the rare air about the summit of the mountain.

Lick Observatory,

Mt. Hamilton,

July 20, 1907. ✶

2025 Awards

Compiled by Charles Ennis

Fellow of the RASC

Paul Gray, Halifax Centre

On behalf of the RASC Halifax Centre, we hereby nominate Paul Gray for the designation *Fellow of The Royal Astronomical Society of Canada (FRASC).* The Fellow of the RASC award is intended to be the Society's most senior award and the highest honour the Society can pay to a member. The service and contributions to the Society must have had a significant positive impact on the work of the Society over an extended period beyond that of the Service Award, and they must have contributed to the Society's success in attaining its stated objectives, mission, and vision.

Since the age of fifteen, when he first became a member, Paul Gray has been giving freely of his time and ever-growing expertise in many ways, to further the objectives of the RASC. We believe that Paul Gray more than qualifies for the Fellow of the RASC (FRASC) Award and offer the following information in support of our nomination.

Paul, a technologist with the Municipality of Kings County, resides in South Greenwood where he is an avid observer and astro-imager. He received three RASC Observing Certificates – *Messier Catalogue* (1994), *Finest NGC Objects* (2001), and *Explore the Universe* (2016).

He became a member of the Halifax Centre in January 1988. Paul is a natural leader and an inspiring mentor to novice and experienced observers alike, including his own children. Two at age 10 were recognized internationally for their discoveries of supernovae. He attended the international Starmus Festival three times: in Norway, Canary Islands, and Switzerland with his family. Each time he informally acted as a worthy ambassador for the RASC.

Paul gave substantial and exemplary service in many roles both at the Centre and national level and consequently received the RASC Service Award in 2016. The original submission for Paul's Service Award nomination which includes his activity prior to 2016 is attached.

Service to the RASC Halifax Centre

In the RASC Halifax Centre, Paul served as a director in 1997 and again in 2019, its President 2015-2018, and its Vice-President in 2020. He has served since 2015 on the Nova East Planning Committee (our Centre's annual star party) where at various times he has also been a speaker, lead organizer of the barbecue and the Astronomer's Breakfast, and liaison with Smileys Provincial Park where the event is still being held.

He is very knowledgeable of our Centre's history, has a vision of what it can become, and takes pride in what has been accomplished to date. He and Dr. Roy Bishop, FRASC, presented Roy's compiled 1951-2019 history of our Centre at our January 2015 member meeting. His love of observational astronomy is evidenced by the many presentations he has made at Member and Public meetings, including this sample of talks since 2016:

- 2016: "The Great American Eclipse in August 2017"
- 2017: "How to Clean Optics"; "Family Trip Travelog" (trip to 2017 Solar Eclipse)
- 2018 (at RASC Halifax Centre AGM): "The Roar of the Draconids!"
- 2019: "Dark Nebulae in New Light"
- 2020: "Meteors"; "How to Observe and record variable star observations"; "The RASC Calendar – Front to Back and Back to Front" (at RASC Halifax Centre AGM)
- 2024: "Solar Eclipse 2024: where best to view it, things to consider"; "Member Eclipse Stories" (his trip to watch the eclipse with New Brunswick Centre friends)

He has been actively involved with our Centre's St. Croix Observatory (SCO) since its conception. In 1996, he drew the site plot after an exhaustive day of surveying the site and was involved in the clearing of the land and construction of the buildings prior to its official opening on June 21, 1997. Over the years, he has assisted with site and building maintenance and, despite the distance from home, has also been present for the Annual SCO BBQ and occasionally for member observing nights.

Paul volunteers at the annual *Dark-Sky Weekend (DSW)* hosted by Kejimkujik National Park and National Historic Site (the Park's most popular outreach program) and has been involved in the DSW planning and implementation.

Service to the RASC New Brunswick Centre

He was an active member with the RASC New Brunswick Centre (2004-2011). He led and coordinated By-Law revisions to have the Moncton Centre name changed to New Brunswick Centre – Centre du Nouveau Brunswick. He also served as Editor of their newsletter *Horizon* 2008-2010. He was the National Council Representative for New Brunswick Centre. He also served on their Council for four years. While there, he successfully led efforts to achieve Dark-Sky Preserve (DSP) designation for both Mount Carleton Provincial & Kouchibouguac National Park (2009) and Fundy National Park (2011). He promoted and organized their star parties at Mactaquac Provincial Park.

Service to the RASC

Paul has always been a strong supporter of the RASC. His interest in observing is exemplified in his RASC national involvement for more than two decades. He was the Editor of the *RASC Observer's Calendar* in 2012-2022. With a special interest in E.E. Barnard's Dark Nebulae, he has contributed the section *Dark Nebulae* in the *RASC Observer's Handbook* since 2004 – 22 editions! He and co-author Don Kelly had their article regarding New Brunswick Centre's grant report published in JRASC in the June 2008 edition.

In addition to contributions to the Society's publications, he took on administrative roles as outlined in his Service Award nomination, serving as a Board Director and as a member of the Board Pilot Committee, acting as the liaison to the Observing Committee then chairing it, and serving on several committees (Observing, Publications). In 2013, he served on the RASC Board of Directors.

While in New Brunswick, he served as Chair of the 2010 RASC New Brunswick GA Committee where his drive and experience was responsible for the highly successful GA. His energy and drive were shown again when he served on the GA Advisory Group and acted as Treasurer for the 2015 Halifax GA.

Summary

For almost four decades, Paul has been an educator to many RASC members and non-members, a mentor to youth interested in astronomy and to novice amateur astronomers and a firm believer in the goals and mission of the RASC.

Instead of promoting just the better-known aspects of astronomy, he chose to focus on meteors and meteor showers, planets, and dark nebula – to have an "oh wow" moment watching a fireworks-like display, to observe changing planetary appearance through the seasons (and their moons), and the latter to inspire members to look for, to understand, and to be in awe of these supposed empty spaces in our night skies.

We the undersigned, nominate Paul Gray for the designation *Fellow of The Royal Astronomical Society of Canada (FRASC).* The RASC Halifax Centre is very proud to have him as one of our members.

Respectfully Submitted,

Judy Black, Secretary, RASC Halifax Centre
Mary Lou Whitehorne, FRASC
James Edgar, FRASC / Editor *Observer's Handbook* / Associate Member RASC Halifax Centre
Dave Chapman, FRASC
Patrick Kelly, FRASC
Board of Directors, RASC Halifax Centre

* * *

Paul Gray Nomination for 2016 Service Award
(see rasc.ca/sites/default/files/Service%20Awards%202016.pdf)

Qilak Award

Geoff Robertson, Edmonton Centre

Geoff has performed in many roles throughout his RASC, Edmonton Centre, including Vice-President, President, Observatory Committee Chair, and Public Education director to name a few. His most recognizable contribution has been conducting the "What's Up Over Edmonton" program. Geoff spent an enormous amount of time putting together an outstanding 1-hour educational session for members and the general public. All sessions eventually being posted on the Edmonton Centre YouTube Channel. Each with hundreds of views.

The amount of time and effort it took to put this program together is nothing short of remarkable. After several years of providing this wonderful service, Geoff has decided to hang it up after December 4, 2024.

We think the Qilak Award is an excellent award recognizing Geoff's contribution to the RASC as well as Astronomy Public Education.

Jay Lavender (President) and Tom Owen (Past President)
Edmonton Centre

Service Award

Chris Beckett, Kitchener-Waterloo Centre

Preamble

The undersigned hereby nominate RASC member Chris Beckett, for the distinction of an RASC Service Award, in recognition for his long and steadfast service to the RASC. This includes his service as National Council Representative for two Centres, President of RASC Regina Centre, Chair of the RASC Observing Committee, Editor of the RASC *Observer's Calendar*, contributor to the RASC Observer's Handbook, membership of several RASC committees, participation in the Dark-Sky Program, and countless episodes of volunteer outreach. The Service Award is a major award of the Society given to a member in recognition of outstanding service, rendered over an extended period of time, where such service has had a major impact on the work of the Society and/or of a Centre of the Society. To be eligible for the Award, a recipient must:

- Be a member in good standing.
- Have rendered substantial service of a well-defined nature to the Society and/or a Centre over a period of at least ten years. Such service should have had a major, constructive impact and would involve a very substantial and continued commitment on the part of the nominee.
- Not have received a Service Award before.

Membership

- Chris Beckett joined RASC Halifax Centre in September 2002. Subsequently, he became a member of both RASC Regina Centre and RASC Kitchener-Waterloo Centre. The year 2025 will mark his 23rd year of continuous RASC membership. He has been an active member of the RASC at the Centre and National level throughout that time.

Leadership and Representation

- Chris served as NC Representative for both KW (2006–08) and Regina (2009–12).
- President of Regina Centre (2013–14).

- Chair of the RASC Observing Committee (2009-13) and is a long-standing committee member.
- Member of the RASC History Committee since 2016.
- Member of informal Committee Chairs group that developed RASC programs for the 2012 Transit of Venus.

RASC Publications

- *Observer's Calendar*—Chris has been Editor of the Calendar since 2023.
- Observer's Handbook—contributed Wide-Field Wonders since 2013 and Feature Star Field (with Randall Rosenfeld) since 2014.
- Journal—Contributing Editor (Observing Tips) 2018–24.
- Editorial Board—a member since 2023.

Outreach and Presentations

- Chris (with others) helped establish the Dark-Sky Preserve at Grasslands National Park in 2009 and regularly leads night sky activities there.
- Since 2020 Chris has co-hosted (with Shane Ludke) the Actual Astronomy audio podcast, numbering over 460 episodes, engaging amateur astronomers around the globe.
- Chris is a long-standing astronomy instructor at the Lifelong Learning Centre at the University of Regina.
- Chris is an accomplished and effective speaker who has presented at multiple General Assemblies, Centre meetings, and star parties.

Impact

Chris Beckett is enthusiastic about visual observing and has devoted much of his volunteer time both inside and outside RASC inspiring observers of all experience levels to explore the night sky. He is one of a few RASC members whose service spans multiple Centres and Committees of the National Society, people who are often overlooked when individual Centres consider Service Award nominations. The undersigned nominators reflect a broad base of support from across Canada for his Service Award.

A RASC Service Award for Chris Beckett is long overdue!

Respectfully Submitted:

Dave Chapman, FRASC (Halifax)
Paul Gray (Halifax)
Clark Muir (KW)
Randall Rosenfeld, FRASC (National)
James Edgar, FRASC (Regina)
Bill Weir (Victoria)

*but currently a resident of Regina.

David Lee, Victoria Centre

In the dictionary the word service means "an act of helpful activity." The National RASC Service Award is given to a member who has made a significant contribution to the life and vitality of the Society over an extended period. The RASC Victoria Centre cannot think of a better statement that defines our member of long standing, David Lee, and we are pleased to put forward this nomination for 2024/2025.

David became a member of the Society in 1993. Since then, he has been involved in every aspect of the Victoria Centre: leadership, mentorship, management, innovation, and technical wizardry. Wherever and when ever there is a need for someone to help with a special event, a local program or to work through a problem, David is there for us. David is a true Renaissance person. His interests lie, just as examples, in art, photography, graphic design, audio and video production, IT, project management, data analysis, adult education and, of course, astronomy. In his former life, before retirement, he worked for the BC Provincial Government at the beginnings of the IT movement, honing many skills that we now use much to our advantage.

We could list off the tasks he has taken on for the Victoria Centre, but it would fill paragraphs. In his earlier years with the Centre, he took on the roles of Secretary, President, and then our Representative on the National Council for several years. David was also the Centre's webmaster when the Victoria Freenet was started in the 1990s. Three decades later he is on Council again, instrumental as part of the technical committee and a committed Member at Large.

He was involved in the initial planning and setting up our Victoria Centre Observatory, has trained and mentored many new observers, and has recently supported the regeneration of our newest equipment on the site, providing leadership with the computer and software configuration.

He has been active in photography for many years and quickly adopted astrophotography to his repertoire. You can see many of his stunning photos on the Victoria Zenfolio site. He particularly enjoys widefield and landscape imaging but will also be found with his trusty telescope and camera out at any hour to catch a conjunction, an occultation or the first sighting of a comet. He is (impatiently) waiting to capture the brightening of the recurrent nova, T Coronae Borealis. We can depend on him to get images the rest of us can only wish for.

He has been the lead on many events and projects over the decades: International Astronomy Days, Annual Star Parties, our Victoria Regional Lighting Survey, and hosting Astro Café's. During the pandemic David suggested starting up Special Interest Groups, or SIGS, for Beginners, for Makers, Citizen Science and Astrophotography and then went ahead and made them all happen. He is presently guiding us through some website and Google Drive renewal. In fact, it is difficult to think of a program or activity that he is not involved with and providing a leading role in our Centre.

David was regularly active at the beginning of the New Observer's to Visual Astronomy programme (NOVA) at the National level and has been a constant source of support for its development and launch in the near future.

He has been a faithful volunteer up at the Dominion Astrophysical Observatory for many years and supports the visitors and the Friends of the DAO by helping with telescopes, audio, and visual production, and making presentations.

The Victoria Centre honoured him with our most coveted prize, the Newton-Ball award, back in 2007, and he has many certificates of thanks and appreciation in the years since but we feel that he needs much more recognition now for his three decades of service.

David is a positive force for our organization and radiates enthusiasm as he so willingly shares his knowledge and skills with others. We are so lucky to have David Lee as a Victoria Centre member and are proud to put his name forward for the National Service Award with the RASC.

Submitted by

Lauri Roche and Chris Gainor (Victoria)

Robert Lenz, Niagara Centre

Robert Lenz joined the Niagara Centre in 1987. Not content to sit on the sidelines, Rob got involved quickly, becoming a Director in 1988. In the early '90s, he also became the Observer's Group chair, a position he held for a decade. He has made several submissions to the Niagara *Whirlpool*, the club newsletter. He was also quick to volunteer on special projects, such as building the Niagara Centre's observatories.

Rob has contributed to the club in many ways over the years, but he has been outstanding in Community Outreach. You can always count on Rob showing up at a public event with one of his telescopes, engaging and educating adults and children. He never stops promoting the Niagara Centre and the science of astronomy.

Rob is an accomplished astrophotographer and he loves camping. He has been going to Starfest since its inception.

Submitted by

Robert Lewis and Stan Sammy (Niagara)

Dennis Lyons, Winnipeg Centre

Dennis has been a long-time member of the Winnipeg Centre, and has served on the Centre's Council for many years, most recently for two terms as President of the Centre, agreeing to stay on an extra term to complete the renewal of the Centre's Bylaws and incorporation as a not-for-profit corporation in the province of Manitoba. In addition to hosting regular meetings and handling his Council duties, Dennis is active in Centre outreach and is always there with a scope and a smile at public events. Dennis has served as Winnipeg Centre's National Representative for several years, and it was in part due to his diligence and probing questions that the Society's financial issues were brought into the light to be faced. Despite splitting his work time between Winnipeg and various locations in British Columbia, he manages to keep Council on task, spearheading a major revision to the Bylaws; Incorporation; administration of funding for flood damage to the Centre's Glenlea Observatory; a revamp of the Observatory Committee; assisting in the creation of a new Dark Sky Preserve in Manitoba (with a second on the way); and many other tasks which often go unnoticed.

Submitted by

Scott D. Young and Judy Anderson (Winnipeg)

Simon Newcomb Award

Betty Robinson, Mississauaga Centre

Betty Robinson has dedicated her career to spreading scientific knowledge, particularly the science of astronomy. As a professional educational science editor and writer, Betty has worked on many publications on astronomy for major educational publishers. She is also writing a series of STEM books for girls, following the adventures of a young science enthusiast named Elizabeth—two of which are about astronomy.

Betty's most recent Elizabeth book was about the 2024 April 8, total solar eclipse: *Elizabeth's First Total Solar Eclipse*. In addition to informing readers about what happens during an eclipse, this book focused on the eclipse path through Canada. Betty also wrote *Elizabeth's Guide to Watching a Total Solar Eclipse*, which is a free handbook describing how anyone can be a citizen scientist and make real scientific observations and data recordings during a total solar eclipse. *Elizabeth's First Total Solar Eclipse* quickly sold out on the RASC's online shop. Her first Elizabeth book was about the technology that has to be in place in order for people to visit *Mars: Elizabeth Goes to Mars!*

When the Province of Ontario issued a new science curriculum in 2022, Nelson Education contracted Betty to write the Ontario Grade 6 Space unit for their Edwin platform, as well as the Alberta Grades 4, 5, and 6 Space units.

Betty has also written two science readers for Rubicon Publishing: Earth's Patterns and Space and *Waves and Information*. In her role as a skilled book editor, Betty has helped many other writers clearly explain scientific concepts to their readers.

For all of the above, especially for *Elizabeth's First Total Solar Eclipse* and the free eclipse handbook, we nominate Betty R. Robinson for the 2025 Simon Newcomb Award.

Nominated by

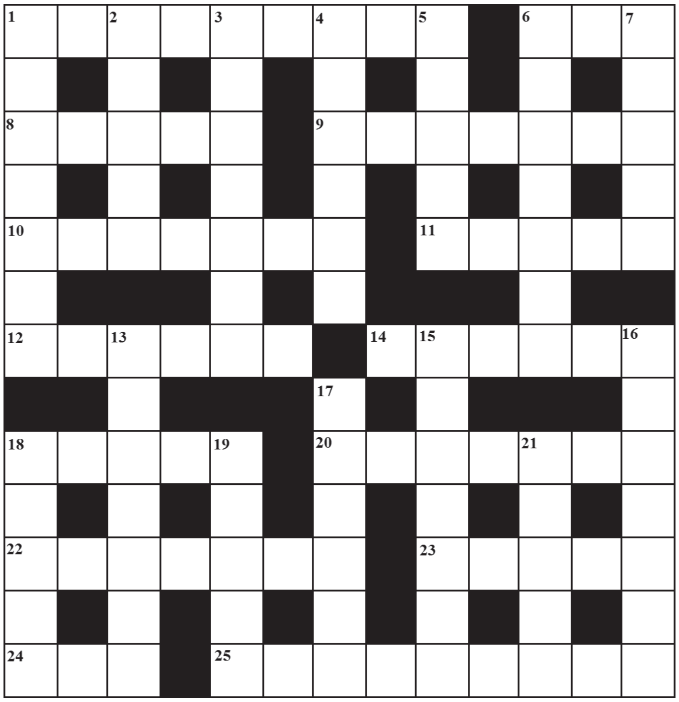
Chris Gainor and Lauri Roche (Victoria) ✶

The August 2025 *Journal* deadline for submissions is 2025 June 1.

See the published schedule at rasc.ca/sites/default/files/jrascschedule2025.pdf

Astrocryptic

by Curt Nason (nasonc@nbnet.nb.ca)



ACROSS

1. Science of a stray moon gone astray (9)
6. After-party drink brewed around Neptune (3)
8. What cows do during a near-occultation (5)
9. Greek character clears away November highlights (7)
10. Dragon's eye on ant swimming in ebbing river (7)
11. German planet finder not French as reported (5)
12. Venerable time for highlights of Perseus (6)
14. Ms. Martin's friendly stars are nominally at harm (6)
18. Arrive on time to see unusually hairy star (5)
20. Bad actor follows regressive company to a salty crater (7)
22. With it stuck in his brain, John Herschel returned to his homeland (7)
23. Baily spun no beads on Martian highlands (5)
24. Where one might kneel in the sky or in Paraguay (3)
25. Opposers of erotic message arise from an equatorial constellation (9)

DOWN

1. Leonine binary resembles a bagel I once ate (7)
2. In the end, solar TRACE makes ET an expanse of land (5)
3. Stormy lunar region from Uranus (7)
4. A short month led to years in France and deep celestial south (6)
5. 19th century solar astronomer was no guy to mess with (5)
6. Huey, Dewey or Louie bought an apochromat (7)
7. Galileo's ear rings of Saturn (5)
13. Disruptive egoism with a part of the little dog (7)
15. Everyone returns after a bad case from the teapot base (7)
16. Oddly, Mars is a reason for extinction at lower altitudes (7)
17. Helical messenger eaten by sly critter in a celestial hot spot (7)
18. Company supporter with head in Schrüter's Valley (5)
19. Salty drops of St. Lawrence in a summer shower (5)
20. Brightest of the lion's hide, a small bird eats a sailor (5)

Answers to previous puzzle

Across: **1** LITTROW (2 def); **5** TYLER (T+anag); **8** CETUS (2 def); **9** RHODIUM (RH+odium); **10** SANDAGE (S(and) age); **11** EAGLE (2 def); **12** ICARUS (2 def); **14** PULSAR (anag+r); **17** MENSA (anag); **19** OPHELIA (anags); **21** LITHIUM (2 def); **22** DABIH (anag-d+d); **23** SODOM (anag); **24** LASSELL (hidden)

Down: **1** LACUS HIEMALIS (anag); ***2*** TITANIA (anag); **3** RASTA (anag); **4** WERNER (an(RN)ag); **5** THOREAU (Thor+eau); **6** LYING (L(Y)ing); **7** RIMAE ARZACHEL (anags+a); **13** URANIUM (2 def); **15** SOLUBLE (sol+anag); **16** HOMMEL (2 def); **18** NOTED (no Ted); **20** HADES

The Royal Astronomical Society of Canada

Vision

To be Canada's premier organization of amateur and professional astronomers, promoting astronomy to all.

Mission

To enhance understanding of and inspire curiosity about the Universe, through public outreach, education, and support for astronomical research.

Values

- Sharing knowledge and experience
- Collaboration and fellowship
- Enrichment of our community through diversity
- Discovery through the scientific method

Great Images

By Shelley Jackson

This lunar eclipse clock was taken by Shelley Jackson under Bortle 4 skies in Athens, Ontario, who says the March 13-14 lunar eclipse was one of the best lunar eclipses she's seen visually. "I chose to use an image of the full Worm Mineral Moon as the centre, which I took well before the eclipse started. The outer images are various phases of the eclipse with full moon at midnight and the deepest part of totality at 6:00. She used an Askar V at 80mm with a flattener - FL 495mm with a 50-mm guide scope, ZWO 120 mono guide camera on a Sky-Watcher EQ6-R pro mount and a Player one Poseidon CMOS camera. Stacked with Autostakkert! With all processing and editing done with PixInsight.

Journal

A final image of the March 13-14 lunar eclipse taken by Steve Leonard. He did a lot of work on the individual elements, including the eclipsed moon, the stars and the glow. Steve explains: "These three images — the lunar disc, starfield, and outer glow—were then carefully composited using masking techniques to preserve both spatial accuracy and crisp detail. I also took steps to faithfully retain the true colour of the Moon." He took the image from Markham, Ontario, under Bortle 8/9 skies using and Astro-Tech AT115EDT on an EQ6-R mount using a ZWO ASI 1600MM Pro camera and Astrodon RGB filters. He used SharpCap for capture and AutoStakkert! For wavelets, and PixInsight for stacking and masking.