The Journal of The Royal Astronomical Society of Canada

Journal

Le Journal de la Société royale d'astronomie du Canada

PROMOTING ASTRONOMY IN CANADA

August/août 2026
Volume/volume 120
Number/numéro 4 [839]

Inside this issue:

Building My Remote Observatory

Surprises under a Namibian Sky

Variable Nebula NGC 2261

The Lion Nebula

Great Images

By Ryan Génier

Ryan writes: We had a wonderful stretch of clear weather in southern Ontario at the end of August, so I wanted to take advantage of this with a deep integration on a new target. (Génier MWP1 and ALV1) The area between Cygnus and Cassiopeia is rising clearly for me this time of year, which allowed several nights of uninterrupted imaging without having to bounce between targets.

This is a new target for me, and I wasn't sure how it would look with the low focal length of the RASA, coupled with being in the city. It took several nights of shooting each Ha/OIII for the details to really start to show up, but I'm very happy with everything that I was able to capture.

It is amazing to me that I'm able to image something so clearly that was only discovered (relatively) recently (or in the case of ALV1, very recently!).

Compared to the busyness that is Cygnus, this area of the sky is a relative void.

Details:

This is a standard HOO combination, with some tweaking to the colours to pull out the lovely purples. Lately I've been doing all of my stacking and linear processing using PixInsight, then moving over to Affinity Photo to do the non-linear adjustments. Back into PixInsight for a final tweak and resample.

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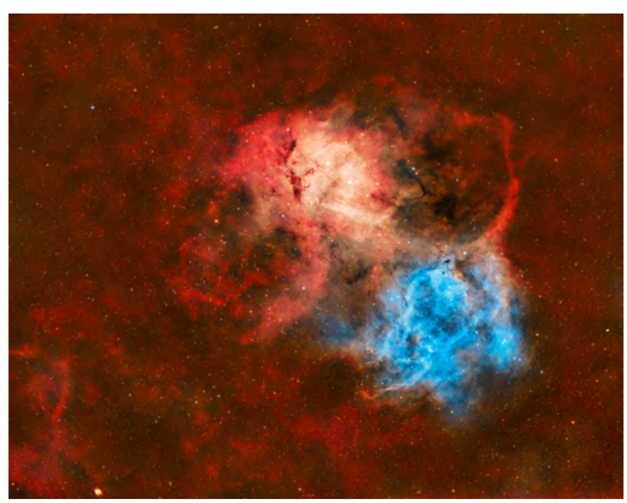
contents / table des matières



Tammy Foley captured this stunning image of Sh-132, a bright emission nebula found in Cepheus. Tammy says, "It is 'focal length friendly' and has plenty to offer in terms of details and dust! It also contains two Wolf-Rayet stars, which are big and very hot." She used a Redcat 51, 183-MC Pro, L-Extreme/L-Pro filters, a CEM70 mount, 30mm f/4 with a ZWO 120mm guide scope, 5-position filter wheel and controlled by N.I.N.A. All processing was done in PixInsight. The 73.51-hour image was captured in July and August 2024 from her Bortle 5 home in Norfolk County, Ontario

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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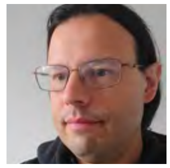
President's Corner



The SummerSolstice andthe Moon

Brendon Roy (Thunder Bay), President
novationheart@hotmail.com

The summer solstice has passed, the days are getting shorter. But the summer solstice is one of my favourite times of year for observing. Before I get into the full reason why, perhaps I should talk a little about the mechanics of what is happening.

For most of my readers, this is information that was likely learned early in school. However, I always like to start with the basics to make sure everyone is following along and doesn't miss out. That is the outreach person in me coming through. I find it is often the best way to clear up misconceptions people may have about things they learned long ago.

The first thing to understand is that Earth is tilted on its axis by about 23.5 degrees. This tilt, combined with the Earth's orbit around the Sun, gives us our seasons. During the Northern Hemisphere's summer solstice, the Earth is tilted toward the Sun, while during the winter solstice it is tilted away from the Sun. One common misconception is that the Earth somehow "flops" back and forth on its axis throughout the year. A simple visual demonstration is often enough to show why this isn't the case.

During the June solstice, the days grow longer, but not equally for everyone. The farther north you go, the longer the daylight becomes. Someone standing at Canada's northernmost point will experience a much longer day than someone at its southernmost point. Or, to put it in a fun way, Canadians driving north at this time of year are literally driving toward more sunlight.

For me, this is where the fun begins. Although the short nights are not ideal for astronomy in general, there are two things I particularly enjoy about this time of year.

First, the short nights make it much easier to truthfully claim that I stayed out all night observing—from sunset to sunrise.

Second, because one of my favourite dark-sky sites is north of where I live, I get to experience an interesting quirk of geography and astronomy. On or near the solstice, the boundary of true night ends between my home and my observing site. I can leave home under a truly dark sky and arrive at my observing location under continuous astronomical twilight. In other words, it can be nighttime at my house and twilight at my dark-sky site. Every year, I find myself amused by this.

This year there was a waxing gibbous Moon on the solstice, and I couldn't help but think of another group of people who recently made a journey to that celestial body. Of course, I am referring to the crew of Artemis II, the first crewed mission to travel to the Moon in my lifetime.

I streamed the entire mission, from liftoff to splashdown, and was impressed by how successful it was. For a mission that accomplished so many historic firsts, it seems fitting that one of the few issues encountered involved the onboard toilet. Once again, this is the outreach person in me addressing one of the first questions people often ask about traveling in space: bathroom breaks. A broken toilet on Earth is an inconvenience; out there, it is a real problem (absolutely relatable to all of us), just like many others that are unique to human space exploration.

Unlike the Apollo missions, modern communications technology allowed us to be virtually along for the ride. We received updates in near real time, watched the crew's closest approach to the Moon, followed their return to Earth, and even saw the astronauts work through challenges as they arose.

Artemis II has paved the way for the missions that will follow. For those of us who believe in the value of exploration, discovery, and pushing the boundaries of human achievement, it is important that we continue to support these efforts as humanity returns to the Moon.

Dream! Do! Support! We will get there! ✶

News Notes / En manchette

Compiled by Jay Anderson

Something hidden lurks nearby

Primordial black holes are hypothetical objects that formed during the period of inflation before the Big Bang from extremely dense collections of matter that were compressed to such an extent that they collapsed into a black hole. These black holes were initiated without the typical compression created within a supernova. In fact, they were created before the first stars had formed and were not subject to the same stellar mass limits that prevail in our current Universe. Some researchers have proposed primordial black holes as an explanation for dark matter.

These are strange beasts, at least in the theoretical world. They may have asteroidal masses compressed into the size of a hydrogen atom, flowing through the Universe with a range of velocities. The fastest could pass through a star without a significant effect, while slower ones could be captured into a star. Stephen Hawking suggested that our Sun might harbour one. A separate estimate suggests that the Solar System contains at least one primordial black hole at any given time.

Now a research team led by Renee Key from the Centre for Astrophysics and Supercomputing at Swinburne University of Technology, Melbourne, reports the detection of an object that they identify as most likely a small black hole lurking in the Milky Way's dark matter halo. Nicknamed Phoebe, the object was found in December 2019 during a search for microlensing events toward the Large Magellanic Cloud (LMC) using the Cerro Tololo Blanco 4-metre telescope in Chile over a five-night period. Microlensing occurs when a small but dense foreground object passes in front of a star, causing it to brighten by gravitational focusing over a period of time that can range from seconds to years.

On the fourth night, the team observed the brightening of a star that exhibited the typical signature of microlensing amplification: a smooth, symmetric curve that brightened approximately 0.12 magnitudes on one night with the remaining nights during the survey free from variability. Phoebe's effect on the microlensed star was to raise its magnitude from about 26.04 to 25.92 over a 1-hour period. None of the other nights showed a similar variation in magnitude as that of the Phoebe star and comparison stars nearby maintained a largely unchanging brightness.

The astronomers tested several alternative explanations: Contamination of the signal from nearby stars; the influence of a star hidden in the background; from flares on the Phoebe star, and variability in the Phoebe star. None were able to satisfactorily explain the observation.

Alternatively, the team advanced three other possible explanations for such an event: passage of a free-floating planet in our galaxy, the same, but in the LMC, or a small black hole, all moving through the line-of-sight toward the star. The length of the event, only 60 minutes, is significant, as the duration of a microlensing event is proportional to the mass (and size) of the object causing the change in brightness: faster means smaller. Phoebe's 60-minute increase in brightness points to a very low-mass object, only 3 times the mass of the Moon.

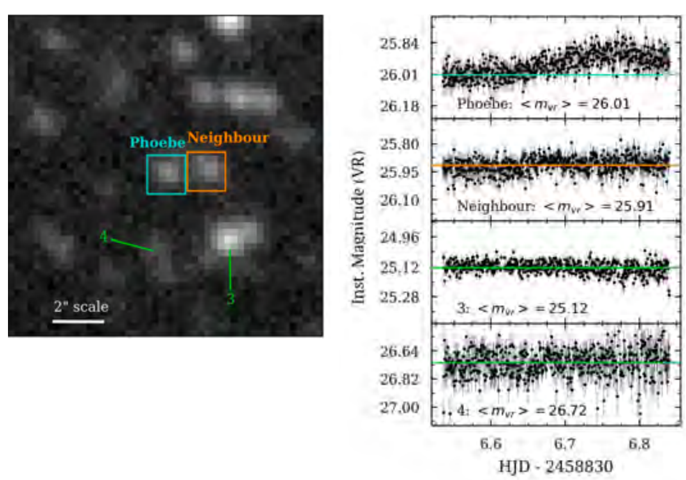


Figure 1 — An image taken at the peak amplification of Phoebe, with light curves showing how its brightness flared when that of neighbouring stars did not. (Key et al. arXiv, 2026)

The team of astronomers suggested one of three possibilities for the lensing object:

- A free-floating planet wandering through the stars of the Milky Way
- A free-floating planet in the Large Magellanic Cloud
- A microscopic primordial black hole

Each of these choices could explain the behaviour of the light curve of Phoebe's star and so the team turned to a statistical probability analysis to identify the most likely explanation. Of the three environments, the sight line through the dark matter halo of our galaxy provided the greatest likelihood of encountering a primordial black hole, by a factor of 100,000. In other words, Phoebe is five orders of magnitude more likely to be embedded in the dark-matter halo and to be a primordial black hole than a free-floating planet. A tiny traveller, crossing the Universe for 13 billion years, may have sent a small clue about the Universe from the Big Bang era.

The identification of a tiny black hole in this study and similar observations in others has implications for the Universe at large as well. Primordial black holes have been proposed as an explanation for dark matter, a hypothesis that could be confirmed with a substantial increase in other, similar discoveries.

Complex new insights in planetary formation

The rotation of a protoplanetary disk (a disk where planets are being formed) has been observed directly for the very first time by mapping the emissions from the dust grains within it. The disk in question surrounds the young star AB Aurigae, a young pre-main-sequence star about 509 light-years from Earth that features "a complex assembly of spiral arms, several compact structures, and a protoplanet candidate, AB Aur b, suggesting ongoing planet formation in this young system." In 2017, the star was found to have a donut-like, dusty disk that hosts two gaseous spiral arms inside the donut cavity.

Although it appears to generally rotate in accordance with Keplerian physics, regions within ~60 au of the star show an unexpected departure from this behaviour. A body of evidence suggests that this anomaly is caused by the presence of multiple protoplanets on elliptical orbits that extend out of the star's plane of rotation, in particular, three compact objects seen in the imagery. The study, led by Anthony Boccaletti and including scientists from the CNRS and the University of Bordeaux, sheds fresh light on the mechanisms of planetary formation and the complex dynamics of protoplanetary disks.

Thanks to the near-infrared capabilities of the SPHERE instrument (Spectro-Polarimetric High-contrast Exoplanet Research) and its exceptional spatial resolution, the team was able to accurately track the disk's structures and their evolution during three sets of observations, collected over a four-year

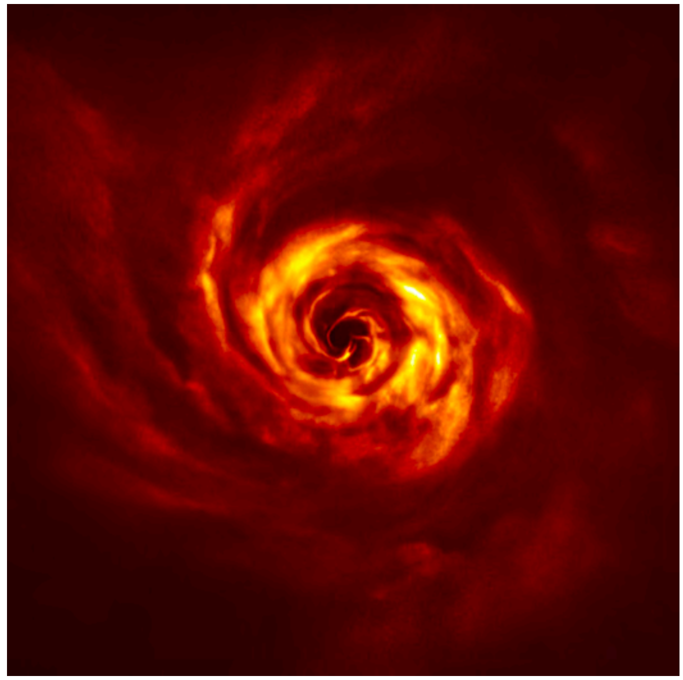


Figure 2 — SPHERE image of the disk around AB Aurigae. Credit: ESO

period. The scientists identified a bright structure, characteristic of accretion zones where gas and dust accumulate and fall onto an object in the process of formation. This phenomenon is closely linked to the formation of gas giant planets. Images of the AB Aurigae disk also reveal the rapid rotation of faint, narrow shadows cast onto its surface by optically dense structures, which could possibly be protoplanets (planets in the process of formation) or opaque clumps of dust orbiting close to the star.

Keplerian rotation beyond the 60-au limit suggest a 2.4 $M_\odot$ mass for AB Aurigae. Slower-than-Keplerian rotation in the central regions of the cavity escapes precise explanation because of complex gravitational interactions between the spiral rings and several mass concentrations, particularly the suspected but unconfirmed presence of a protoplanet AB Aurigae b.

These findings, which are more complex than those predicted by theoretical models, invite follow-up observations and underline the importance of continuing research aimed at directly detecting the properties of the protoplanets or clumps associated with the structures observed in the AB Aurigae disk.

Composed in part with material provided by the Centre national de la recherche scientifique (CNRS)

Iron-60 dust from the Local Interstellar Cloud

Our Sun is located within a hot, nearly empty (~0.3 atoms/ cm^3) cavity in the interstellar medium about 325–650 light-years across, called the Local Bubble. This cavity is the result of 14–20 nearby supernova explosions around 14 million years ago, possibly from fast-evolving stars in the Scorpius-Centaurus Association. Currently, all young stars and star-forming regions within 500 light-years lie within the bubble.

Inside this bubble are approximately 15 small low-density structures known as the Cluster of Local Interstellar Clouds (CLIC)—regions of slightly higher hydrogen abundance. Currently, our Sun and Solar System are near the edge of one (or perhaps two) of these clouds, which were formed around 130 ky ago. It has been estimated that the Sun will exit the cloud, known as the Local Interstellar Cloud (LIC) in the next 2,000–6,000 years.

In its passage through the galaxy, the Earth continuously accumulates iron-60, a rare radioactive isotope of iron produced in large quantities during supernova explosions. Iron-60 is unstable with a half-life of 2.6 million years. If it had been present when the Earth first formed, 4.6 billion years ago, it would have disappeared completely by now, so its presence in sediments indicates a comparatively recent cosmic origin, as there are no naturally occurring terrestrial sources of the isotope. However, if a supernova explosion occurs in the Earth's vicinity—say within a few hundred light-years—its explosive debris can reach us.

In 1999 and 2004, scientists have found evidence of iron-60 in marine sedimentary crusts and in deep-sea sediment cores from the South Pacific. These deep-sea deposits are rich in iron and increase very slowly at the rate of only a few millimetres every million years. This leads to the material being considerably compressed, so that rare substances such as iron-60 are compressed into small volumes, preventing researchers from

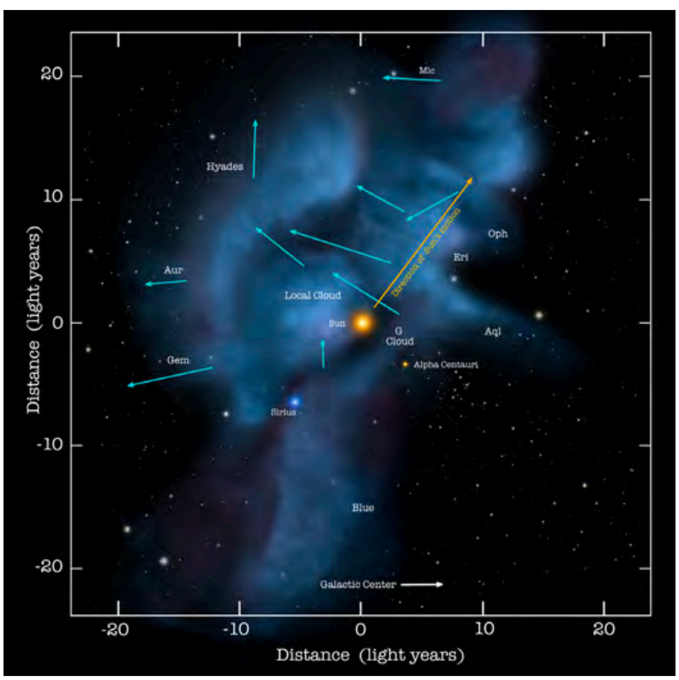


Figure 3 — The Solar System moves through the Local Interstellar Cloud. Image credit: NASA / Adler / University of Chicago / Wesleyan.

precisely determining exactly when the supernovae occurred. To obtain a more detailed record of the iron-60 accumulation, a less-compressed sample was needed.

Now a team led from Helmholtz-Zentrum Dresden-Rossendorf (HZDR) has detected minute traces iron-60 in nearly 295 kg of ice taken from a core drilled in Antartica's Dronning Maud Land as a part of the European Project for Ice Coring in Antarctica (EPICA). The core covered a period of 40–81 ky, covering the time that the Solar System entered the Local Interstellar Cloud. It is a measure of the sensitivity of the process that only 538 iron-60 atoms were collected from the ice sample.

But these few particles were in a class of their own: "Surprisingly, we found not only one peak in the sediment samples within a time span of 1.7 to 3.2 million years ago; there was a second one, taken from new manganese crust samples, in a manganese crust dating from 6.5 to 8.7 million years ago," says Jenny Feige from TU Berlin, who prepared the samples. The temporal breadth was also amazing; it indicates that not only one supernova left its tracks behind, as hitherto assumed—it was rather 2 or 3.

With the aid of computer models, they were able to explain the emergence of the local interstellar bubble. These revealed that, initially, approximately 16 supernovae exploded one after the other in a young star cluster. The explosion clouds then spread out and unified into the bubble we see today. The iron-60 that emerged from the explosions settled on dust particles that were also spread out at high speed through space. After about 100,000 years the iron-60 from the last 2 or 3 supernovae made its way to the Earth's atmosphere, falling to the ground and into the oceans.

Produced with material provided by the Helmholtz Association of German Research Centres/ Thomas Bührke

Longest orbital period exoplanets

An international collaboration of astronomers led by the Universidad de La Laguna (ULL) and Instituto de Astrofísica de Canarias (IAC) has identified two intriguing, humongous but light planets orbiting HD 114082, a star that is only 15 million years old, spins 15 times faster than our Sun, has 28 percent more mass, and is about 1000 degrees hotter and almost 4 times more luminous. Its planets receive about 200 times more light and heat than Jupiter.

The two planets stand out for having the longest orbital periods of the current crop of exoplanets; 225 and 314 days. Planets at this distance—a significant fraction of the Earth's—are difficult to detect using the transit method and serve to illustrate why Earth-type orbits are rare in the pantheon of exoplanets. More than 80 percent of confirmed exoplanets have orbital periods shorter than 50 days, and lie closer to their stars than Mercury does to our Sun.

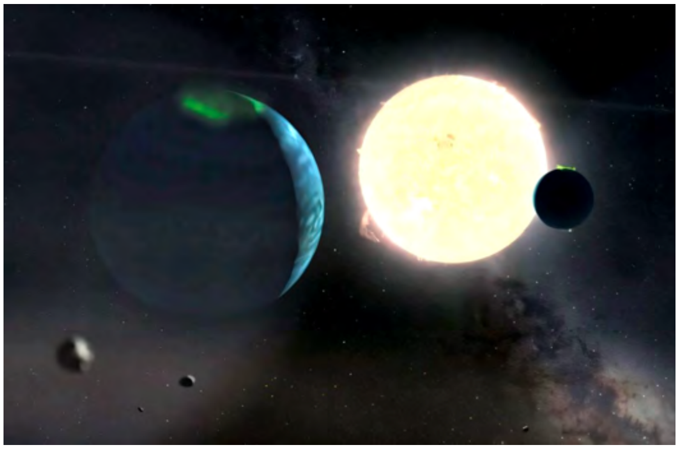


Figure 4 — Artist's rendering of the HD 114082 system. Credit: ESO/S. Brunier

Carlos del Burgo Díaz, Beatriz Galindo Senior distinguished researcher at ULL, details the findings: "We have identified a strange pair of giant exoplanets. They stand out among the youngest detected by passing in front of their star because they take longer to complete an orbit. The inner planet, 20 percent closer to its star than Earth is to the Sun, has Jupiter's size. The outer planet is at the same orbital distance as Earth, and has a radius 36 percent larger than that of Jupiter and a mean density more than 7.5 times less than that of water, so it would float on it." Alejandro Suárez Mascareño (ULL/IAC), coauthor of the paper, adds: "The planets move in almost circular orbits in the same plane, and may be in or near a resonance."

The study uses data taken with the *TESS* (Transiting Exoplanet Survey Satellite) and *CHEOPS* (CHaracterising ExOplanet Satellite) space telescopes, and ground-based facilities including NGTS (Next-Generation Transit Survey; Chile), ASTEP+ (Antarctic Search for Transiting ExoPlanets telescope; Antarctica) and Las CumbresObservatory (LCO). From these observations, stellar light curves were generated that showed four non-consecutive dips of the inner planet HD 114082 b. Every dip or transit is due to the planet passing in front of the star, blocking a small fraction of its light from our point of view. These data enabled the accurate determination of its orbital period: 314 days with a margin of error of 9 percent.

The gravitational pull between the two planets reveals itself through a tug-of-war, which delays or advances the transit of the companion, an effect that is more pronounced the closer these giants are to a resonance and so can be measured even if their masses are small. Carlos del Burgo adds: "Following our discovery, the exoplanet community is expected to join the search for a second transit of the outer planet, which would allow us to pinpoint its period. Once this is achieved, refining the masses of the two planets will require measuring the mid-transit times of several dips for each one. This method could also reveal additional bodies in the system."

These giants formed within the protoplanetary disk, rich in gas and dust, around the star. They first accumulated material until they formed a solid core. When they reached a certain mass, a runaway gas accretion process began and the internal heat generated caused its envelope to expand. The theory suggests that two planets born in close proximity to each other tend to reach similar masses. The measured mass of the outer planet is at most 24 percent of Jupiter's, i.e. 4.4 times Neptune's mass. The planets of HD 114082 could have formed in situ. Or, they formed in a distant, cold region, and migrated to their current orbits, where they receive more light and heat.

Carlos del Burgo explains: "These giants must have influenced the orbits of asteroids and comets closest to the star, arranging them into a belt that lies in the same plane than the planets' orbits." Jonathan Marshall (ASIAA), co-author of the paper, adds: "Whereas the outer ring of icy dust grains and debris, located at a distance 25 percent greater than Neptune's orbit, is inclined with respect to the planetary orbits and likely primordial." ✶

Compiled with material provided by the Instituto de Astrofísica de Canarias

Feature Article / Articles de fond

Building My Remote Observatory at 15: Engineering for Millimagnitude Photometric Precision

by Arushi Nath,Toronto, Ontario

Abstract

At age fifteen, I built and commissioned a remote astronomical observatory at AstroCamp in Nerpio, Spain, to support millimagnitude photometry, asteroid astrometry, asteroid light-curve studies, and exoplanet transit timing. The observatory, now assigned Minor Planet Center code R60, was designed around specific performance requirements: dark skies, stable tracking, repeatable calibration, rapid response to time-sensitive targets, and practical maintainability from Toronto. This article describes the transition from science goals to engineering requirements, the fundraising and logistics that made the project possible, the selection of a dark-sky site, the hardware architecture, collimation and polar alignment, and the operational lessons learned from remote troubleshooting. First results include a seven-night light curve of asteroid (2977) Chivilikhin and accepted ExoClock transit observations contributing to ephemeris refinement for ESA's Ariel mission.

Keywords: remote observatory; photometry; minor planets; exoplanet transits; asteroid light curves; student research; R60

Background

I was four years old when I pressed my eye to the eyepiece of a 14-inch telescope at the Carr Astronomical Observatory in Collingwood, Ontario. Saturn came into view with its rings sharply tilted against the blackness of space. I drew what I saw and wrote about it in my best handwriting. That observation was later published in The Royal Astronomical Society of Canada's *Scope* magazine.

Eleven years later, I operate a research-grade remote observatory on a mountain in southern Spain, about 7000 kilometres from my bedroom in Toronto. The observatory has International Astronomical Union Minor Planet Center observatory code R60. Every asteroid position I submit from it is tied to that code and becomes part of the global astrometric record.

This article describes how I built it: the engineering requirements, fundraising, logistics, site selection, remote troubleshooting, and first science results that turned an idea into a working observatory.

Why I needed my own telescope

Since 2021, most of my observational research had been carried out on borrowed time. I wrote proposals for the Faulkes Telescope Project, the American Association of Variable Star Observers, and the Canadian Space Agency. I coordinated with citizen scientists across four continents. Using shared instruments, I accumulated more than 55 hours of observations of the Didymos binary asteroid system that contributed to a peer-reviewed paper in *The Planetary Science Journal*.

Figure 1 — At age four at the Carr Astronomical Observatory in Collingwood, Ontario, and the Saturn drawing made that night, later published in Toronto Centre's Scope *magazine.*

Criterion	Why it mattered	Nerpio, Spain
Sky darkness	Faint-target signal-to-noise ratio	Bortle 2; SQM about 21.5 mag arcsec^-2
Clear nights	Schedule reliability	About 300 per year
Elevation	Atmospheric stability	About 1650 m
Time zone	Compatibility with school schedule	Six hours ahead of Toronto
Weather automation	Equipment safety	Roof closure on unsafe cloud, humidity, or wind conditions
Supply chain	Minimizing downtime	EU/Spain-based supplier; replacement parts in days
On-site support	Physical intervention from 7000 km away	AstroCamp technical team

Table 1 — Observatory performance requirements

Borrowed telescope time made that work possible, but it also defined the limits of what I could attempt. Sessions were scheduled in fixed windows. Targets were shared. Some of the observations most important to my research, particularly exoplanet transits, require as long as six continuous hours on a specific night. Binary-asteroid and Near-Earth Object windows can be even less forgiving, because the target may be bright enough for only a few days.

I had to choose between adapting my science questions to whatever telescope time was available or building infrastructure that would let me pursue the observations that mattered.

I chose infrastructure.

A backyard observatory in Toronto would not solve the problem. The city sky is extremely bright, and faint-target photometry requires both darkness and consistency. The observatory had to be remote, at a dark-sky site, and robust enough to operate while I was still a full-time high-school student.

From science goals to engineering requirements

Dreams are easy to start. Turning one into hardware requires enthusiasm, time, fundraising, logistics, troubleshooting, and persistence when the plan stops behaving like a plan. I treated the project as my annual Misogi challenge: one genuinely difficult scientific project that would stretch what I knew how to do.

The first step was not choosing a telescope. It was defining what the telescope had to measure. The most demanding requirement was millimagnitude photometry: detecting changes in stellar brightness of about 0.001 magnitudes, or roughly one-tenth of one percent. That precision is useful for measuring exoplanet transit depths, improving mid-transit timings, and modelling asteroid rotation light curves.

Once the science goals were written down, they became engineering requirements. The system needed stable tracking for multi-hour sessions, round stars across the camera field, repeatable calibration frames, rapid response to time-sensitive targets, dark skies, many clear nights, and a supply chain that could recover from component failures in days rather than weeks. I also wanted the observatory to be ready for the coming era of high-volume time-domain astronomy, when surveys such as the Vera C. Rubin Observatory's Legacy Survey of Space and Time will make rapid follow-up observations increasingly valuable.

I built an equipment and cost model around those requirements. Optical design, mount payload margin, camera sensitivity, cooling performance, filter compatibility, power and data reliability, hosting costs, and replacement cycles all had to be considered together. The goal was not a temporary telescope, but a sustainable instrument.

Figure 2 — Building the R60 observatory at AstroCamp: mount installation on a permanent pier, telescope tube attachment, and optical-train integration.

Fundraising and partnerships

Fundraising was one of the most difficult parts of the project. It meant asking people to believe not only in an idea, but in my ability to build and use the instrument responsibly.

I learned that showing previous work is more persuasive than describing future intentions. By the time I began fundraising, I had published research using shared telescopes and had received recognition at the European Union Contest for Young Scientists, the Regeneron International Science and Engineering Fair, and the Canada-Wide Science Fair. That record helped others see the observatory as an extension of work already in progress, not as a speculative wish list.

At one annual meeting, my presentation opened the first door. AstroCamp, a dark-sky hosting site in Spain, offered to hold a reduced-rate space for the observatory. Telescope Ontario offered to donate the imaging camera. Celestron offered a mount for testing. Those early commitments made the project feel possible.

For the remaining funds, I wrote a research proposal to the Masason Foundation in Japan. Preparing the application forced me to explain the scientific goals, the engineering plan, and the budget in detail. After review, the foundation agreed to fund the remote observatory.

Choosing the site: Nerpio, Spain

I evaluated potential hosting locations in Australia, Chile, southern Spain, and the United States. The selected site was AstroCamp in Nerpio, Spain, at an elevation of about 1650 metres. The site offered Bortle 2 skies, a Sky Quality Meter value around 21.5 mag/arcsec^{-2}, and approximately 300 clear nights per year.

Those numbers mattered, but the practical considerations mattered just as much. The site has weather automation that closes the roof in unsafe conditions, and it has an on-site technical team. For a telescope 7000 kilometres away, human support is not a convenience. It is a reliability requirement.

Requirement	Target	Purpose
Photometric precision	0.001 mag	Exoplanet transit depths and reliable asteroid rotation curves
Tracking stability	Sub-arcsecond over multi-hour sessions	Long exoplanet transits without trailing or aperture losses
Optical quality	Round stars across the sensor field	Comparable photometry at the field edge and centre
Calibration repeatability	Reproducible bias, dark, and flat calibration	Night-to-night measurement consistency
Response time	Hours to days from alert to observation	Near-Earth Object follow-up while targets are still bright
Sky darkness	Bortle 2 or better	Higher signal-to-noise ratio on faint targets
Clear nights	About 300 per year	Reliable scheduling for time-critical observations
Spare-parts logistics	Days, not weeks	Reduced downtime after component failure

Table 2 — Site-selection criteria for AstroCamp, Nerpio

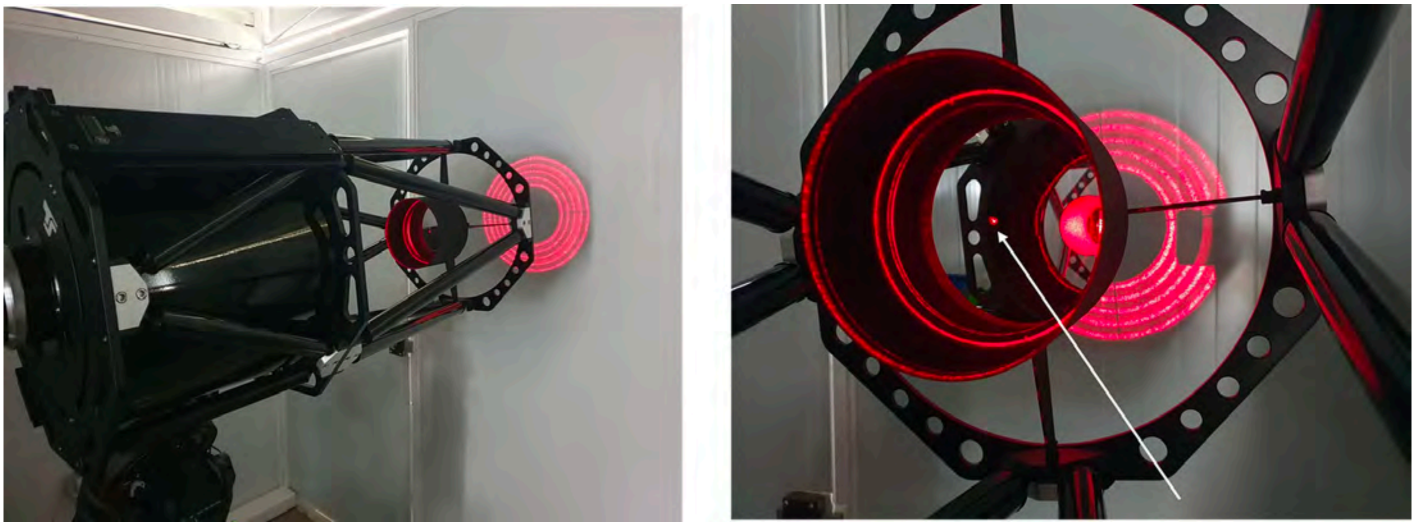


Figure 3 — Laser-ring collimation of the Ritchey-Chrétien telescope, showing the alignment pattern before and after adjustment.

Supply-chain geography also affected the decision. Sourcing equipment from a Spain-based vendor reduced customs risk and meant replacement parts could reach the site within days. I did not fully appreciate how important that would become until later, when a single loose screw reminded me how physical a remote observatory still is.

The time zone was another advantage. Spain is six hours ahead of Toronto, which allows me to start evening sessions after school, check early diagnostics remotely, and analyze the data the next morning. The site had to fit not only the sky, but also the practical schedule of a student.

Hardware architecture

The instrument was designed to be reliable, modular, and interoperable. Every component was selected for its role in producing repeatable photometry rather than simply for impressive specifications.

The telescope is a 12-inch f/6 Ritchey-Chrétien Cassegrain. This optical design is widely used for research imaging because it controls off-axis coma, an important consideration when photometric measurements must remain reliable across the sensor field. In practice, star shape at the edge of the image matters almost as much as star shape at the centre: elongated or asymmetric stars can introduce systematic errors into aperture photometry.

The mount is a Sky-Watcher EQ8-R Pro equatorial mount. I chose it for its payload margin and for its ability to support guided, multi-hour observations without operating close to its mechanical limits. For millimagnitude photometry, the mount is not just a pointing device. It is part of the measurement system.

The imaging camera is a cooled monochrome ZWO ASI2600MM. A monochrome sensor avoids the light loss and colour-sampling complications of a Bayer matrix, and active cooling suppresses thermal dark current. Stable temperature control is essential for dark-frame calibration and for comparing measurements taken on different nights.

For guiding, I use an off-axis guider with *PHD2*. A separate guide telescope can introduce flexure, in which the guide scope and science telescope move slightly differently. An off-axis guider samples light from the same optical path as the science camera, reducing that source of error. The guide camera measures a star's position and sends corrections to the mount during long exposures.

The control computer is a PrimaLuceLab EAGLE 6 Pro. It integrates the Windows computer, USB ports, and power distribution into a single unit, reducing cabling complexity and the number of connection points that can fail. During installation, however, I noticed that the EAGLE was producing enough heat to be a concern near the optical tube, so it was moved to the tripod to reduce thermal effects near the mirrors.

Vendor selection and logistics

Designing the system on paper was only the first part of the project. Turning it into hardware required vendor comparisons, warranty checks, compatibility reviews, and shipping coordination. I requested quotes from multiple European suppliers and compared price, availability, support, and proximity to the host site.

I selected Valkanik, a Spain-based astronomy supplier. The company was competitive on price and, just as importantly, was relatively close to AstroCamp. Buying within Spain avoided import duties and reduced the chance that an essential component would be delayed in customs.

Shipping astronomical equipment is not trivial. Mirrors, cameras, filter wheels, mounts, and electronics each have

Figure 4 — A three-minute unguided exposure of the Eagle Nebula (M16), used to evaluate tracking and star-shape performance.

different handling risks. Delivery had to be sequenced so that the on-site team could assemble and test the observatory during the installation window. If one small adapter had been missing, the whole schedule could have shifted.

By this stage, the project felt less like a telescope purchase and more like systems engineering. The instrument would only work if the optical, mechanical, electronic, software, and logistical parts all worked together.

Assembly, collimation, polar alignment, and calibration

Physical assembly took place at AstroCamp on 2025 March 18 with the on-site team. Three steps determined whether the system would produce useful scientific data: collimation, polar alignment, and calibration.

A Ritchey-Chrétien telescope is very sensitive to mirror alignment. A small tilt or decentring of the secondary mirror can produce asymmetric star profiles, which then affect photometric measurements. I used a laser-ring method in which a collimation laser projects concentric rings onto the optical system. The secondary mirror tilt is adjusted iteratively until the rings are centred. Defocused star images provide a practical check: an irregular, off-centre pattern becomes a symmetric ring when alignment improves.

Polar alignment was equally important. An equatorial mount must have its rotation axis aligned with the celestial pole. The first alignment reached arcminute-level accuracy, enough for short snapshots but not for longer exposures. A later alignment using a three-point TPoint routine in *TheSkyX* brought the system to arcsecond-level accuracy. With that improvement, the telescope could record three-minute unguided exposures with round stars, and guided sessions could continue for many hours.

The final step was building a repeatable calibration pipeline. A raw astronomical image is not science data. It contains read-out structure from the camera electronics, thermal signal and hot pixels, vignetting, and dust shadows. For a typical session I use bias frames, dark frames, and flat frames to remove these systematics before performing photometry.

Remote troubleshooting: the loose-screw lesson

From 7000 kilometres away, a physical failure can look exactly like a software failure. I learned this during a guiding problem that seemed, at first, to be a configuration issue.

Figure 5 — Example bias, dark, and flat calibration frames used to remove camera and optical systematics from science images.

Figure 6 — Camera adapter coupling where a loose screw caused micro-vibrations and uncorrectable guiding drift.

During one session, the guiding system repeatedly reported that it could not make sufficient corrections to hold the target. I recalibrated the guiding algorithm, rechecked polar alignment through software, and inspected every setting I could reach remotely. Hours passed and nothing improved.

The on-site team then performed a physical inspection and found a single loose screw in the camera adapter coupling. It was causing micro-vibrations: too small to identify easily in the science images, but large enough for the guide camera to detect as uncorrectable drift. A few seconds with a screwdriver solved what hours of remote debugging could not.

The lesson changed how I operate the observatory. Remote systems need diagnostic procedures that begin with physical possibilities, not procedures that turn to them only at the end. I now use a pre-session checklist that includes physical verification steps with the on-site team before deeper software troubleshooting begins.

First light and observatory code R60

First light occurred on 2025 June 12. The target was the Eagle Nebula, not because it was the main science target, but because it provided a useful field for evaluating tracking stability and star shape. The cooling system stabilized below 0 °C as expected, and calibrated images showed round stars across the 26-megapixel sensor.

The next major step was receiving an official Minor Planet Center observatory code. To obtain it, I submitted astrometric measurements of more than 10 Near-Earth Asteroids, each observed on at least two nights with multiple images per session, together with instrumentation details for verification.

Code R60 marked the transition from building infrastructure to contributing data. Asteroid positions measured from the observatory could now be submitted under an official site code and used in the same global system that professional and advanced amateur observatories support.

First science results

The first extended campaign targeted main-belt asteroid (2977) Chivilikhin. Over 7 nights, I obtained 25 hours of photometry. As the irregular asteroid rotated, its brightness changed because different facets reflected different amounts of sunlight. Combining the measurements produced a rotation period of 6.257 ± 0.001 hours and a light-curve amplitude of 1.030 magnitudes, fitted with a fourth-order Fourier model. The data have been submitted to the Asteroid Lightcurve Database format.

The observatory also began contributing exoplanet transit observations to the ExoClock Project in support of the European Space Agency's *Ariel* mission. Three transit observations were accepted and published by ExoClock: KELT-12b on 2025 July 7, with a transit signal-to-noise ratio of 13.43 and a mid-transit timing O-C of 2.39 ± 3.02 minutes; WASP-59b on 2025 August 4, with a signal-to-noise ratio of 38.61 and O-C of 2.47 ± 0.79 minutes; and KELT-16b on 2025 August 8, with a signal-to-noise ratio of 15.01 and O-C of –1.92 ± 1.35 minutes.

These measurements help refine ephemerides so that future space-based observations can be scheduled accurately.

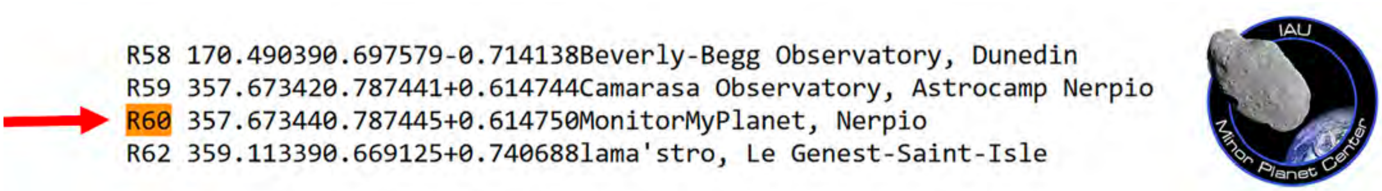


Figure 7 — R60 - MonitorMyPlanet, Nerpio, in the Minor Planet Center observatory-code listing.

Frame type	Typical count	Exposure type	Corrects
Bias	60	Near-zero exposure	Read-out pattern and camera electronics offset
Dark	60	Same exposure and temperature as science images	Thermal signal and hot pixels
Flat	40	Evenly illuminated short exposures	Vignetting and dust shadows

Table 3 — Calibration-frame plan

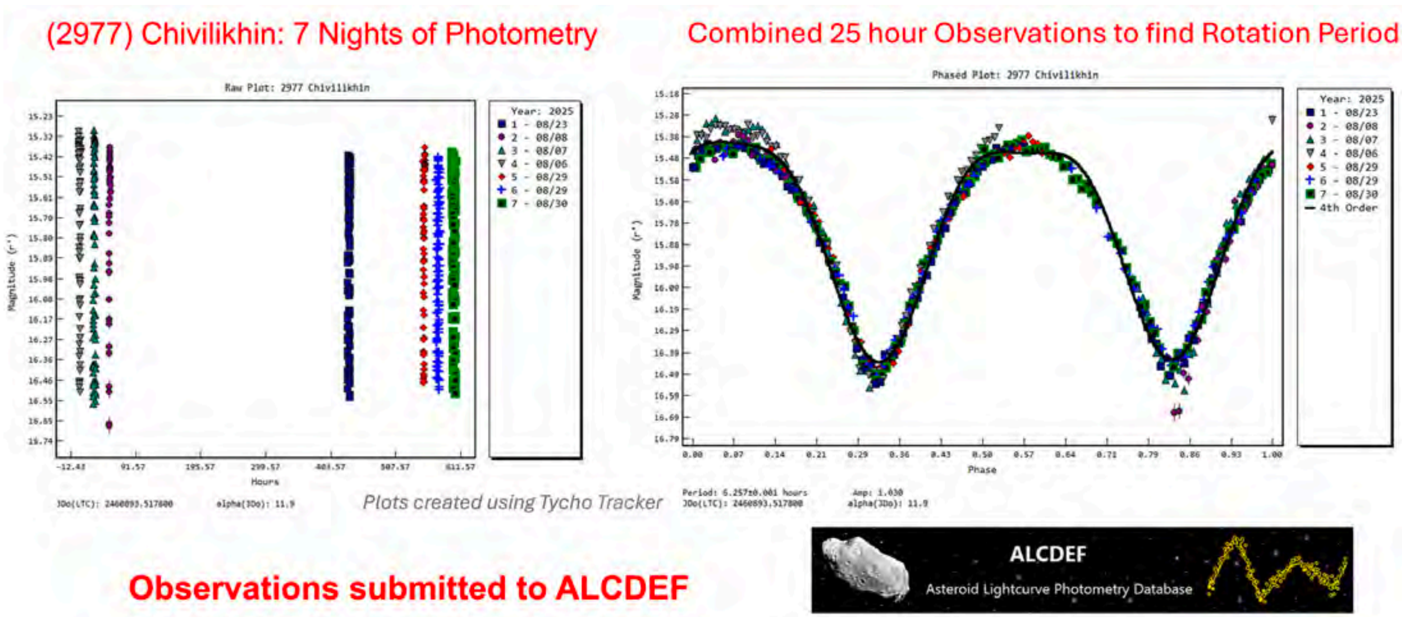


Figure 8 — Rotation light curve of asteroid (2977) Chivilikhin from seven nights of photometry.

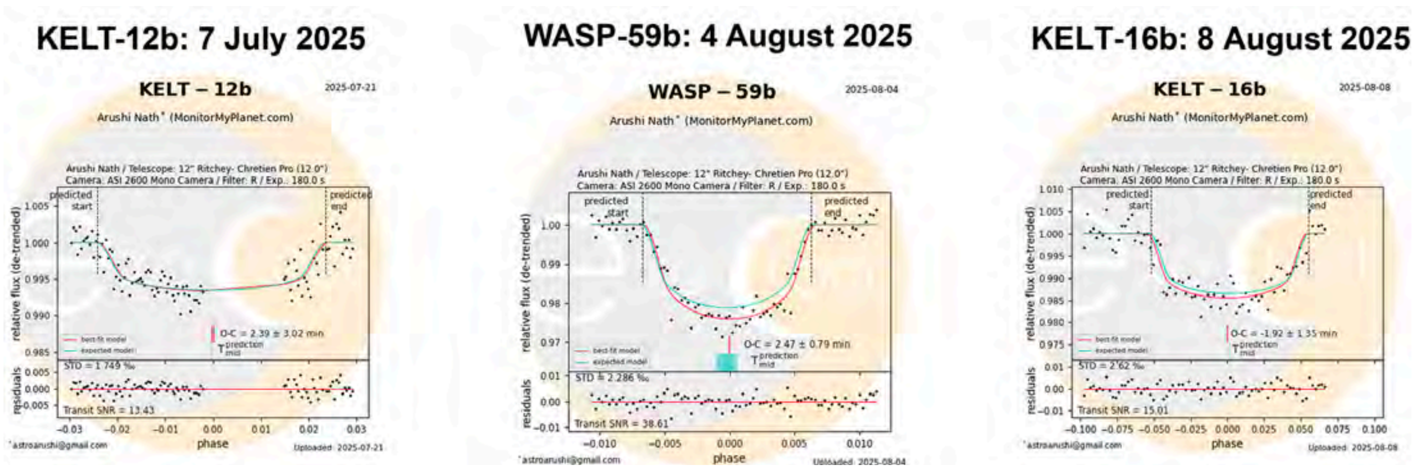


Figure 9 — Exoplanet transit light curves for KELT-12b, WASP-59b, and KELT-16b, accepted by the ExoClock Project.

They also demonstrate why the observatory was built: sustained, precisely timed, multi-hour photometry is difficult to obtain casually, but it becomes possible with dedicated infrastructure.

What comes next

The observatory is now in science operations. My near-term priorities are to expand the exoplanet transit program for *Ariel* support, measure additional asteroid rotation periods, and begin multi-filter campaigns that can provide colour information about asteroid surfaces.

The longer-term goal is to observe binary asteroid candidates. Mutual events in binary systems can produce shallow photometric signatures that require extended, dedicated coverage. Those observations were not realistic when I depended entirely on shared telescope time. They are possible now.

At four years old, I drew Saturn with my best handwriting. At fifteen, I built the instrument. What gets measured next is the open question. ✶

Acknowledgments

I thank the AstroCamp team for hosting the observatory and providing essential on-site support, Telescope Ontario for donating the imaging camera, Celestron for providing a mount for testing, Valkanik for equipment support and logistics, and the Masason Foundation for funding that made the observatory possible. I am also grateful to the communities and organizations that provided shared telescope access and mentorship before R60 existed, including the Faulkes Telescope Project, the American Association of Variable Star Observers, and the Canadian Space Agency. ✶

Surprises under a Namibian Sky

by Alister Ling, Edmonton Centre

I hoped to be caught off guard while stargazing in Namibia. Although I anticipated many moments as Astronomer in Residence at Sossusvlei Desert Lodge in Namibia, highlighted in previous articles (Ling, JRASC Feb 2026), the unexpected delivers an extra delight.

Given my meteorological career of examining weather maps, my nights of poring over paper star charts, previous visits to Australia, and a fair bit of planning, I have my cardinal directions sorted out. Nope, habit dies hard.

Figure 1 — With a lifetime of observing from northern mid-latitudes, one learns how the sky is tilted when looking above the eastern horizon, the pole is to the left. On spring galaxy nights, the Dipper is high up and north is down.

From Namibia in April, the wonderful starfields of Vela have the pole to the left. The other pole. Catching Crux above the pole through an SCT with a diagonal provides yet another orientation. Which controller button do I push to slew up in the eyepiece?!

Now I'm having to double-check myself while navigating a car back home.

As I showed guests sunspots (Figure 2) through my travel scope on a manual mount, muscle memory kept me turning the azimuth knob the wrong way. Also, the spots about to disappear around the limb kept getting easier to see. Right, they travel "backwards" because we're "upside down."

The zodiacal light is so bright, it is the worst source of light pollution in the new Moon sky. I was warned about this, but it's just not believable. I must admit I've rarely experienced skies better than Bortle 2-3. Considerably after astronomical darkness, this slowly narrowing column of light reaches up to the zenith and down the other side, getting lost in the Milky Way.

I briefly noted the gegenschein in a previous article—every other hour an unexpected glow high up would trigger my peripheral vision and distract my telescopic observing. How about that light dome from the capital city Windhoek to the northeast? Ha, that's the Milky Way slowly giving way to the morning zodiacal pyramid until it's enough to light up the floor more than an hour before dawn begins.

Figure 2 — A simple smartphone image of the Sun on 2025 May 29.

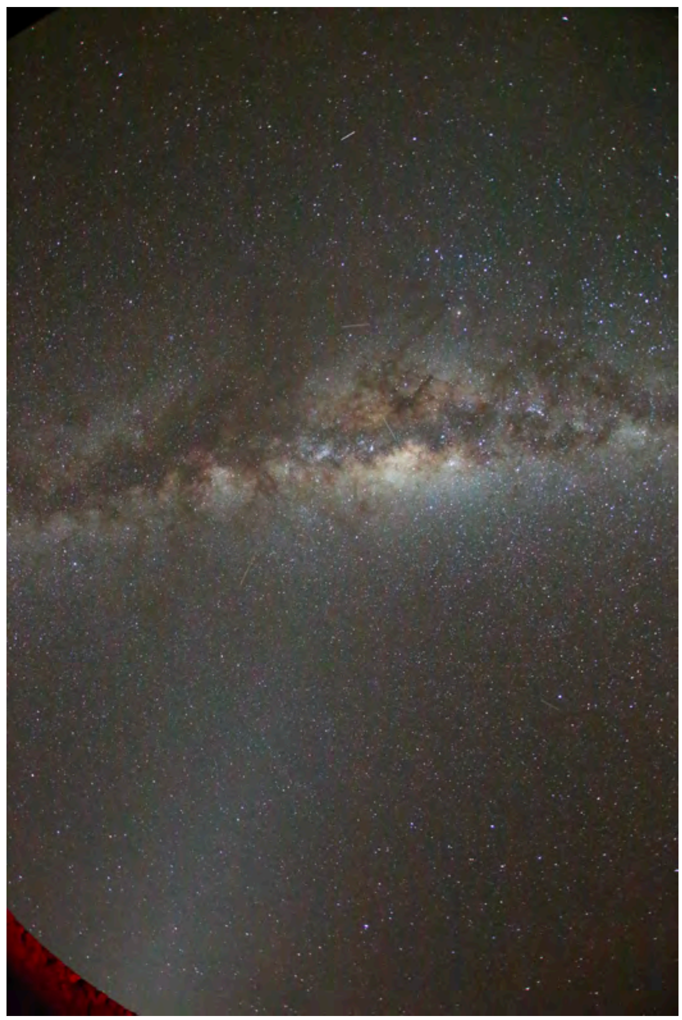


Figure 3 — Zodiacal light

Terrestrial light pollution? There is trespass from the main lodge itself, particularly during the supper and breakfast dining hours. At other times much of it can be switched off and mitigated with slipcovers and small bags.

Everyone is familiar with the gradual fading of the post-sunset glow into civil then nautical twilight. The same thing happens with the Moon! For my entire observing life, I've repeated the classic comment "Okay, Moon has set, it's deep-sky time." At the desert lodge, there is no city to the west, no Bortle 3 glow that masks the lunar twilight glow, prompting a "Geez…the Moon set 20 minutes ago, and it's still not dark!" Equivalently, "Whoa! The contrast is dropping…" And then in an offended tone "But moonrise isn't for 20 minutes!"

Speaking of moonglow, my word, the three-day crescent is bright. There's light everywhere; better shift observing to small planetaries and clusters. By the time first quarter arrives (Figure 5), the nocturnal landscape is a greyscale version of daylight. As city-dwellers, back home when the Moon is up, we're typically in-town with streetlights or driving with car headlights in our eyes, leaving only our daytime scotopic vision active. We see a black background, unable to detect the widespread glow.

One's own animal instincts are fun to notice. At full Moon, I found I carried myself with an air of confidence. I could see dangers approaching from kilometres away: I am in control. A week later, being alone in the dark, I almost cowered at the on-rush of thundering hooves, about to crush me in a stampede. They stopped at the waterhole, some 200 metres away. Darkness intensifies volume, proximity, and imagination. One midnight, after intently concentrating on camera settings and triggering the intervalometer, I stepped backwards down from the outer bench, then was jumped-scared as a silent figure loomed high behind me, between me and my only exit. It was only the telescope.

I've heard that some observers have been just able to detect colour with the light source being the core of the galaxy high in the sky. I brought a photographer's calibrated colour matrix with me to see if I could do it too. Alas, no. Perhaps after cataract surgery?

I had read that Alpha Crucis (Acrux) was a double. Indeed, it's a very nice, quite unequal pair at 16× in my travel scope. One night later, I had to use the star for alignment in the 11-inch SCT, and upon looking in the eyepiece, I shouted out loud "No way!" Its piercing white, nearly equal AB pair at 4.8 arcseconds, is stunning atop a star-peppered background.

One night, I swung the scope nearly overhead to reach the grand spiral galaxy M83. Finally, a view where it's not a sickly blob barely managing to get through the horizon murk. Puzzled and disappointed at the low-contrast view, I went to a bright double star that sported a halo, the telltale sign of dew. In the desert. It had showered earlier, so I shouldn't have been surprised. It was past 11 p.m., too late to ask for a hair dryer, but somehow my neurons were firing well: I placed a couple of chemical hand warmers in the scope's lid with the optics face down. Thirty minutes later, M83 was quite impressive.

For more than 70 nights, I showed guests the magnificent globular cluster Omega Centauri, and despite my preference of 47 Tuc's central packing, it was an absolute delight to watch this absurd collection of stars slew into view. Likewise, I never tired of the personal interaction on those tours.

Figure 4 — The fact that these clouds are backlit indicates that skyglow seen at other times is not from a distant city, else they would be lit from beneath.

Figure 5 — Approximating what the human sees at first quarter.

At one point, I was looking at some dark areas in Sagittarius and could see that I had left the O III filter screwed in. I pulled the eyepiece out to discover it wasn't there. The background sky really was that dark.

Another surprise was watching Orion rising at dawn only six weeks after seeing it set in the west. "It's July, let's look at M42": now there's a statement that makes a northerner's head spin. As I continued these pre-dawn sessions so the guests could see Saturn, I noticed that the belt stars became easier and higher before the lighter sky, and within days, Sirius crested the ridge line. I was witnessing the famous heliacal rising just like they did in olden days. Back home the weather simply wouldn't allow the required continuity.

Did I get my fill from all those nights? Less than a week after returning home, I found myself eager to stargaze from my backyard. Perhaps that was the most delightful surprise of all: the only thing that truly matters is a clear sky, I'll find tranquility looking up. ✶

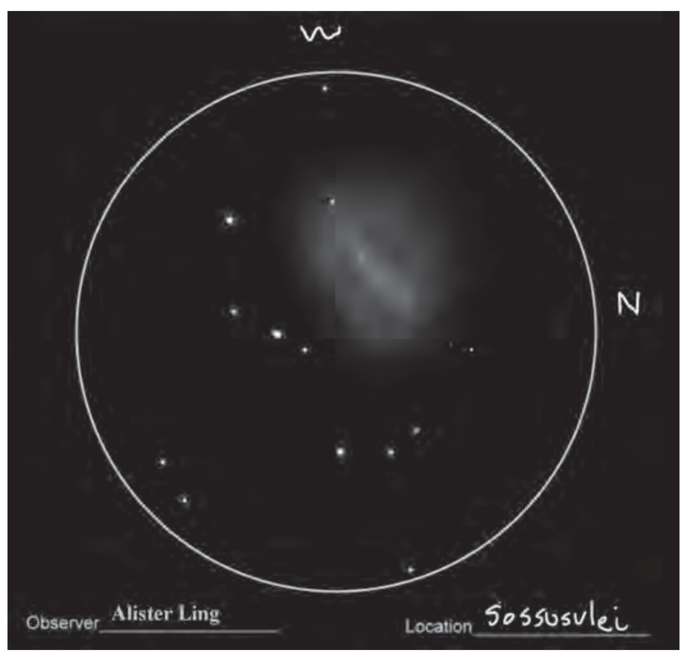


Figure 6 — A view of Messier 83 at 170× through the lodge's CPC1100, drawn directly on a tablet running Android Sketchbook Pro.

Monitoring the evolution of the southern region of the Variable Nebula NGC 2261

Some images reveal the changes in the jet-like Nebula region from 1952 to 2026a

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Abstract

Our extensive monitoring of the variable nebula NGC 2261 has highlighted the disappearance of a jet-like nebula (jet-like structure) in the southern part of the large nebula NGC 2261 since 2015. The "jet-like nebula" observations spanned over an extended period, ranging from 1951 to 2015 in images from various sources, including our own. Then after 2015, it is no longer detected.

This region has now changed since 2023. South of the star, a large circular nebula is now visible, covering the entire region, including the area where the pre-2015 jet-like nebula was observed. The lighting conditions south of the star have therefore changed significantly in recent years. We can assume that the cavity allowing the light beam to illuminate the jet-like nebula is now obstructed by these dust regions and that new regions near the star have opened. The light now reaches other areas of the nebula south of the star.

Résumé

Notre grand suivi de la nébuleuse variable NGC 2261 a mis en évidence la disparition d'une nébuleuse en jet (jet-like structure) dans la partie sud de la grande nébuleuse depuis 2015. Les observations de la « structure en jet » couvrant une période prolongée s'étendant de 1951 à 2015 dans les images de sources variées, incluant les nôtres.

Cette région est maintenant bien différente depuis 2023. Nous avons observé de nouvelles nébuleuses couvrant la région des observations. Ces nouvelles nébuleuses montrent un déplacement tangentiel apparent de l'ouest vers l'est et elles se retrouvent au sud de l'étoile R Monocerotis (R Mon). Elles couvrent tout le sud de l'étoile d'une grande nébuleuse circulaire dont le centre est moins intense, telle la forme d'un tore. Toutefois, depuis 2015, il n'y a pas encore de trace de la nébuleuse en jet d'avant 2015. Les conditions d'éclairage de cette grande région ont donc changé dans un temps bref. Nos observations pourraient nous permettre de mieux comprendre ce qui s'est passé près de l'étoile, là où se produisent les conditions responsables des variations dans la nébuleuse, pour paraphraser Lightfoot (1989), expliquant pourquoi cette grande région est si différente.

Introduction

Our first observations of NGC 2261 were made in early 1990. At the time, they were mainly focused on apparent variations of the nebula's north region, and the variable intensity of the star R Monocerotis (R Mon). Then, over time, we were able to detect the jet-like nebula (structure), an elongated nebula that is very close to the star and extends from it toward the south. Further north, at approximately 7.5 arcminutes (7.5′) according to Walsh and Malin (1985), the Hα emission knots region of the Herbig-Haro 39 object (HH 39), which is related to the star R Mon, was also detected.

Images from 2019 by Jean-Guy Moreau revealed the complete disappearance of the reflection nebula, which was named at that time the "jet-like structure," extending to the southwest of the star R Mon position. From there, a sustained followup of NGC 2261 was established. This followup confirmed the disappearance of the elongated reflection nebula "jet like structure" south of the star R Mon, and that it has been absent since 2015.

At the same time, we were also able to focus on some Hα emission sources far to the north, which are components of HH 39. At the same time, we also focused on a newly identified Hα source south of the star at ~7.5′, which was named the "Hα South" for now, this one is not discussed in this section of the project, these two regions, north and south, are in preparation for another paper.

Observations

Our program

In addition to following, the usual rapid period variations over a few months of the main nebula NGC 2261, we focus more on monitoring the changes on the region where the elongated nebula, now named jet-like nebula (structure) south of the star R Mon, was observed before it disappeared in 2015. It has not reappeared since. It can be seen in the 2014 image by C. Dupriez, at the bottom of the star (Figure 1).

Our observations allow for the first time to see such a change that persists over a very long period. It is an elongated and

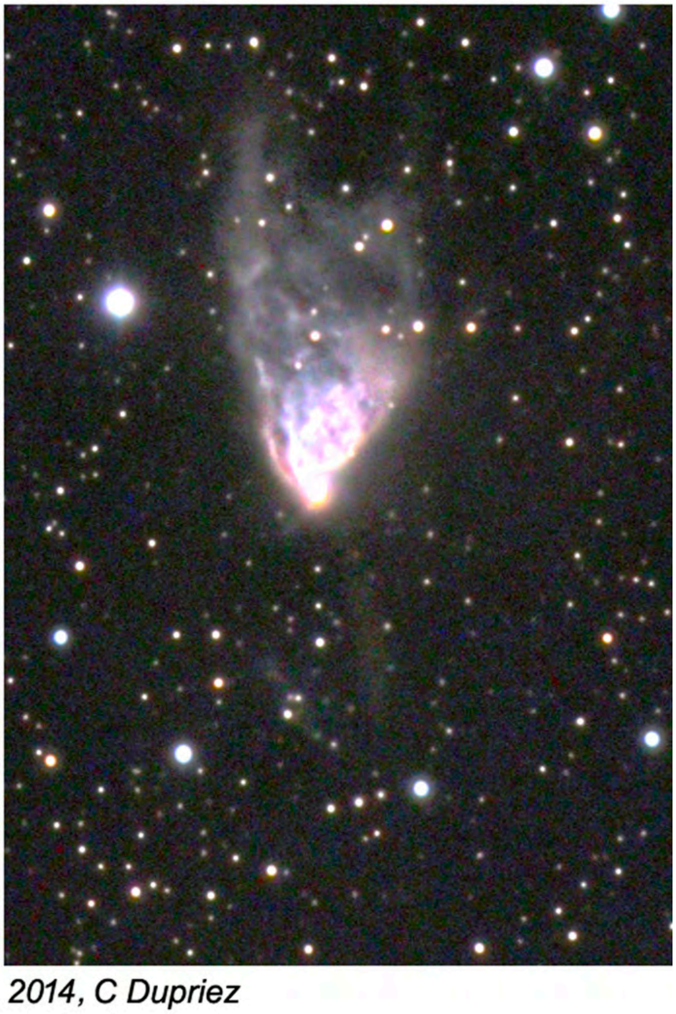


Figure 1 — *This is an image from 2014 by C. Dupriez. We can still see the jet-like nebula, shortly before it disappeared, south of the star R Mon.*

thin reflection nebula, whose light source comes from the star R Mon. We therefore hope to be able to document the reappearance of this region or, at least, the appearance it will take over time. We hope our work can contribute to a better understanding of certain properties of the cloud of matter (dust/gas), denser in the environment of the star R Mon, according to Lightfoot (1989), which is responsible for this unique disappearance lasting for almost 10 years.

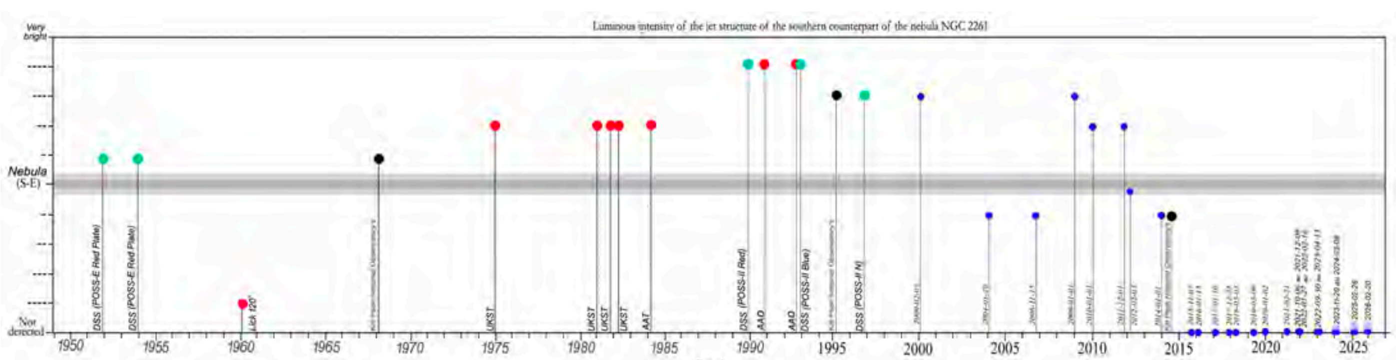
The following new Graph 1 presents all the data concerning the variations of intensity in the jet-like nebula over time, from ~1952 to 2026a.

A description of the different instruments mentioned in Graph 1 can be found in table 1.

On Graph 1, we have expanded our search period for the jet-like nebula (J-1 nebula). Images from several programs have made it possible to observe the presence of this J-1 nebula on old images. The DSS (Digital Sky Survey) makes it possible to note its presence on images as old as November 1951.

Graph 1 (Summary)

The horizontal and dark central line corresponds to the reference point of the intensity. This is the intensity of the small, curved nebula to the southeast. It is detected throughout all observation periods and can therefore be used as a reference to estimate the approximate intensity of the J-1 nebula we are searching for. The dots above this line correspond to periods when the J-1 nebula was more intense than the curved nebula to the southeast. The measurement points below this central horizontal line indicate that the J-1 nebula is less intense than the curved nebula to the southeast. The dots on the axis line,



Graph 1 — Summary: Set of data concerning the visibility of the jet-like nebula over time. The intensity of the jet-like nebula is compared to the intensity of the arc nebula just at its southeast, whose intensity is represented by the dark horizontal line in the centre of Graph 1. From 1952 to 2015, it was visible. Then, at the end of 2015, it was no longer detectable in the images.

- *Lick 120 telescope, 3.05-meter (120-inch) reflector at Lick Observatory in California.*
- *Kitt Peak's, 0.9-meter telescope, National Observatory, Tucson, AZ, U.S.A.*
- *UKST, (UK Schmidt Telescope) is a 1.2-meter Schmidt telescope, administered by the Anglo-Australian Observatory.*
- *AAT, Anglo-Australian telescope, of 3.9 m of diameter located at the Observatory at Siding Spring, in Australia.*
- *AAO, Australian Astronomical Observatory, 3.9 m of diameter located at the Observatoire de Siding Spring, in Australia.*
- *Observations of this region by our group since ~2000.*
- *Images that come from (DSS) DSS Plate Finder / NGC 2261*

Table 1 — The different instruments indicated on Graph 1.

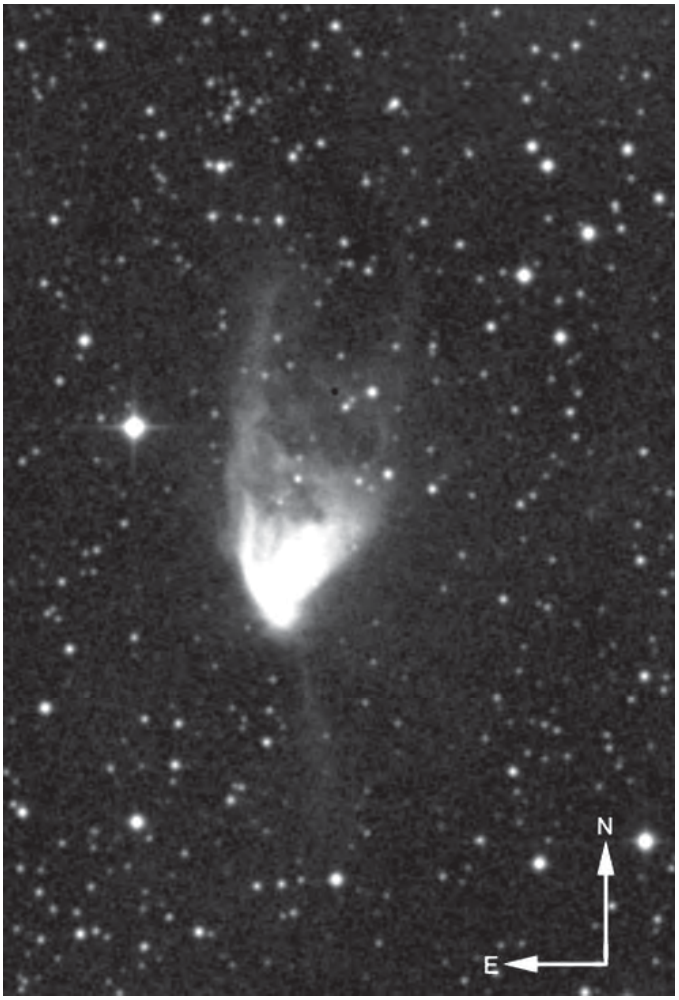


Figure 2 — From 1951 to the end of 2014, approximately 63 years, one can observe the presence of the J-l nebula to the south of the star R Mon.

Figure 3 — In 2015, the J-l nebula disappeared and has never reappeared under the same morphology, this region is very different today.

labelled "Not detected," represent the periods when this nebula was absent from the images, i.e. since November 2015.

The great follow-up and the evolution of the "jet-like nebula" between end of 1951 and 2026a

We have seen larger nebulosities appear south of the star R Mon gradually from west to east since our observations in 2023. In Figure 4 this region consists of a large circular nebula seen from the front, whose central region is more transparent on its eastern side. Inside, we observe the small blue nebula, which has a curved shape, and has always remained visible, serving as a reference.

Refer to Photo Contact Sheet-3 and 4, to precisely follow the evolution from 2023 to 2026a of this large nebula south of the star R Mon.

Questions:

Is the south arc nebula physically connected to the southern section of NGC 2261?

We could make observations to determine if there are changes in the intensity of the small nebula, which are synchronized with those of the star R Mon, or with those of the larger surrounding nebula.

As it is a reflection nebula, is it illuminated by the star R Mon?

To check if the star R Mon is indeed responsible for the light that illuminates the small arc nebula, we can use polarimetric surveys of this nebula. A polarization map should reveal where the light source of this small nebula comes from. On the map, we should see polarization vectors pattern (centrosymmetric) centred on the star that is the source of light responsible for the brightness of this nebula (Bastien & Ménard, 1990).

Figures 4 and 6 indicate that the arc nebula seems to be either along the line of sight in front of the large southern nebula of NGC 2261, or physically part of it.

Photos Contact Sheet-1

This shows the evolution of the jet-like nebula south of the star R Mon from 1951 to 1992.

In images from the early 1950s, the jet-like nebula south of the star R Mon is visible in at least two images from the DSS, namely from 1951 November 30 and 1953 December 10.

Figure 4 — In 2025a, a large pale nebula of circular shape, with a diameter quite similar to the size of the major axis of the main nebula on the northern side, begins to dominate the star's southern region.

Figure 5 — The circle represents the new large circular nebula to the south. The arrow indicates the small curved nebula, which is always detectable.

Figure 6 — This is a high-resolution view of the southern counterpart of the nebula NGC 2261. Here we can see several intense filaments heading toward the arc nebula, which, in turn, is constantly detected south of the star R Mon.

Images from 1989 November 7 and from 1992 December 20 also show it very well.

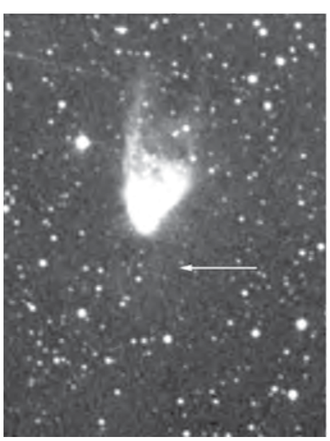
Photos Contact Sheet-2

This shows the evolution of the jet-like nebula south of the star R Mon from 2000 to 2014.

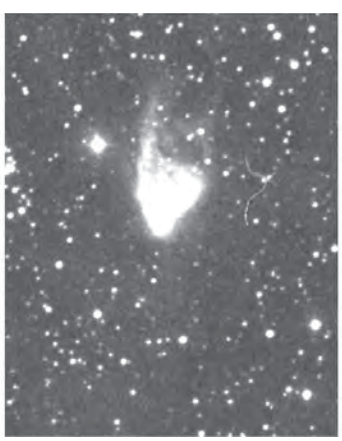
Contact Sheet-2 summary

These images are from our group, and they are presented in the following order, from left to right: 2000, followed by those from 2009, 2011, and 2014. These four periods in images clearly show the constant presence of the J-l nebula south of the star, even with rather short integration times for its images. In graph 1, you can see our estimate of the intensity of the J-l nebula during the corresponding periods.

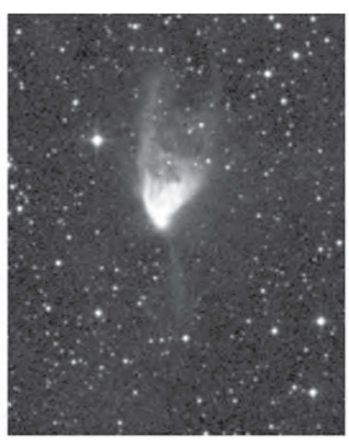
The disappearance of the J-l nebula is consistent with our observations from 2015. Valère Perroud (Figure 7), provided us with an image from 2015 November 7, in which the J-l nebula is no longer detected.



1951-11-30 (DSS)
Expo = 50 m
Survey POSS- red plate



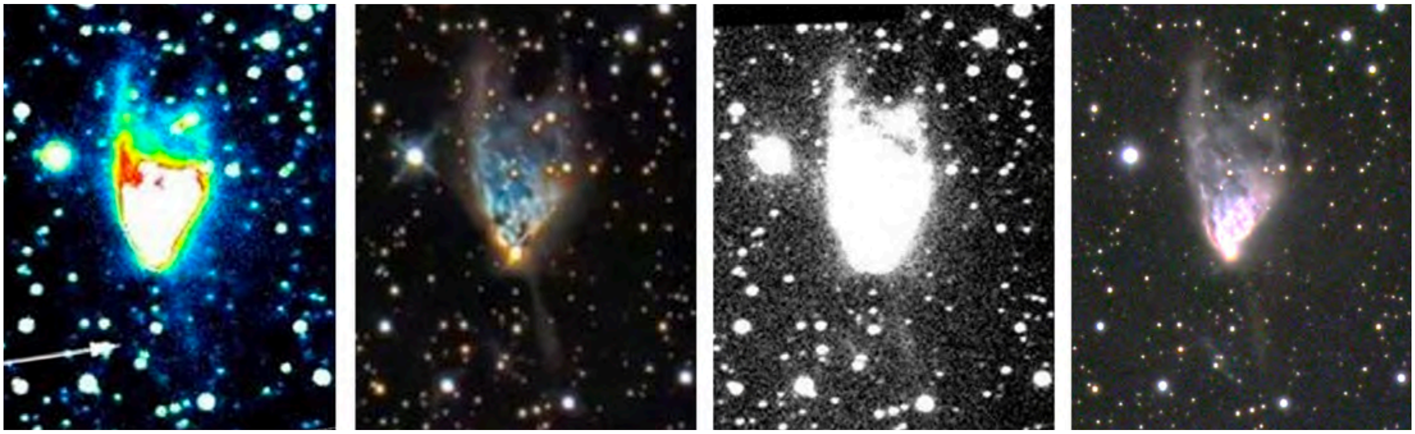
1953-12-10 (DSS)
Expo = 45 m
Survey POSS-E Red Plate



1989-11-07 (DSS)
Expo = 70 m
Survey POSS-II-red

1992-12-20(DSS)
Expo=50 m
Survey POSS-II Blue

Contact Sheet 1



Contact Sheet 2 – Shows the evolution of the jet-like nebula south of the star R Mon from 2000 to 2014.

It is therefore clear that, by the end of 2015, this nebula was no longer visible.

To validate this observation, we consulted several images from the web covering a longer period, including the same period in 2015.

The summary below and Table 2 present some examples that support this observation of the J-1 nebula disappearance at the end of 2015.

As we had no images from 2016 and 2017, in order to cover the time gap in the chronology of our images, we were able to check some pictures available on the web to know the state of the region of the J-1 nebula during that period.

Kitt Peak 2014a

Visitor Center during 2014a. Release date: 2014 June 11.
The jet-like nebula is detectable there, very long, rather pale, a little less intense than the reference arc nebula.
Credit: KPNO/NOIRLab/NSF/AURA/Carole Westphal/Adam Block
https://noirlab.edu/public/images/noao-n2261westphal/

2015 November 7, "astro.perroud-net"
There is no longer any trace of the Jet-like nebula in 2015
https://astro.perroud-net.fr/NGC2261.htm

2016, NGC 2261, "2016 Oleg Bryzgalov"
Picture was photographed 2016 February 4 and 6, in Khlepcha observatory, Ukraine.
There is no trace of the Jet-like nebula in 2016
www.cloudynights.com/topic/528106-ngc-2261-hubbles-variable-nebula-ver2016/

2017 December 25, view from.earth/past-articles/item/62-hubble-s-variable-nebula
There is no trace of the jet-like nebula in 2017
https://viewfrom.earth/astrophotography/nebulas/35-ngc-2261-hubble-s-variable-nebula

Table 2 — Images we found on the web; we integrated them into the large graph to cover the period from 2014 to 2017.

Figure 7 — From 2015 November 7— confirms the disappearance of J-l nebula.

In 2014a, this image still shows the J-1 nebula, which corresponds well to what is observed in our 2014 image by Christian Dupriez. Then, in the images from 2015 to 2017, there is no detectable trace of the J-1 nebula south of the star R Mon. It can therefore be concluded that this structure disappeared in 2015.

Contact Sheet-3

The jet-like nebula south of the star R Mon from 2018 to 2025a.

In the 2018 image by Mark Hanson, an arrow at the bottom slightly to the right indicates the position angle previously occupied by the luminous structure J-1 nebula from before 2015. Our images from 2018 to 2022 show no trace of this nebula south of the star R Mon. One can rather see in this area a band darker than the surrounding sky.

The images from 2019, 2020, and 2022 all show traces of the curved nebula to the east of the J-1 nebula's position. These images reveal some faint traces of nebulosity on the southern side of the star, but no trace of the nebula we are looking for.

In 2023, our images, including some taken by the group of the sixth-grade students from Mauzan College in Gap (Hautes-Alpes, France), are among the first to show more significant nebulosity to the south of the star R Mon. Mainly, two tip-shaped nebulae curve away from it, one toward the

Continues on page 156

Pen & Pixel

Figure 1 —Who doesn't love a good galaxy cluster? Accomplished astrophotographer Ron Brecher imaged the Coma Galaxy Cluster, also known as Abell 1656 from his SkyShed in Guelph, Ontario, from 2026 May 21–31. The cluster contains at least 1,000 galaxies with an average distance of 321 million light-years. "The two large galaxies in the centre are NGC 4874 (left) and NGC 4889. Both are supergiant elliptical galaxies," he notes. Acquisition, focusing, and control of his Paramount MX mount was done with N.I.N.A. and TheSkyX. No guiding. Primalucelab low-profile 2" Essato focuser, ARCO rotator and Giotto flat panel. Equipment control with PrimaLuce Labs Eagle 4 Pro computer. All pre-processing and processing in PixInsight. He used a Celestron 14" EDGE HD telescope at f/11 (3,931 mm focal length) and QHY600M-SBFL camera binned 2×2 with Optolong filters. 225 × 1m Red; 220 × 1m Green; 215 × 1m. Total: 11hr 00m

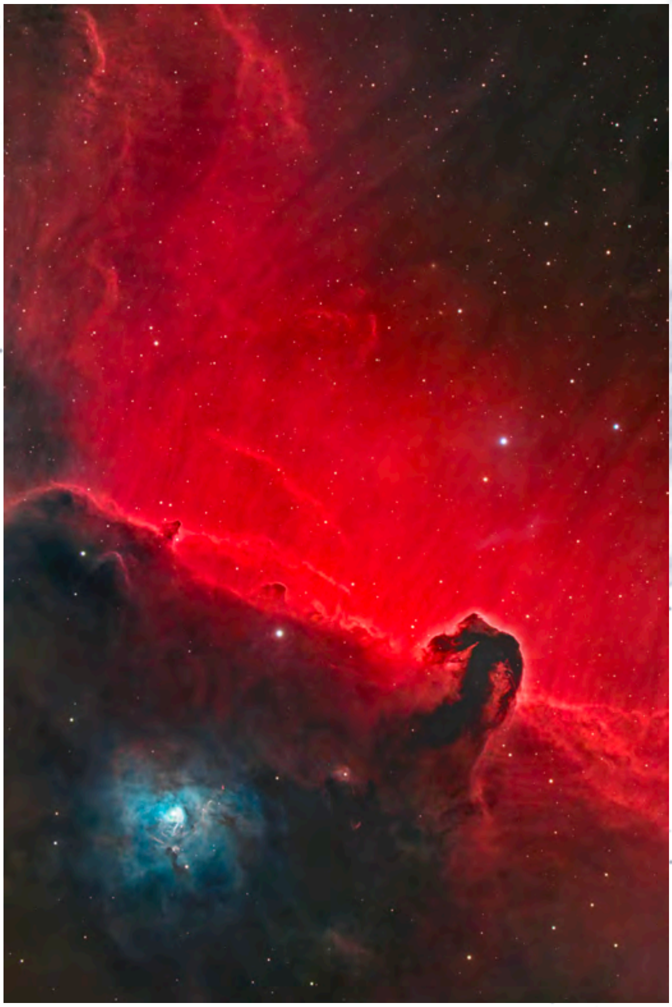


Figure 2 —The beautiful Horsehead Nebula is seen here courtesy Rob Lyons. He collected this data between 2025 December 26, and 2026 January 16, using a matching pair of 8" Edge HD telescopes, one with a monochrome 2600MM Pro, and the other with a colour 2600MC Pro. "I used an Antlia Quad Band light pollution filter on the colour camera to collect RGB data and a hydrogen alpha filter on the monochrome camera to get the lovely red background." This is a total of 28.25 hours from Bortle 9, Vancouver.

Continues on page 155

What's Up in the Sky?

August/September 2026

Compiled by James Edgar

August Skies

The Moon is just past full as the month opens, reaching last quarter on the 5th. Two days later, the Moon is among the Pleiades (the Seven Sisters) with Uranus, then, on the 9th, Mars is 4 degrees south. Perigee is when the Moon is at its closest orbital point to Earth—this occurs on August 10, when our satellite is 363,284 km away. The following day, Mercury is 2 degrees south of a very slender Moon. New Moon is on the 12th, which is a total solar eclipse over the North Atlantic Ocean and Spain. The lack of an interfering Moon on the night of the Perseid meteor shower will be welcomed by viewers. On the 16th, Venus is 2 degrees north of the waxing crescent Moon. The 21st sees Antares only 0.6 degrees north of the just-passed first-quarter Moon. Apogee is when the Moon is at its orbital farthest from Earth—on the 22nd, at 404,642 km. The Moon is full near midnight of the 27th, which generates a partial lunar eclipse. This might be a good reason to stay up for late-night photo op, as most of the Moon's disk will be in shadow.

Mercury makes for a great viewing opportunity for the Northern Hemisphere. In the morning sky, close to nearby Jupiter, the speedy planet is joined by the Moon on the 11th. By the 15th, Jupiter is less than half a degree away from Mercury. If you've never seen Mercury before, this is a great opportunity, using Jupiter as your guide.

Venus remains bright as the Evening Star, but hugs the horizon. It can be seen in twilight, as the Sun begins to set. The Moon slides by on the 15th.

Mars is quite visible in the eastern dawn sky, among the stars of Taurus, The Bull. As the month progresses, the Moon enters the scene on the 9th and Mars moves eastward into Gemini, The Twins. The cluster M35 is in conjunction with Mars on the 16th.

Jupiter is too close to the Sun for the first part of the month, but becomes increasingly visible in the east before morning twilight. Mercury is very close on the 15th, just west of the Beehive Cluster in Cancer, The Crab.

Saturn, in Pisces, The Fish, rises in the east shortly before midnight. Neptune hovers close by all month, and the Moon joins them on August 3 and again on the 31st.

Uranus rises close to midnight among the stars of Taurus. The Moon slides by on the 7th.

Neptune, in Pisces, is leading Saturn across the night sky, only 10 degrees apart, and the waning Moon makes for a trio on the 3rd.

The **Perseid meteors** peak the night of August 12. That's when Earth passes through the cloud of tiny particles left behind by Comet 109P/Swift-Tuttle in its many passes by the Sun. It has been confirmed that the earliest sighting was over 2100 years ago, returning approximately every 130 years. The comet is next due to appear in 2126.

August: On August 9, every planet except Venus (and including Earth) will be available for viewing in the morning sky. A telescope will likely be needed to see Neptune. Image courtesy Starry Night Pro Plus 8.

Continues on page 154

The Sky August/September 2026

Compiled by Nicole Jiang, Toronto Centre

Celestial Calendar (bold=impressive or rare)

August 2026

Aug. 5 Moon at last quarter

Aug. 7 Moon in Pleiades (M45)

Aug. 9 Mars 4° south of waning crescent Moon

Aug. 10 Moon at perigee (363,284 km)

Aug. 11 Mercury 2° south of waning crescent Moon

Aug. 12 new Moon (lunation 1282)

Aug. 12 partial solar eclipse

Aug. 13 Perseid meteors peak at 10:53 a.m. EDT

Aug. 14 Mercury 0.7° south of Beehive (M44)

Aug. 15 Mars 0.6° south of Shoe-Buckle (M35)

Aug. 15 Mercury 0.6° north of Jupiter

Aug. 16 Venus 2° north of waxing crescent Moon

Aug. 19 Moon at first quarter

Aug. 21 Antares 0.6° north of waxing gibbous Moon

Aug. 22 Moon at apogee (404,642 km)

Aug. 28 full Moon 12:18 a.m. EDT

Aug. 28 partial lunar eclipse

September 2026

Sep. 2 Venus 1.7° south of Spica

Sep. 3 Moon in Pleiades (M45)

Sep. 4 Moon at last quarter

Sep. 6 Mars 3° south of waning crescent Moon

Sep. 6 Moon at perigee (368,259 km)

Sep. 8 Moon 0.5° north of Beehive (M44)

Sep. 8 Jupiter 0.8° south of waning crescent Moon, occultation

Sep. 9 zodiacal light visible in east before morning twilight

Sep. 9 Regulus 0.6° north of waning crescent Moon

Sep. 10 new Moon (lunation 1283)

Sep. 14 Venus 0.5° south of waxing crescent Moon

Sep. 17 Antares 0.6° north of waxing crescent Moon

Sep. 18 Moon at first quarter

Sep. 18 Moon at apogee (404,221 km)

Sep. 22 equinox at 8:05 p.m. EDT

Sep. 26 full Moon at 12:49 p.m. EDT

Sep. 30 Moon in Pleiades (M45)

Planets at a Glance

	DATE	MAGNITUDE	DIAMETER (″)	CONSTELLATION	VISABILITY
Mercury	Aug. 1	0.3	7.9	Gemini	Morning
	Sep. 1	—	4.9	Leo	—
Venus	Aug. 1	–4.3	20.9	Virgo	Evening
	Sep. 1	–4.6	30.1	Virgo	Evening
Mars	Aug. 1	1.3	4.7	Taurus	Morning
	Sep. 1	1.2	5.1	Gemini	Morning
Jupiter	Aug. 1	—	31.3	Cancer	—
	Sep. 1	–1.8	31.8	Cancer	Morning
Saturn	Aug. 1	0.6	18.5	Pisces	Morning
	Sep. 1	0.5	19.3	Pisces	Morning
Uranus	Aug. 1	5.8	3.5	Taurus	Morning
	Sep. 1	5.7	3.6	Taurus	Morning
Neptune	Aug. 1	7.7	2.3	Pisces	Morning
	Sep. 1	7.7	2.3	Pisces	Morning


NORTH
SOUTH
WEST
NW
SW
AURIGA
LYNX
PERSEUS
TRIANGULUM
Double Cluster
CAMELOPARDALIS
ANDROMEDA
CASSIOPEIA
M31
URSA MAJOR
Polaris
Little Dipper
URSA MINOR
CEPHEUS
Big Dipper
CANES VENATICI
LEO
DRACO
LACERTA
Deneb
Venus (August 19)
COMA BERENICES
BOÖTES
PEGASUS
CYGNUS
Northern Cross
M13
Vega
LYRA
CORONA BOREALIS
Arcturus
DELPHINUS
SAGITTA
VULPECULA
HERCULES
Altair
SERPENS CAPUT
VIRGO
SERPENS CAUDA
AQUILA
Spica
OPHIUCHUS
SCUTUM
LIBRA
CAPRICORNUS
M8
Antares
SCORPIUS
SAGITTARIUS
M7

Continued from page 151

September Skies

The Moon begins the month at waning gibbous phase, among the stars of Taurus. On the 3rd, the Pleiades share the spotlight, rising just before midnight. Last quarter occurs on the 4th, with Mars 3 degrees south on the 6th; this is also when the Moon reaches perigee of 368,259 km. On the 8th, the Moon is 0.5 degrees north of the Beehive Cluster (M44), and later on occults Jupiter in the daytime sky. The next day, Regulus is 0.6 degrees north of the Moon, while new Moon occurs on the 10th. Venus is occulted on the 14th for Southern Hemisphere viewers; the close-up event is a poor showing for Northern Hemisphere viewers, though, as the bright planet hugs the horizon at sundown. On the 17th, Antares takes the stage, hovering just 0.6 degrees north of Luna–another occultation in the south. First Quarter is on September 18, with the Moon at apogee of 404,221 km. The Moon is at full phase on the 16th and once again among the stars of the Pleiades on the 30th.

Mercury remains elusive for northern viewers owing to the tilt of the ecliptic at this time of year.

Venus is also plagued by the low ecliptic, in addition to being, at the same time, several degrees south of the ecliptic. Venus had reached greatest elongation east (GEE) in mid-August, and is heading toward inferior conjunction in late October. Experienced telescope users might find a challenge to see Venus south of the Sun during daylight hours. Use extreme caution while viewing so close to the Sun!

Mars rises in the east shortly after midnight, among the Gemini stars. The waning crescent Moon passes to the north on the 6th.

Jupiter rises in the east around 4 a.m., climbing the steep ecliptic (steep in eastern mornings; shallow in western evenings). The very thin crescent Moon occults the gas giant on the 8th in a daytime event. This is the first of four monthly consecutive Jupiter occultations, with the remainder visible in the early morning before sunrise.

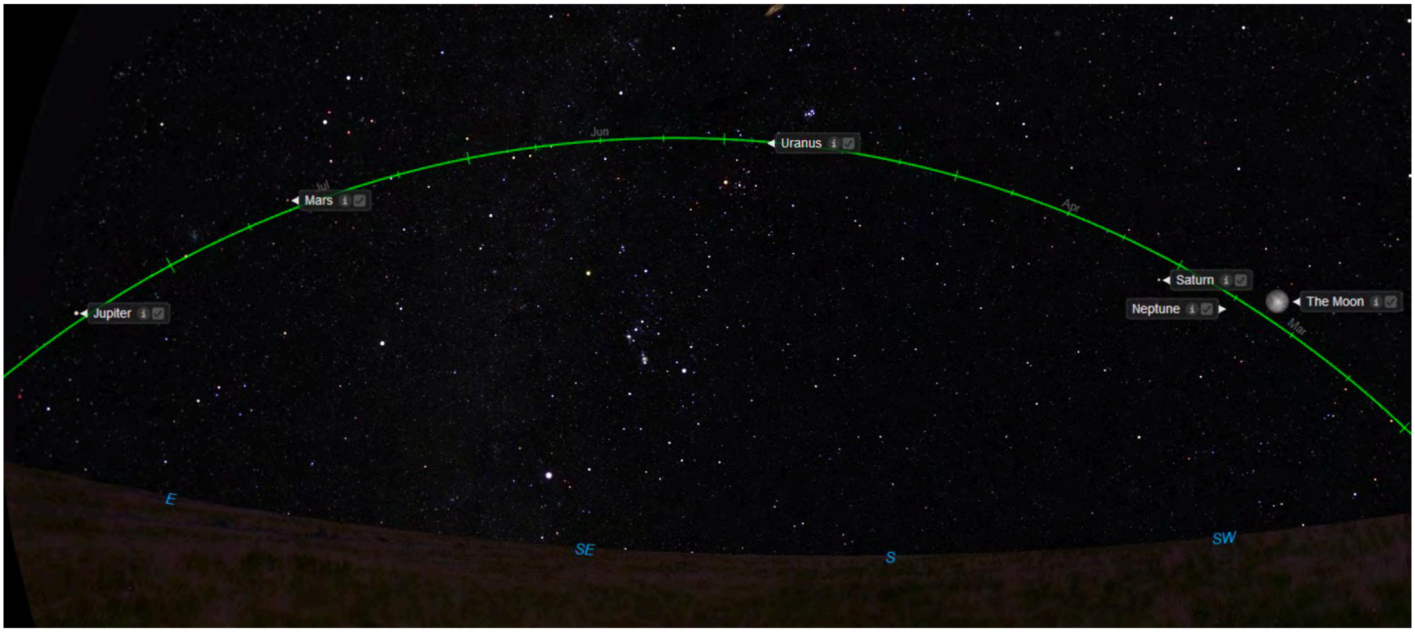
Saturn presents a good viewing opportunity, rising at sunset and crossing the sky all through the night. The full Moon glides by on the 26th.

Uranus is up all night among the stars of Taurus, The Bull. On the 10th, the distant gas planet appears to stop its eastward movement, then apparently move westward. This is an illusion, of course, because it's the faster Earth orbit that overtakes and moves past Uranus. This illusion puzzled ancient astronomers (and astrologers), because right up to Copernicus, it was thought that the Earth didn't move–that it was the centre of the Universe. Copernicus and Kepler showed that the Sun was at the centre and all the planets were in orbit around the Sun.

Neptune is in the sky all night, leading nearby Saturn. The full Moon is a few degrees away on the 26th.

The zodiacal light is visible before eastern morning twilight for the middle two weeks of the month, beginning on the 9th.

The autumnal equinox occurs in the late evening of September 22.



September: On September 26, six of the eight planets are visible in the early morning sky, plus the full Moon hovering near Saturn and Neptune. Winter constellations are beginning to appear, with Orion prominent in the southeast. The green arc is the Ecliptic. Image courtesy Starry Night Pro Plus 8.

Pen & Pixel

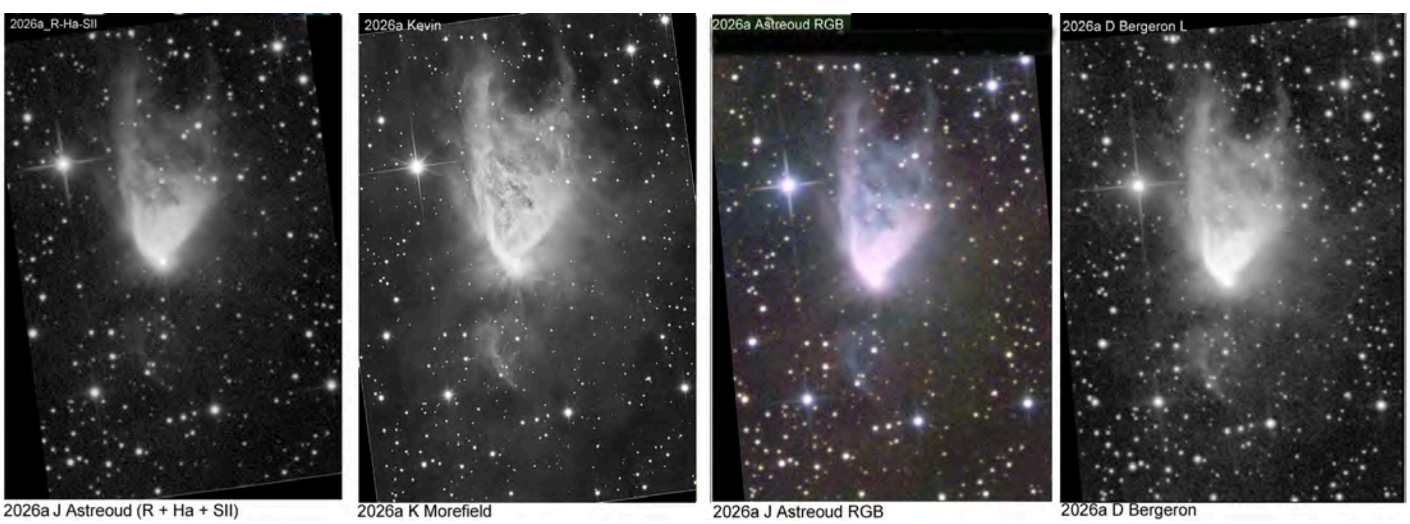
Continued from page 150

Figure 3 — On 2026 June 17, the Moon occulted Venus, which was visible across Canada. Debra Ceravolo captured the pair after the occultation at 12:56 p.m., PST from her home in southern B.C. She used a Ceravolo 300mm astrograph (1480mm focal length), with a Canon R6 camera, 1/1600 second exposure, ISO 100.

Figure 4 — Ryan Génier captured the magnificent Small Sagittarius Star Cloud, IC 1284, and more using a Celestron RASA 8″ with a ZWO ASI2600MC Pro on an iOptron GEM45 mount. He used Astrodevice filter drawers for ZWO cameras with tilt plate (FD 900 M87), a Pegasus Astro Powerbox Advance Gen2, and a ZWO EAF. Processing was done using Pleiades Astrophoto PixInsight.

Continued from page 149.

Contact Sheet 3 –Shows the jet-like nebula south of the star R Mon from 2018 to 2025a.



Contact sheet 4 — Shows the jet-like nebula south of the star R Mon for 2026a

southwest and one toward the southeast of the star. The nebulosity in the southwest begins to cover a large region of the location where the J-1 nebula was observed before 2015.

In 2024, the two large regions, southeast and southwest of the star were still evolving. They seem to cover a large area to the south of the star with a pale circular nebula. This new nebula seems to have a diameter that resembles the size of the major axis of the main nebula to the north.

At the beginning of 2025, this large nebula region to the south was now more intense; one can clearly see a large circular luminous region with its interior eastern section being the most transparent. We can observe the curved nebula that was used to estimate the intensity of the J-l nebula in our Graph 1; it dominates the inner northeast interior section of this new large circular nebula.

Contact Sheet-4

This shows the evolution of the jet-like nebula south of the star R Mon for 2026a

In late 2025 and early 2026, images were taken by Jérôme Astreoud, from the French group. These observations from Chile were obtained with the telescope of the SADR association, on 2025 November 2, (using R, Hα and SII filters), and on 2026 January 10, (using RGB filters). To the left, from November 2, is a composite of image filtered with R, Hα, and SII filters. It reveals the very stable arc nebula to the south along with some fainter traces of the two nebulous regions extending southeast and southwest of the star R Mon. Faint nebulosity can also be distinguished in the large southern region, which also covers the sector of the J-l nebula detectable before 2015.

Next is an image from Kevin Morefield (centre left), adjusted to better highlight the southern region of the star. It reveals two spiky nebulae curving away from the star's region, one toward the southwest and the other toward the southeast. The large circular nebula south of the star is also visible, as well as the arc nebula at its core. This image confirms our observations of the evolution of the large circular nebula south of the star R Mon, which was first detected in 2023. For reference, see the images in Contact Sheet-3.

The next image (centre right) is from Jérôme Astreoud with the French group from the Collège Mauzan à Gap (Hautes-Alpes, France); it's an RGB image. We can see pointed, luminous structures extending away from the star, mainly to the south and east. To the west, we can make out fainter nebulosity covering a larger area, which even extends into a portion of the area where the J-l nebula was observed before 2015. South of the star R Mon, one can see the large circular (toroidal) nebula, which now covers this large southern region of the nebula NGC 2261, as well as the arc nebula at its core.

On the right is a beautiful picture by Denis Bergeron, dated 2026 February 18. It was taken with his PlaneWave CDK 12-inch f/8 telescope at a 2555-mm focal length and his Player One ZEUS 455M Pro camera in 2×2 binning, luminance exposures. The nebulosity on either side (southeast-southwest) of the star is clearly visible, more intense on the southwest side. Further south, the small arc nebula is well resolved and appears to be connected to the main nebula to the north by a thin, elongated structure. The large circular nebula, newly detectable south of the star, is also visible.

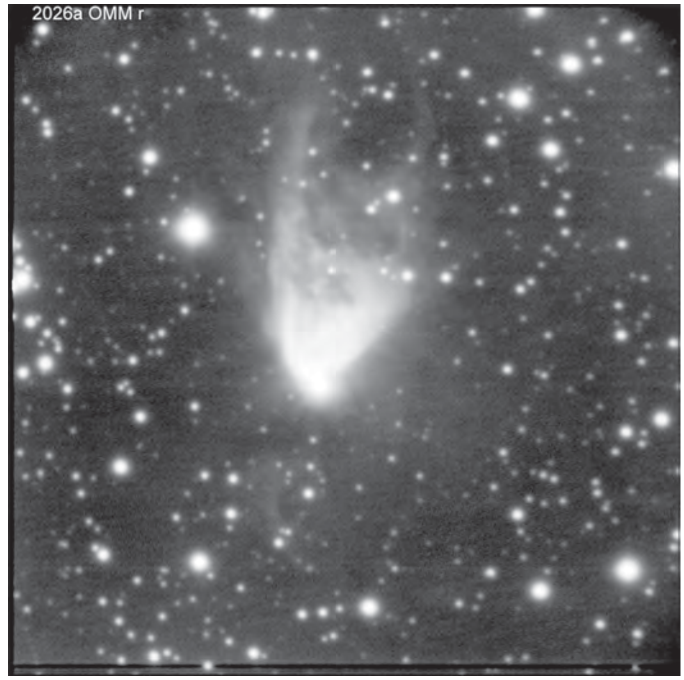


Figure 8 —, The OMM images (2026a) confirm that there are no significant traces of the J-l nebula south of the star R Mon. These images will also be used in an upcoming paper by the group, which will allow for estimates of the movement of the knots of HH39, among other things.

We also received contribution from the Observatoire du Mont-Mégantic (OMM) this year. The GAUL (Université Laval) is the principal investigator for its images. The PESTO imager was used at the telescope of 1.6 m at f/8, this is the detector NüVü 1024x1024 pixels, EMCCD, with a field of view of 7.95′x7.95′. The filters r' (562-695 nm) and i' (695-844 nm) manufactured by the company ASTRODON (photometric Sloan filters) were used for the central region of the nebula.

In Figure 8, the OMM images (2026a) confirm that there are no significant traces of the J-l nebula south of the star R Mon. These images will also be used in an upcoming paper by the group, which will allow for estimates of the movement of the knots of HH39, among other things.

2026a

Image requested by the GAUL, who had access to the OMM telescope on 2026 February 9, using an "r" filter. A serious attempt was made to achieve more detailed images using mainly the Astropy package in Python. The main advantage is the freedom associated by this approach. However, it was difficult to achieve a good contrast between the extreme values (photon counts caught by CCD) associated to the pixels since a deep knowledge of mathematical techniques taught in physics courses, along with knowledge of image treatment and programming are required to do so. It should at least serve as a

Figure 9 — OMM 2026a

good practice for subsequent papers, aimed at other objects of interest presented in our introduction.

This image allows us to track several nebulae that extend away to the southwest and southeast from the position of the star R Mon. The small curved nebula further south is also clearly visible.

No trace of the J-1 nebula. We can even observe that in its pre-2015 position, we now detect a darker elongated region than its surroundings

OMM 2026a

An image in false colours, the image in "r" filter and the one in "i" filter were inserted as follows;

Filter r = R, Filter i = B, Filter (r + i / 2) = G

So, in red we have the r filter, in blue we have the i filter (close to Ir), and in green we have the average of the two filters r + i / 2.

This image is adjusted to highlight several structures of varying intensity within the main nebula, including several darker structures.

The "r" filter allows us to cover some emission line spectra, such as Ha, while the "i" filter is mainly from the near IR continuum.

Question;

What factors might contribute to the inability to detect the trace of the jet-like nebula in our images?

Three situations:

- Image exposure times were too short, preventing the J-1 nebula from being detected.
- Poor seeing quality.
- The use of inappropriate filters.

Verification;

The 1989 SDSS image, 70-minute exposure / POSS-II Red, allows us to select a very faint star located at RA; 06h 39m 14.322sec. / DC; 08° 43′ 17.38″, with a magnitude (r) a magnitude r estimated at ~17.94 ±0.46. The reference star is detected in all our images, except one due to poor seeing.

Conclusion;

Our images are mostly in RGB or L filter mode, and they all have a sufficient signal to allow detection of the J-1 nebula, if it were detectable after 2015. Furthermore, several images are available online (on the web) from other observers. There has been no trace of the J-1 nebula on these images since 2015.

To better understand the evolution of the southern region of the NGC 2261 nebula, we have included an animation available online, showing images from the early 1950 to 2026a. This animation clearly illustrates the changes in this region, known as the "jet-like nebula," over more than 70 years.

The animation images come from the NGC 2261 monitoring group (St-Onge et al. (2026)) and the DSS and SDSS for the older ones, and from the OMM. The animation was primarily edited by Taïna Cloutier of the GAUL group at Laval University in Québec City.

Animation editing using Siril software.

© monitoring group NGC 2261 (St-Onge et al. (2026)) / GAUL, Université Laval, QC).

* **The link is;** http://www.astrosurf.com/cdadfs/anim/NGC2261_EN.pdf

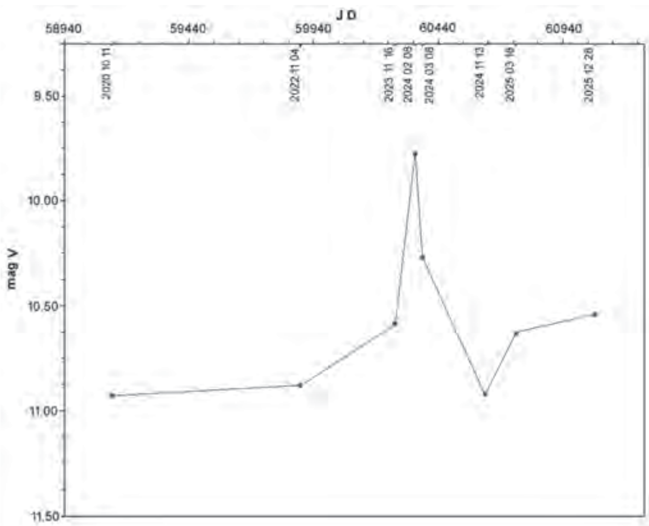
* **The link in French is;** http://www.astrosurf.com/cdadfs/anim/NGC2261_FR.pdf

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.*

The follow-up (photometry and spectroscopy) of the star R Mon and its immediate environment

As the apparent variations of NGC 2261 nebula are attributable to the environment of the star R Mon, according to Lightfoot (1989), it is necessary to monitor the region near the star R Mon, through spectra and intensity readings of the star R Mon, looking for indications that could explain among other things the disappearance of the jet-like nebula.

Jean-Bruno Desrosiers from the OMSJ (Observatoire du Mont St-Joseph), presents photometric observations and spectroscopy of the environment of the star R Mon covering the periods from 2022 to 2025.



Graph 2 – Changes in the brightness of the star R Mon (2020b to 2025b)

The luminous intensity of R Mon;

This region experienced an increase in magnitude peaking in February 2024.

Then it underwent a notable decline until November of the same year.

In 2025, there is a trend towards 'stabilization' around mag. 10.4 in V. See Graph 2

Other follow-ups are currently underway to monitor the evolution of this dynamic phase.

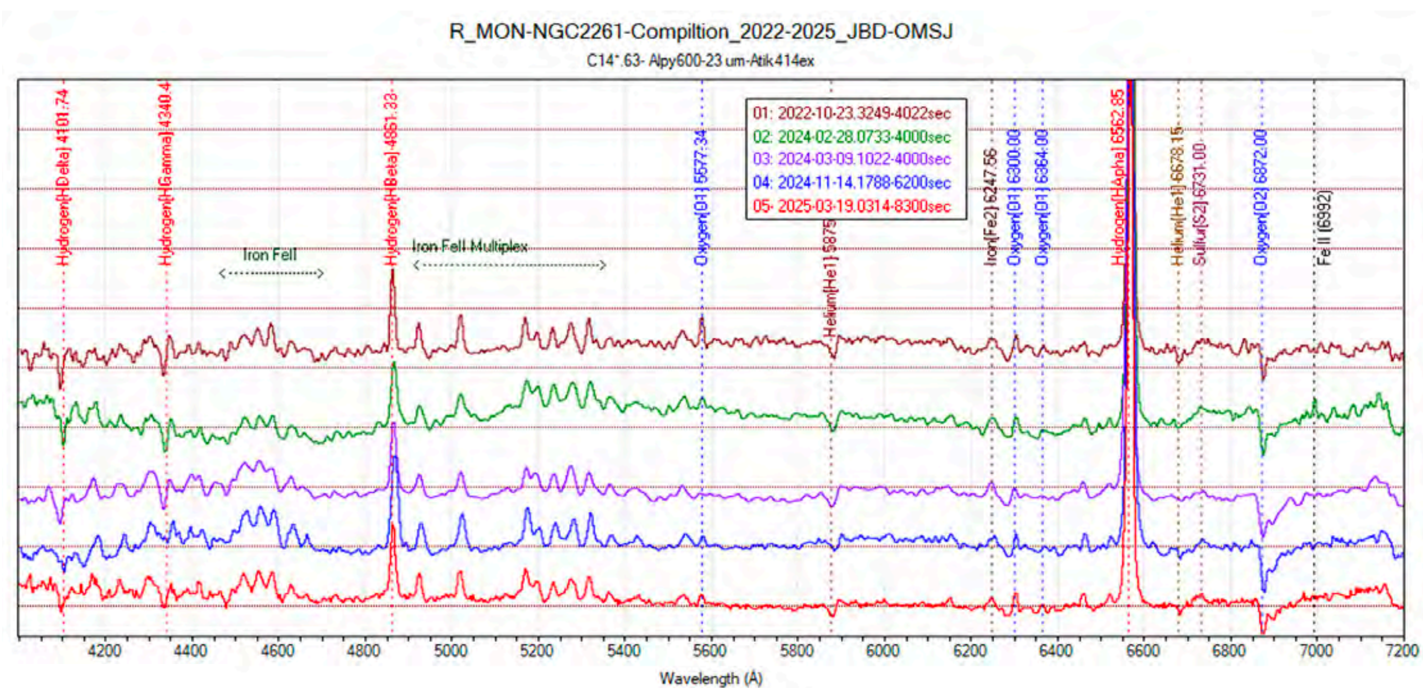
Summary 2022 to 2024;

A compilation of the spectra obtained from 2022 to 2024 has been carried out on Graph 3. The analysis revealed significant changes in several lines of the nebula. Being a reflection nebula hosting a young stellar object (YSO), it is a young star in the stabilization phase towards the main sequence. Through its activity and mass, it illuminates the surrounding nebulosity that it has itself expelled. This dynamic makes NGC 2261 an excellent laboratory for spectroscopy, combining the intrinsic variabilities of the star (stellar winds, accretion) and those extrinsic to the reflection nebula, where lines switch from absorption to emission according to the stellar activity. The results of these analyses were also published in this Journal of April 2025.

In March 2025, another spectrum was possible and was added to previous follow-ups:

Spectroscopy observations of the 2025

The tracking has been enriched with a new spectrum captured in March 2025. Highlights of this update include:



Graph 3

- Hydrogen Variability (Balmer Series): The H-Delta (4101.74 Å) and H-Gamma (4340 Å) lines, which had lost intensity in November 2024 (blue spectrum), regained their brightness level of early 2024 in March 2025.

- P Cygni profile: On the spectrum of March 2025, the "P Cygni" profile redraws slightly on the H-gamma line. This absorption trough adjacent to the emission peak can be interpreted as a signature of a powerful stellar wind emanating from the star R Mon.

- Oxygen (O II at 5577.34Å) remains very stable.

- Helium (**He** at 5875.97 Å and 6678.15 Å)

- Moreover, on the spectrum in green (2024 February 28, right in the middle of the maximum magnitude), a small Fe II line at 6962 Å is observed, it is probably coming from the northern cone of matter facing us.

- Iron multiplet: The "forest" of Fe II lines is still clearly distinguished between 5wwwwww100 Å and 5300 Å, which can be characteristic of the dense envelopes surrounding stars in the accretion phase.

Comment

The literature makes no mention of iron at 6992 Å, nor of helium in the star's spectra. This could be a strong indication that it is a Herbig Be star (B0 to B9 → 10,000–30,000 K → 3–15 $M_\odot$). The documents consulted mention HI (Balmer), FeI/FeII (classical multiplets) Ti I / Ti II, Cr II, Sc II, Ca II K et H, [O II] 3727 Å, [S II] 6716 Å / 6731 Å, [O I] 6300 Å / 6364 Å.

However, Jean-Bruno points out that in his spectra, Calcium C II in the K and H bands was found to be almost absent during our observations (although they are regularly cited in the literature).

Further observations are expected to follow this fascinating object.

Conclusion

In recent years, mainly since 2023, we have detected low intensity nebulosities that gradually appear from the southwest side of the main nebula. These are starting to cover a large region, including the area where the J-1 nebula, which is a reflection nebula, was detected before 2015. At the moment, we do not recognize the J-1 nebula in these new nebulae. It may be that the lighting conditions in this region have changed since 2015, to the point where one wonders if the J-1 nebula, which was so constant over a long period, from the early 1950s to 2015, or for ~65 years, will be observed again in the future.

What is observed from this region for the moment in 2026a are significant apparent changes in the southern nebula. We now detect a large nebula of rather circular shape, somewhat like a large toroid seen from the front. In the centre of its eastern side, we see the curved reflection nebula which is always detectable and serves as a reference for intensity estimation.

Since 2019 we have focused on the southwest region of the star, which has allowed us to observe that the nebulosity has progressed from west to east covering the entire southern region of the star. The large circular nebula (toroidal shape) to the south is less intense at its centre on the eastern side, where a large region in a darker arc can be seen. This arc runs alongside the visible blue arc nebula, passing from north to south while bending towards its east.

To see the latest changes in this southern region, refer to the images from 2023 to 2026a on the Photo Contact Sheet-3 and Sheet-4.

The southern lobe of NGC 2261 is usually hidden by the star's parent nebula due to the system's inclination at approximately 75° towards us, Bastien & Ménard (1990). Therefore, the star's southern region doesn't reveal much visible light. However, we see no trace of the J-1 nebula even on images which total more than 11 hours of integration. It is presumed that there was a permanent cavity (at least from 1952 until 2015) in the star's southern region that allowed a beam of light to illuminate this small J-1 nebula.

Now the lighting conditions of the south of the star have therefore changed significantly in recent years. We can assume that the cavity allowing the light beam to illuminate the J-1 nebula is now covered by these dust regions. And that new regions near the star have opened. The light now reaches other areas of the south nebula.

It is therefore necessary to continue the observations of the southern section of the NGC 2261 nebula, if we want to understand how its appearance will evolve over time. At the same time, we should check if the lighting conditions of the nebula will allow the reappearance of the nebula known as the jet-like nebula (structure) over time.

Considering that, this is the first time we can detect such significant changes over a long period of nearly 10 years, we believe that close monitoring of this region is appropriate. It may be possible to describe some properties of the denser dust region near the star, which is responsible, according to Lightfoot (1989), for this apparent transformation of the southern component of the nebula NGC 2261. Moreover, photometric surveys and spectroscopy of the R Mon star region are valuable assets. As they may help correlate the observations in the visible spectrum through imaging with certain physical properties of this region, which can inform us about what is happening there.

We would like to thank Dr Sylvie Beaulieu for useful discussions during this project and the entire OMM team, for using the observatory instrument for the NGC 2261 project.

Facilities: Observatoire du Mont Mégantic, Québec

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We would like to thank;

- the GAUL (Groupe Aérospatiale de l'Université Laval), for their important collaboration on this project.
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Dish on the Cosmos

Radio Astronomy: a Serendipitous Science?

by Pamela Freeman
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In 1983, to celebrate the 50th anniversary of Karl Guthe Jansky discovering extraterrestrial radio waves, a workshop was held at the National Radio Astronomy Observatory in Green Bank, West Virginia. This workshop, titled "Serendipitous Discoveries in Radio Astronomy," highlighted the seemingly lucky ways in which radio astronomy has developed (though, as you go through the proceedings, the definition of "serendipity" is never fully agreed upon). Luckily for me, the proceedings from this workshop are shared online, and one of the editors, Ken Kellermann, has continued to preserve and share the history of radio astronomy. It has inspired me to share some of the stories of serendipitous discovery in radio astronomy. Radio astronomy was the first non-optical form of astronomy, so naturally it had a whole universe of discoveries waiting for it.

We, of course, must start with Jansky. A radio engineer for Bell Telephone Laboratories, he was assigned with finding sources of interference in transatlantic communications. Radio technology was novel, as the radio part of the electromagnetic spectrum was only proven in the late 1800s. Soon after, experiments began to try to detect cosmic radio signals. If the cosmos emitted optical light, why not radio? Jansky's imperative, though, was closer to home. He was to build an antenna and monitor the radio emission in the atmosphere. In Jansky's months-long monitoring campaign, he noticed a persistent noise in the data reappearing every sidereal day but slowly shifting in its position on the sky. Given the period, an astrophysicist friend of Jansky's helped him understand that this signal was coming from some distant fixed point past the Sun. After consulting astronomical maps, Jansky understood his signal to come from the Milky Way, in the constellation Sagittarius.

Jansky's detection was published in 1933 on the front page of *The New York Times* with the headline "New Radio Waves Traced to the Centre of The Milky Way." (In the symposium, Ken Kellermann pointed out that this was the first and only time radio astronomy had made the front page, but luckily, we can update that with the first image of a black hole making the front page in 2019.) With his set-up, Janksky had many key things going for him. First, the design contained many important features for radio astronomy: the antenna was directional, had a low-noise receiver, and a way to smooth the noise in the data. Second, there was some serendipity: the telescope operated at a wavelength where galactic radiation is strong, and the Sun didn't get in the way as it was near a minimum in its activity. It was a major breakthrough, yet radio astronomy blossomed only after World War II. Jansky did not continue with the field after his discovery, pressured by the Great Depression and the lack of support from folks at Bell Labs.

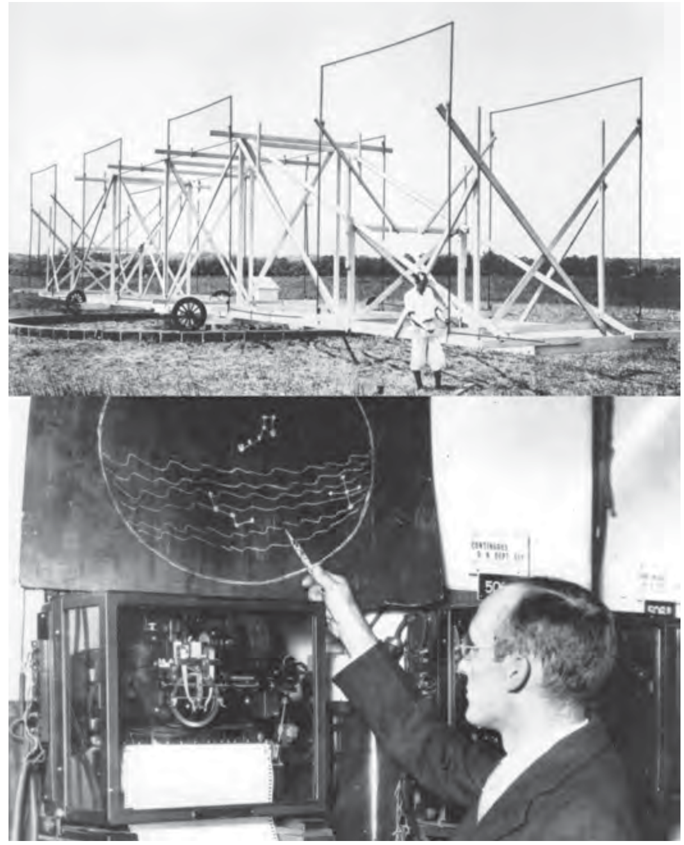

Figure 1 — Top: Karl Jansky in front of the rotating antenna he built, which was also dubbed "Jansky's Merry-go-round." Initially built to monitor radio interference in the atmosphere, it was sensitive enough to pick up radio signals from the centre of our galaxy. Bottom: Karl Jansky consulting a map of the night sky. Credits: NRAO/AUI/NSF.

The next few discoveries I'll share happened a few decades later. In the early 1960s, peculiar and bright radio sources were found—point-like objects that looked like stars but weren't. They had strong, broad, unidentifiable emission lines and no explanation suited them. A couple of years went by with astronomers collecting objects of this type. In 1963, Maarten Schmidt, using optical spectra of these sources to help with identification, realized the hydrogen emission lines had a large redshift—their lines were not at the expected frequency, but lower, due to the expanding Universe stretching their light on their way to us. These objects were very far away from Earth, and thus, had to be much brighter than a regular galaxy.

They were soon dubbed quasi-stellar radio sources, or "quasars." In a Science News article by Ann Ewing, they were described as "rating the 'mostest.' They are the most distant, brightest, most violent, heaviest, and most puzzling sources of light and radio waves." A solution was provided to the puzzle in 1969, when Donald Lynden-Bell suggested these bright objects are powered by matter accreting onto massive black holes. The gas and dust spiralling in is very fast and very hot and can give off more energy than entire galaxies.

This next phenomenon was not unexpected—it is a story of missed connections as well as serendipity. In the early 1960s, the Big Bang theory was still in development and there was one key observational clue missing. This clue was the so-called "Primeval Fireball," residual radiation from the Big Bang that permeates the Universe. It was theorized independently by two groups, one in 1948 and one in 1964, approaching the problem from two differing viewpoints. The team in 1948 estimated this radiation to be at a temperature of 5 K. There was also unexplained spectroscopic data—in the late 1930s, cyanogen radical was observed to be excited to an energy state of 2.3 K with no mechanism for that excitation.

In 1964, encouraged by the theoretical predictions of Robert Dicke, a research group at Princeton built a radiometer to measure the intensity of this microwave radiation. Around the same time, two radio astronomers at Bell Telephone Laboratories, Robert Wilson and Arno Penzias, were repurposing a horn reflector from a communications instrument into an astronomical instrument. The horn reflector had incredible shielding from Earth-based noise sources and so was ideal for faint cosmic radio sources. However, in their initial observations they consistently found excess noise to the tune of a few degrees K. They puzzled over this noise for months, investigating everything from the Milky Way to the Van Allen belts to pigeon droppings in their antenna as sources of interference. Luckily, after not too long, a serendipitous game of telephone alerted the Bell astronomers to the work going on at Princeton. After the two groups convened, Penzias and Wilson reported their results marking the discovery of the cosmic microwave background. The Princeton group followed up with observations from their radiometer, fortunately built for a different wavelength, as confirmation of this fireball radiation.

The last tale for today became a Nobel Prize controversy. Also in the 1960s, Jocelyn Bell Burnell joined Anthony Hewish's lab at Cambridge for a project, building and working with the Interplanetary Scintillation Array. A team of a handful of people, including Bell Burnell, built this instrument from scratch, a set of poles and wires covering 4 acres (like the area of 57 tennis courts). It was to measure radio scintillation: compact radio sources twinkled similarly to stars as their light passes through an area with density instabilities. This was ideal for studying small, bright objects like quasars.

Once the telescope was commissioned, the data analysis fell solely on Bell Burnell's shoulders. At the time, data was written out onto chart paper. The high-time resolution data

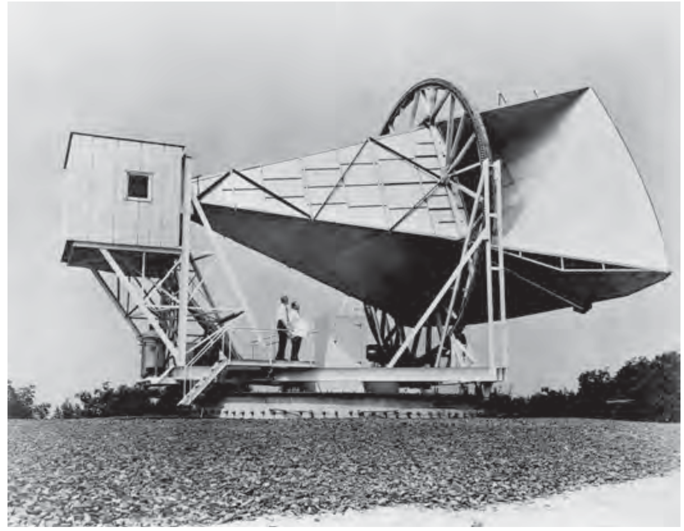

Figure 2 — The horn reflector used by Robert Wilson and Arno Penzias at Bell Telephone Laboratories. Initially built for communications purposes, Wilson and Penzias refitted it for various radio astronomy studies. It is now best known for something unplanned: detecting the cosmic microwave background. Credit: NASA.

dumped a hundred feet of paper every day for her to pore over. While computers were an option, the team didn't know if they could program one adequately enough to distinguish the scintillation signals from other interference. This may have proven a good choice. Bell Burnell identified some "unclassifiable scruff" passing in the data at the same rate as the stars passed overhead, always in the same patch of sky. Baffled at first, they called the phenomenon "Little Green Men"—a facetious name. The puzzle grew as Bell Burnell detected similar pulses from other patches on the sky (which definitively ruled out aliens), and as they confirmed with another telescope that these pulses were real. These yet-to-be explained objects were dubbed pulsars, and soon after were independently theorized and observed to be rotating magnetized neutron stars. For this work and his role in the discovery, Hewish was awarded the Nobel Prize while Bell Burnell was snubbed. While she has taken this in grace, the decision remains a controversy.

Since 1983, there have been incredible technological developments in radio astronomy with greater efficiency, sensitivity, and higher resolution—spatial, spectral, and temporal. It may be argued that the rate of these discoveries has gone down, though it has not gone to zero. We have unexpected discoveries like fast radio bursts, another that came right after the commissioning of a new telescope. We also have many non-serendipitous observations, like the long-predicted images of protoplanetary disks from ALMA and black holes from the EHT.

In 2026, many of the complaints and hopes are still the same as what was discussed in 1983. There are still qualms

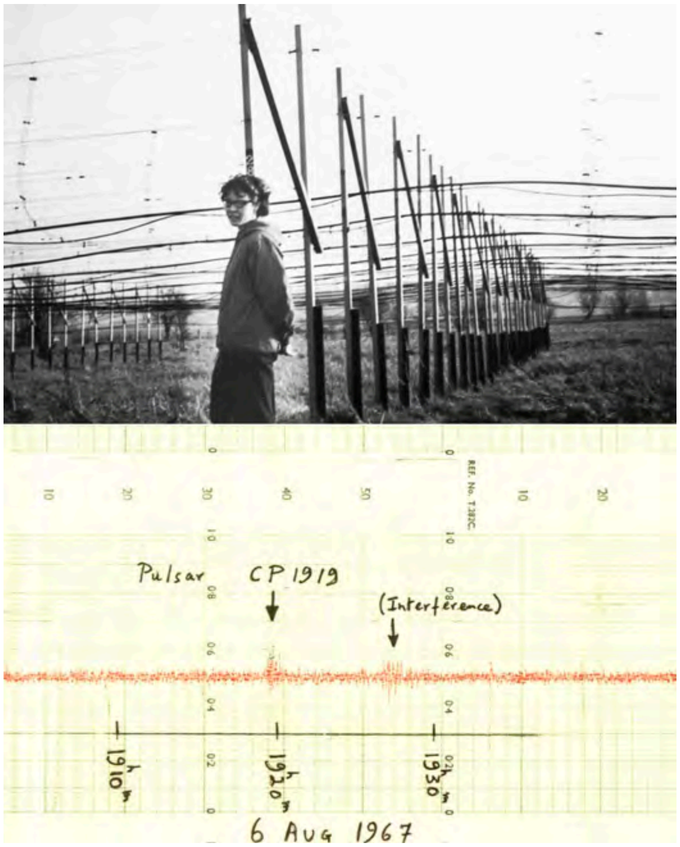

Figure 3 — Top: Jocelyn Bell Burnell in front of the Interplanetary Scintillation Array, a four-acre telescope made of poles and wires that she helped build. Bell Burnell was the sole analyst scouring the data for twinkling point-like radio sources. Bottom: The unusual "scruff" Bell Burnell found in the data, later found to be pulsars—rotating magnetized neutron stars. Credits: Churchill Archives Centre, HWSH Acc 355.

about the influence of peer review and funding bodies in astronomy, about young researchers following what will suit their career over the science. We have no qualms these days about computers sifting through our data—human power is no match for the amount of data modern telescopes collect. The question has only shifted, as we're now at the frontier of machine learning in astronomy.

One encouraging difference is that astronomy these days is a much more diverse discipline. The large majority of people in discussion at this workshop were white men. They were also discussing discoveries made by small teams within a different funding and academic landscape. The large, international collaborations of recent decades may direct research fields in certain ways, but there has also been a democratization of access to the field. The progress radio astronomy has made has necessitated these collaborations in order to continue pushing scientific limits.

In the stories above, and with many others, perhaps it was Peter Wilkinson who described it best: "radio telescopes are not known for what they are built for." A lot of these serendipitous discoveries came when good research was pushing the bounds into what had not yet been observed. It was people and teams, with expertise, competence, and innovative desires, developing the field. How are we to know what we don't know? What will new telescopes reveal about our universe? ✶

Read more:

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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.

Mostly Variable Stars

Thinking About Transits and Sunspots

by Hilding Neilson
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We don't really think about the Sun as a variable star, but it is in multiple ways. Of course, the Sun undergoes non-radial pulsations and there is the five-minute granulation signature, but most of interest at this moment are the sunspots. Sunspots are stunning darker spots that appear, move along the disk of the Sun, and eventually disappear as shown in Figure 1. Sunspots have been observed and studied for centuries, and the best model for understanding them comes from solar rotation winding up and tangling the solar magnetic field so that a loop penetrates above the surface of the Sun. The magnetic field loop acts to create pressure that makes the area cooler hence appear dark.

But how the magnetic field works in the Sun is still a topic of interest, largely because we still have trouble understanding how magnetic fields in stars work in general. In fact, it's a bit of a running joke at stellar physics conferences to ask a presenter if they considered magnetic fields in their work. Yet we know magnetic fields are important as they occur in many stars, from the little M dwarf stars to about 10 percent of the most massive O-type stars. Even Betelgeuse appears to have a magnetic field.

If there are magnetic fields then there are likely also star spots. For instance, Cantiello and Braithwaite (2011) predicted that magnetic fields in B- and A-type stars could lead to star spots that are brighter than their surroundings instead of dimmer like we see for the Sun. RS CVn binary stars can have really big spots, covering about 20 percent of the surface of the stars. Star spots on Sun-like stars or solar analogues have been considered for decades now, but thanks to exoplanets, it is becoming more urgent to understand them.

Most exoplanets are detected using the transit method when a planet passing in front of the star blocks a tiny bit of light and the blip repeats in a regular period. But star spots can confuse the observations. If there are spots on the surface of the star, the total flux of the star decreases, which can create an error. If, somehow, the exoplanet passes in front of a star spot, there will be a "dimple" in the light curve that deviates from the normal transit light curve. As such, star spots are a nuisance for exoplanet observers. This is becoming even more important as we start using the *James Webb Space Telescope* and other satellite telescopes to conduct transit spectroscopy.

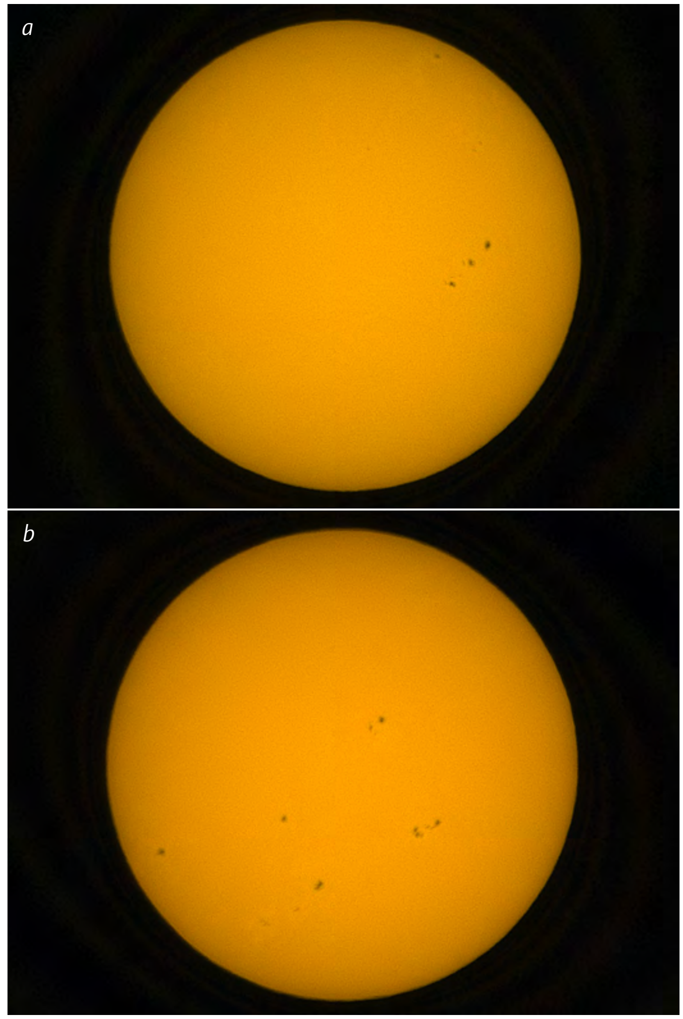

Figure 1 (a and b) — Images of the solar disk 2025 September 10 and 18, using a UniStellar EVScope at Memorial University in St. John's, Newfoundland and Labrador.

Transit spectroscopy is the observation of a transiting system over many wavelengths. When we observe a transit, we measure a transit depth that is the function of the size of the exoplanet. If the transit depth varies as a function of wavelength, then we have an indication and measurement of the atmosphere of the exoplanet. But these variations as a function of wavelength tend to be of the order of 100 parts per million, so we need very precise observations and data if we want to characterize an exoplanet atmosphere. As such, star spots are going to be a nuisance. At the same time, we also have to worry about stellar activity, and flares can be a problem, too. In M-dwarf stars, flaring may be common and can make the star appear slightly brighter than usual. This will be less important for Sun-like stars, but it's still there; stellar activity is a bit of nuisance, too.

But nuisances can be fun, as long as they're not mosquitoes.

How might we learn to understand these nuisance parameters and better characterize exoplanet transits? Well, to better know

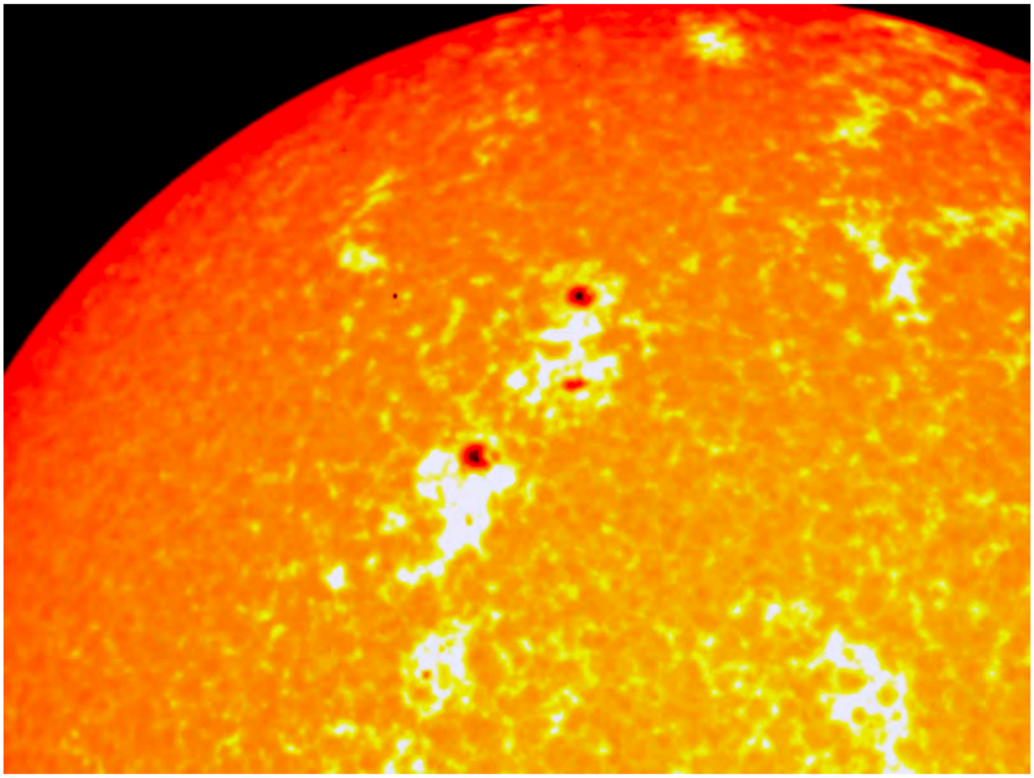

Figure 2 — Image of the solar disk with sunspots and faculae. Credit: NASA/Goddard Space Flight Center Scientific Visualization Studio. Source data courtesy of HAO and NSO PSPT project team. HAO is a division of the National Center for Atmospheric Research, which is supported by the National Science Foundation. Special thanks to Vanessa George (University of Colorado/LASP) and Randy Meisner (Michigan State University).

our planets, we need to know our stars better. However, it is unclear how to know star spots better when we do not resolve the stars. For instance, in Figure 1 we have an image of the Sun with about five or six small sunspots distributed on the surface. If we integrate the light from the solar disk into a flux, it will be slightly less than without sunspots. If we consider a situation where there is only one spot but the size of the spot is equal to the sum of the five or six spots from the first case, then we will observe pretty much the same result. Add to the fact we don't have the ability to predict star spots in terms of location, size, and motion, then we are quickly overwhelmed by too little information. I haven't even thought about the fact that sunspots have a darker central structure and an intermediate penumbral ring.

So, star spots and sunspots are hard. But they are far from the only thing happening on the surface of stars. Faculae are like sunspots except they are brighter regions on the Sun that form between solar granules when the magnetic field gets squeezed as shown in Figure 2. Even though this is like sunspots, sunspots deflect heat while the magnetic fields in a facule channel heat from the interior upwards, making them brighter and hotter than the surrounding region. What makes faculae really interesting is that they appear brighter near the edge of the stellar disk. And faculae exist in other stars and do different things. Zaleski et al. (2020) noted in mapping the surface brightness of the M dwarf Kepler-45 that the faculae were dark spots not brighter. This is largely due to differences in magnetic field structures in M-dwarf stars versus G and K dwarf stars that is caused by the transition from a convective envelope in G and K stars to being completely convective for the M dwarf stars.

So, faculae, flares, and star spots all impede the ability for astronomers to measure the detailed properties of exoplanet atmospheres using the transit method, because stars continue to be hard to understand. I've been rambling in this essay, mostly because I am thinking about a research project to test how spots and faculae and magnetic field tangling can impact transit observations and measurements but am not sure what the best way is for me to proceed. If we ever want to confirm what exoplanet atmospheres look like, then we need to understand these issues better. ✶

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Keep Calm and Orbit On

Cow-culating Reentry Risks

By Samantha Lawler, Regina Centre
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In my last couple of columns, I talked about interdisciplinary work that's needed to understand and mitigate the many harms caused by rapid, almost entirely unregulated commercialization of low Earth orbit: light pollution and night sky brightening, increased collision risk in orbit, dramatically increased atmospheric pollution from launches and reentries, and ground casualty risk from reentries. While in Aotearoa, New Zealand, on my sabbatical, I collaborated quite a bit with Dr. Michele Bannister, a Solar System small-body expert and dark-sky advocate, and Dr. Laura Revell, an atmospheric chemist. While most of our discussions were focused around atmospheric pollution, the most unknown and potentially most consequential issue from the billionaire space race, we all agreed that the most headline-generating, attention-grabbing issue is re-entries of space debris.

I have firsthand experience with this: when a SpaceX *Crew Dragon* trunk re-entered over Canada, and terrifyingly large pieces fell on farmland near Ituna, Saskatchewan[1], in early May 2024, I received an email inquiry from a local journalist, as I often do, because I am the only full-time research astronomer in Saskatchewan. But this one was different from the usual email about astronomical events or *Starlink* sightings. The email said a local farmer thought he had found a piece of space debris.

Little did I know that this would lead to me learning a heck of a lot about international law and treaties that govern "space objects" set down during the Apollo era. The Outer Space Treaty and Space Liability Convention were written in a time when the governments of the U.S. and the U.S.S.R were the only ones launching anything into space. It's not even clear how they apply to private companies. But space debris from SpaceX, a U.S.-based, billionaire-owned, for-profit corporation, is falling around the world, including on Canada.

In 2024 alone, two SpaceX spacecraft dropped potentially lethal debris on Saskatchewan. There is now an official Senate inquiry into this and other unsafe practices now happening in orbit[2]. It's unclear where this will all lead, but with more than 10,000 satellites in just one megaconstellation (*Starlink*) orbiting above our heads today, we're going to have a lot more debris coming down in the near future.

So, back to my New Zealand collaboration: We spent a lot of time bemoaning the fact that none of us have research funding for satellite pollution studies, even though it's a rapidly growing, severely consequential area. In New Zealand, there is a concerted push by the government toward large-scale cattle and dairy farming (this is true to a lesser degree in Canada, as well). While enjoying New Zealand cheese, we decided that we should milk this particular situation as much as we could by writing a paper convolving the two issues. Astronomy has a fine tradition of April Fool's Day papers, and because I was leaving New Zealand on April 3, we took the bull by the horns.

The three of us wrote "Cow-culation: Reentry Impact Risk to Livestock in the Satellite Megaconstellation Era"[3]. This paper was heavily based on excellent public code[4], which did a much more careful job of calculating casualty risks from several different megaconstellations. They assumed that one potentially lethal piece of debris survives from each reentry. This is not a terrible assumption: *Starlink* satellites are designed to "fully demise," which means they are supposed to burn up completely. However, one *Starlink* piece (large enough to be potentially lethal) was discovered in Saskatchewan in 2024[5].

Saskatchewan is the easiest place in the world to find space debris: more than 50 percent of the land area is for large-scale grain and legume field crops, which requires the land to be completely denuded or reduced to stubble at least once a year. Any debris that falls here will be easy to find. If that *Starlink* piece had fallen a little further west, in the mountains of B.C., or a little further east in the woods of Ontario or Québec, it never would have been found. So, the fact that there is one piece of a *Starlink* satellite on the ground in the easiest place in the world to find it means it is very likely that more is surviving to impact the ground.

Satellite megaconstellations are on gridded, inclined orbits, which result in higher densities above certain latitudes, set by their orbital inclinations. (One of those high-density bands is around 50–54 degrees north and south, hence the increased likelihood of *Starlink* debris falling on Saskatchewan.) A couple of higher density bands due to *Starlink*'s orbital choices also fall over New Zealand.

The next step is to cow-culate how likely these falling pieces are to intersect with a target, which would have udderly disastrous results. The Wright et al. paper uses a realistic human population distribution model and human cross-section. We did a much messier version of this using data from the UN about the distribution of both dairy cows and beef cattle just in New Zealand.

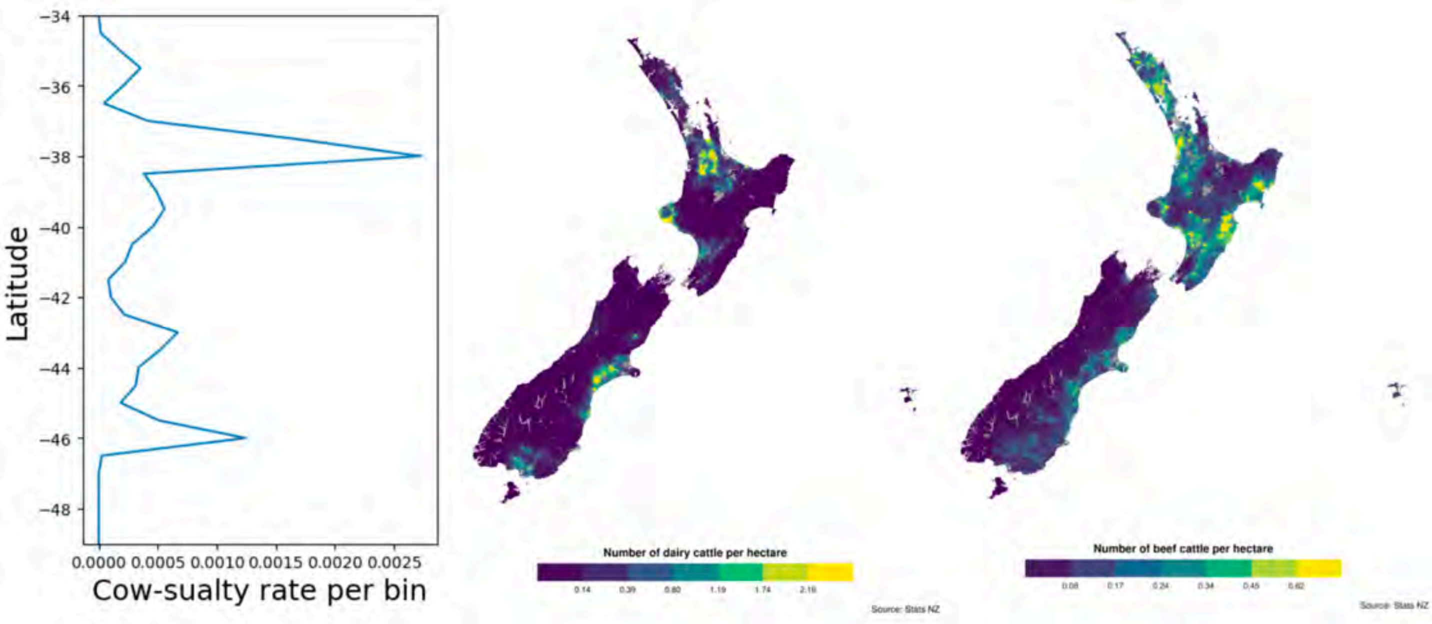

*Figure 1 — The left panel shows the cow-sualty rate per latitude bin per **Starlink** Gen2 five-year life cycle, while the right two panels show the 2022 New Zealand livestock density for dairy cows and beef cattle respectively. Credit: Lawler et al. (2026).*

Like many classic physics problems, we, of course, were required to assume a spherical cow, with cross section μ (mu). (We also considered calculating this value for sheep, which would naturally be λ lamb-da, but we ran out of time.) We find that there is between a 0.3 percent to 1 percent chance of a cow-sualty using 30,000 Gen2 *Starlink* satellites. The steaks are actually much higher than we expected!

Time to ruminate: This is a very silly paper about a very serious topic. It shows very clearly that the fast megaconstellation duty cycle of five years and tens of thousands of satellites could have actual deadly consequences on the ground, and not just for humans. If the satellites are indeed fully demisable as claimed, that's good for ground casualty risks, and terrible for atmospheric pollution. The only solution here is to accept that there are hard limits to how many satellites can orbit Earth without dire environmental consequences, and that require corporations to stay within those limits. If companies do not follow these limits voluntarily, the bull-in-a-china-shop scenario of Kessler Syndrome will force limits in the worst possible way, and humanity could completely lose the ability to use satellites in the future. ✶

The October 2026 *Journal* deadline for submissions is 2026 August1.

See the published schedule at rasc.ca/sites/default/files/jrascschedule2026.pdf

Endnotes

1 Lawler (2024). A New, Deadly Era of Space Junk Is Dawning, and No One Is Ready. *Scientific American.*

2 See sencanada.ca/en/senators/simons-paula/interventions/689271/41 for more information about this ongoing inquiry initiated by Senator Paula Simons.

3 Lawler, Bannister, and Revell (2026). Cow-culation: Reentry Impact Risk to Livestock in the Satellite Megaconstellation Era. *arXiv*. DOI: 10.48550/arXiv.2603.29324

4 Wright, Boley, & Byers (2026). Satellite megaconstellations and collective casualty risks. *Journal of Space Policy*. DOI: 10.1016/j.spacepol.2026.101749

5 See www.cbc.ca/news/canada/saskatchewan/2nd-piece-of-space-junk-landed-on-saskatchewan-farmland-in-2024-1.7502192

Sam Lawler is an associate professor of astronomy at the University of Regina. She studies the orbits of small bodies in the outer Solar System, and increasingly studies and advocates for regulation of the thousands of new artificial satellites streaking through her research images, crawling across her huge prairie skies, and crashing onto nearby farmland. She's active on Mastodon@sundogplanets@mastodon.social and BlueSky@sundogplanets.mastodon.social.ap.brid.gy

John Percy's Universe

Cepheids

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Cepheid pulsating variable stars—Cepheids—are young, massive stars of moderate surface temperature which are thermodynamically unstable to in-and-out vibrations or *pulsations.* These produce periodic brightness variations that astronomers have followed for up to a century or more. In this column, we shall emphasize the human-interest aspects of the topic. You can find the gory details on Wikipedia or in my book *Understanding Variable Stars* (Cambridge 2007).

Edward Pigott discovered the variability of the Cepheid eta Aql on 1784 September 10; John Goodricke did likewise for delta Cep a few weeks later. Goodricke tends to be better known than Pigott; he dealt with disability and illness and died at the tragic age of 21, but not before being elected a member of the Royal Society of London. But keep in mind that the discovery of variable stars may have been made by earlier civilizations that may not have "published" that knowledge in the same ways that Western science now does (Neilson 2026).

Observations of delta Cep continued. In 1884, with regard to variable stars in general, German astronomer Friedrich Argelander issued a plea with regard to the observation of these stars: "could we be aided in this matter by the cooperation of a goodly number of amateurs, we would perhaps in a few years be able to discover laws in these apparent irregularities, and then in a short time accomplish more than in all the 60 years which have passed since their discovery." Well, it has taken more than "a few years" or "a short time," but the contributions of amateurs have certainly helped immensely.

By the mid-19th century, professional astronomers were developing a stronger interest in stellar astronomy and astrophysics. Harvard College Observatory (HCO) became active in these fields in a big way, thanks to philanthropy. HCO and its southern stations in Peru and South Africa amassed a collection of half a million photographic plates of the sky, for research on variable stars and other celestial objects.

Edward Pickering, HCO director from 1877 to 1919, was known for hiring mostly women as research assistants or "computers," as they were called in those days. They generally worked harder and better than men and presumably received lower salaries. Several went on to make important discoveries, for which they were recognized and honoured: Adelaide Ames, Annie Jump Cannon, Williamina Fleming, Henrietta Leavitt, Antonia Maury, Cecilia Payne, and Helen Sawyer Hogg (Figure 1). The tale of HCO and of "Pickering's women" is brilliantly told by Dava Sobel in her book *The Glass Universe* (Viking 2016).

Figure 1 — Henrietta Leavitt **(third from left)** *is shown working among "the Harvard computers" who assisted astronomer Edward Charles Pickering at the Harvard College Observatory. Credit: Harvard College Observatory Archives. Public domain.*

Perhaps the most important of these discoveries was by Leavitt: the relation between the observed period of pulsation of a Cepheid and its absolute brightness. Leavitt studied 25 Cepheids in the Magellanic Cloud galaxies (out of a total of 1,777 variable stars therein). The observed period was correlated with the mean *apparent* brightness of these stars but, since all the stars were at roughly the same distance from us, the period was also correlated with the mean *absolute* brightness. If that relation could be calibrated, then a measurement of the observed period gave the absolute magnitude which, when compared with the observed apparent magnitude, gave the distance via the inverse-square law of brightness. It was not until a century after this work was done that the term *period-luminosity relation* was changed to *Leavitt Law.*

Delta Cep has a period of 5.37 days, a V amplitude of almost a magnitude, and a light curve that brightens more quickly than it fades. It is typical of Cepheids in general and is referred to as a "classical" Cepheid.

But there are other kinds. *Double-mode Cepheids* pulsate simultaneously in two different modes, usually the fundamental and the first overtone. They provide additional information about the properties of the star, notably its mass. There are *small-amplitude Cepheids.* Polaris is the prototype. Unusually, its V amplitude decreased from 0.12 to 0.02 between 1900 and 2000. It continues to pulsate. *Population II Cepheids* are old, low-mass supergiant stars that formed billions of years ago when elements heavier than hydrogen and helium were very rare in the Universe. *Anomalous Cepheids,* as the name suggests, don't fit any of these categories; their masses and evolutionary histories are ambiguous and/or uncertain. There are related objects, such as *RV Tauri stars*; they have Cepheid-like periods and alternating deep and shallow minima in their light curves.

Why do Cepheids Pulsate?

By the mid-20th century, atomic and nuclear physics had advanced to the point where this question could be addressed. The mechanism was the effect of the "ionization zones" of the elements hydrogen and helium. These are the layers in which the hydrogen and helium can change, during the pulsation cycle, from neutral to ionized and back again. When these are at a crucial distance below the surface of the star, they act as a "heat engine," absorbing radiant energy when the star is contracting, and releasing it when the star is expanding, thus driving the pulsation.

This Cepheid pulsation mechanism was first proposed by S.A. Zhevakin in the U.S.S.R. in the 1950s, and independently by Norman Baker and others in the west a few years later. (Remember that there was an almost-impenetrable "Iron Curtain" between the U.S.S.R. and the west in those days.)

Some Canadian Connections

When Helen Sawyer completed her doctoral studies at HCO, she married Frank Hogg, a Canadian. They then came to Canada where Frank was offered positions, first at the Dominion Astrophysical Observatory in Victoria in 1931, and then at the David Dunlap Observatory of the University of Toronto in 1935. In both places, Helen continued her studies of variable stars in globular clusters, including Population II Cepheids and related objects (Clement 2024).

Don Fernie joined the staff of the Dunlap Observatory in 1961 (Percy 2022). He became a world expert on Cepheids, and also served as National President of the RASC (as did Helen Sawyer Hogg). He co-authored several papers with his undergraduate research student, Sara Seager, who subsequently went on to a Ph.D. at Harvard, a professorship at MIT, a MacArthur "genius" award, and Honorary Presidency of the RASC. She will be returning to Canada this fall. See (1) for a comprehensive database of Don's observations.

Doug Welch began observing variable stars as an amateur astronomer in high school and is recently retired from McMaster University where he was a Department Chair, Vice-Provost, and Dean of Graduate Studies. Among his many important contributions to astronomy are extensive infra-red observations of Cepheids. He too has created a database of his observations (2).

David Turner, St. Mary's University, has published over 200 papers on various aspects of Cepheids, including their long-term changes in period, which can be used to measure their evolution as their radius (and therefore their period) changes.

Wendy Freedman, a Canadian now at the University of Chicago, shared the Gruber Cosmology Prize in 2009, largely for her work in refining and using the Leavitt Law for precision studies in cosmology—the age and distance scale of the Universe—using data from the *Hubble Space Telescope* and other facilities.

My fellow *JRASC* columnist Hilding Neilson has made important studies of the pulsating atmospheres of Cepheids, from which comes the light that we observe. This type of information is essential if we are to use Cepheids for precision cosmology.

And I have published a few papers on Cepheids myself!

Your Homework

If you have never observed variable stars before, I strongly recommend that you start by observing delta Cephei, if it's in season. There is a finding chart on page 296 of the 2026 RASC *Observers Handbook*. Delta Cep forms a nice little triangle with zeta Cep (visual magnitude 3.6) and epsilon Cep (visual magnitude 4.2). Estimate the magnitude of delta Cep relative to that of these two comparison stars. Continue your observations for long enough to detect the variability, and to perhaps even estimate the period of variability. ✶

Endnotes

1 www.astro.utoronto.ca/DDO/research/cepheids/cepheids.htm
2 https://dogwood.physics.mcmaster.ca/Cepheid/

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

Blast from the Past!

Compiled by James Edgar
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[This article, presented here in two parts, first appeared in the May–June 1907 issue of this *Journal*. Part 2 will be in the October *Journal*.]

Some Cosmical Aspects of Radioactivity.

By E. Rutherford.

The subject of my address this evening quite naturally divides itself into two parts): one dealing with the properties of the radioactive bodies themselves and the other with the distribution of radioactive matter throughout the surface of the earth, and throughout the volume of our atmosphere.

It is the latter division of the subject that I wish more particularly to discuss this evening, but before doing so, it may be advisable to mention briefly some of the more important properties of the radioactive bodies themselves, so that we may be able to judge of the methods employed to detect and measure the minute quantities of radioactive matter scattered throughout the earth and atmosphere.

I shall not speak here of the early history of Radioactivity, which is no doubt well known to most of my audience. As a result of a large amount of detailed investigation, a considerable number of distinct radioactive substances have been isolated. Among the best known of these are uranium, thorium, actinium, radium and polonium, and the numerous substances which arise from their transformation.

Of all the substances separated from uranium or thorium minerals, radium has occupied the most important position. This is partly due to the comparative ease with which it can be chemically isolated and purified, but mainly to its great activity or radiating power, which is about two million times as intense as that of uranium.

The distinguishing feature of radioactive bodies in general, is their power of spontaneously and continuously emitting special types of radiation, of giving out heat, and also in some cases of giving out light. These properties in the case of radioactive substances like uranium and thorium, continue, if not indefinitely, at any rate for periods of time measured by millions of years. In the case of radium, the duration of the activity is shorter, but is still measured by thousands of years. This emission of radiations is spontaneous and is completely independent of control, whether by physical or chemical agencies.

I shall take radium as an example of a typical radioelement, but it must be borne in mind that most of the other active substances possess similar radioactive properties. Radium emits three types of rays, called the α, β and γ rays. The α rays are distinguished by their slight power of penetration of matter. A thin sheet of notepaper suffices to cut off the α radiation completely. These rays have been shown to consist of heavy atoms of matter carrying a positive charge of electricity, expelled from the active substances at a speed of about 20,000 miles per second. It seems probable that the α particle consists either of a charged hydrogen or helium atom, and most probably the latter.

The β rays are more penetrating than the α rays and carry a negative charge of electricity and are projected from the active substance at a speed much greater than that of the α particle. Some of the β particles from radium escape with a speed nearly equal to that of light, or 186,000 miles per second. Their apparent mass is only about one thousandth of that of the α particle, and in fact they are identical with the electrons produced in the cathode ray discharge of a vacuum tube.

The γ rays possess extraordinary penetrating power, passing readily through several inches of iron. It is now fairly certain that the γ rays are ethereal waves similar in character to the well known Rontgen rays. only of a more penetrating kind. All of these types of radiation possess in common the properties of acting on a photographic plate and of producing phosphorescence in a certain class of substances, but from the point of view of measurement, their most important property is their power of causing the discharge of electricity from electrified bodies. This property is by far the most delicate test of radioactive matter and we shall consequently consider it in some detail. If we take an ordinary well-insulated gold-leaf electroscope and charge it so that the gold leaves diverge widely, it is well known that under ordinary conditions with good insulation, the leaves collapse extremely slowly, and over a few minutes' interval the leaves will appear to be almost stationary. Now·bring some radioactive matter near the exposed plate of the electroscope. The leaves at once commence to collapse rapidly. This is due to the loss of charge from the electrified system, and takes place with equal rapidity whether the charge is positive or negative. The mechanism by which this discharge is produced has been most carefully studied, and it is known that the effect is due to the property possessed by these radiations of making the volume of the air surrounding the electroscope, a partial conductor of electricity. The radiations in passing through a gas produce a number of positively and negatively charged carriers or "ions." These ions move in an electric field. If, for example, the electroscope is charged positively, the negative ions are drawn towards the charged system. The discharging effect is thus due to the drawing in of a great number of negatively charged ions to the positively charged conductor or vice versa. The moment the radioactive substance is removed, the rapid movement of the leaves at once ceases.

This property of the radiations of ionizing the air or other gas is an extraordinarily delicate test of the presence of radioactive matter. I bring up near the electroscope a watch glass on which has been evaporated a solution, containing only one millionth of a gram of radium bromide. The leaves collapse in a few seconds. If I place the watch glass on the plate attached to the electroscope, a charge given to the electroscope is almost instantly dissipated. The discharging effect in this case is due mostly to the α rays. This can be shown by placing a sheet of ordinary paper, which absorbs the α rays, over the watch glass—the rate of collapse of the leaves becomes now much slower. The residual discharging effect is then due to the β and γ rays from the small quantity of radium.

From the point of view of measurement, a millionth of a gram of radium produces far too large an effect. In practice, it is found that a quantity of radium measured by one thousand millionth (10^{-9}) of a gram produces an effect of magnitude suitable for accurate measurement. With care, in a suitably designed electroscope, it is possible to measure the presence of one hundredth of this latter amount and in some cases of one thousandth. The electroscope is thus capable of detecting by its increased rate of discharge a quantity of radium measuring 10^{-12} of a gram. As an agent for detecting minutest quantities of radioactive matter, the electroscope is far more sensitive than the spectroscope.

Such measurements do not of themselves throw any light upon the type of radioactive matter which produces the discharge. It would be difficult, for example, to be sure whether the radioactive matter present was radium, actinium or thorium. But there is another property of these substances which allows us to distinguish readily between them. Each of the substances, radium, thorium and actinium gives off steadily a radioactive "emanation" or gas which has very intense radioactive properties. If a current of air, for example, is passed over a thorium or actinium compound and then carried into an electroscope, a rapid collapse of the leaves is observed. This is due to the radiation from the emanation, which produces a large number of ions in the air with which it is mixed. In the case of radium, the emanation does not escape from a solid compound but is readily released by heat or by solution. I have here a solution of radium in a closed bottle. The emanation has collected in the air space above the solution, and on passing a. slow stream of air through the solution into the electroscope, some of this emanation is carried with it, and as you see, causes an extremely rapid discharge of the electroscope. If the emanation were left in the electroscope, it would preserve its discharging power for several weeks. The discharging effect would not be constant but would decrease to half value in four days, to one quarter value in eight days, and so on: and would still be appreciable after a month's interval. In fact, the radium emanation is an unstable substance which breaks up with the emission of α particles. On an average, half of it breaks up in four days. The emanations of thorium and actinium are chemically quite distinct from that of radium and can be at once distinguished from it by the rapid rate at· which their activity dies away with time. The emanation of thorium falls to half value in 54 seconds and that of actinium in 3.9 seconds.

The production of the radioactive emanation by radium offers an extremely simple and reliable method of determining not only whether radium is present, but also of measuring accurately the quantity present. Suppose, for example, that we wish to determine the amount of radium present in a given specimen of rock. This is dissolved and placed in an air-tight vessel and left for about one month. During this time the emanation collects in the solution and the air space above it, and reaches a steady equilibrium value where the rate of production of new emanation compensates for the disappearance of emanation due to its further transformation. The solution is then boiled, and the air mixed with emanation is passed into a suitable electroscope and the rate of movement of the gold leaves noted.

If the rate of discharge decreases to half its initial value after about four days, it is certain evidence that the radium emanation is present in the electroscope. The amount of radium in the rock is determined by treating in a similar manner a solution containing a *known* quantity of radium and observing the rate of discharge of the electroscope, produced by the emanation from it. By this method, we are not only able to detect the presence of radium in a substance, but also to determine the amount present with considerable accuracy. In this way, a quantity of radium in a solution of only 10^{-11} gram can be readily measured.

The emanation from radium is an unstable substance and breaks up into another substance which behaves as a solid and has quite distinct radioactive properties. The inside surface of a vessel containing the radium emanation becomes coated with an invisible deposit of radioactive matter. If the emanation is rapidly blown out by a current of air, this "active deposit," as it is called, remains behind. The activity of this deposit is not permanent but decays rapidly with the time. After several hours, the activity decreases in a geometrical progression falling to half value in about 28 minutes. For thorium, the active deposit loses half of its activity in 11 hours, for actinium in 34 minutes. The production of this characteristic active deposit from each emanation offers another very useful method of distinguishing whether thorium, radium or actinium is present.

An interesting property of the active deposit, which we shall see has played a notable part in the analysis of the radioactive state of the atmosphere, is its concentration on a negatively charged conductor in an electric field. The carriers of the active deposit become in some way positively charged and are drawn in to the negative electrode and adhere to it.

Radioactive State of the Amosphere.

I have now passed rapidly over some of the more important properties of radioactive bodies, which have proved of great utility in the attack on the question of the distribution of radioactive matter in the earth and atmosphere. The pioneers in this work were Professors Elster and Geitel, teachers in the Gymnasium of Wolfen-büttel, Germany, and to these investigators we owe a large amount of the information now collected in this important and rapidly growing branch of radioactivity.

Geitel had observed in 1900 that the open air possessed the property of causing a slow discharge of an electroscope, and showed that this effect was due to the production of positive and negative ions in the air. In seeking for a possible cause of this effect, it occurred to Elster and Geitel that it might be due to the presence of some radioactive matter in the atmosphere. They then tried an extremely bold experiment. I have shown you that the emanations from the radioactive bodies produce an active deposit, which can be concentrated on a negatively charged wire. If any radioactive emanation were present in the atmosphere, the active deposit should collect on a negatively charged wire exposed in it. An insulated wire 20 or 30 metres long (Fig. 1) was strung outside a laboratory window and kept charged negatively to a potential of several thousand volts by means of a battery or electrical machine. After several hours, the wire was rapidly removed, coiled round a frame attached to the electroscope, similar to that shown in Fig. 2, and the rate of discharge of the electroscope observed. The gold leaf was found to collapse rapidly, indicating that some radioactive matter was present upon the wire. The magnitude of this effect was independent of the material of the wire and was conclusively shown to be due entirely to the presence of radioactive matter on its surface.

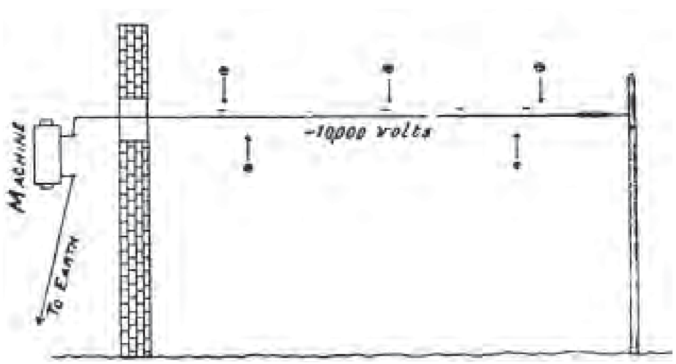


Figure 1 —Earth

We must next consider how to determine the kind of radioactive matter concentrated upon the wire. In the first place, it is improbable that particles of the solid radioactive bodies like radium, uranium or thorium should be present in the atmosphere. But the emanations from radium, thorium and actinium are gaseous, and if the earth contains these substances, we might reasonably expect that some of the emanation released from them might escape into the atmosphere. We have at once a means of definitely settling this question. If the radium emanation alone is present in the atmosphere, the active deposit collected on the wire should decay at the rate characteristic of radium, *i.e.*, after some hours, the activity should decay exponentially decreasing to half value every 28 minutes. The rate of decay of the active deposit from the air has been shown to be very similar to this, so we conclude that the radium emanation is present in the atmosphere.

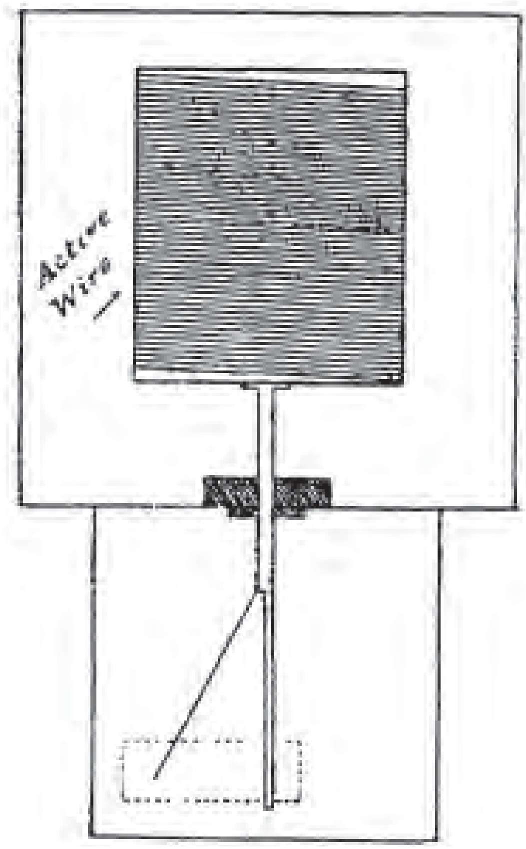


Figure 2

The experiment of Elster and Geitel in Germany was repeated by Rutherford and Allan in Montreal and by Professor McLennan in Toronto and the results showed that the air of Canada is as radioactive as that of Germany. Falling rain, or snow is also radioactive, and its activity decays at the characteristic rate to be expected if the falling rain or snow collects upon it the active deposit of radium distributed throughout the atmosphere.

Preliminary experiments showed that most of the radioactive effect of the atmosphere was due to the presence of the radium emanation. Bumstead, in New Haven, and Blanc, in Italy, have however clearly shown that in these localities some thorium emanation is also present. This can be tested in a very simple way. A wire is made active by exposure as negative electrode to the open air for several days. On removal, part of the activity due to the active deposit of radium decays rapidly. After 5 or 6 hours, an activity still remains which decays much more slowly, decreasing to half of its value every 11 hours. This is the rate of decay characteristic of the active deposit of thorium and shows that the thorium emanation must also be present in the atmosphere. In some parts of Italy, Blanc has recently shown that fully 70 percent of the activity on the wire must be ascribed to thorium, but apparently the effect due to radium predominates in most other localities.

We may consequently conclude that the atmosphere over the surface of the earth contains everywhere small quantities of the radium and thorium emanation and also the active substances arising from their transformations *in situ* in the atmosphere. The amount of ionization thus produced is small, but can be accurately measured by apparatus specially designed by Ebert for the purpose. By means of a fan driven by a spring motor, a steady current of air is drawn between two concentric cylinders. The inner insulated cylinder is charged and connected with an electroscope. As the ionized air passes between the cylinders, the ions are removed by the strong electric field between them. The rate of discharge of the electroscope serves as a measure of the number of ions per cubic centimetre of the volume of outside air. In the open air, there are usually about 1,500 ions per c.c. of the air; the number is not constant but fluctuates considerably. This number of ions present in the atmosphere is extraordinarily small compared with the number of un-ionized molecules. Each cubic centimetre of air contains about 4×10^{19} molecules, so that on an average only an infinitesimal proportion of the molecules are ionized at one time. While this ionization appears very insignificant, needing a delicate electroscope to detect and measure it, yet it has a very important bearing on the electrical state of the atmosphere.

We must bear in mind that all of us are continuously inhaling the radium and thorium emanations and their products, and ionized air. In addition we are continuously undergoing a type of mild X-ray treatment, for the β and γ rays from the earth and atmosphere continuously pass into and through our bodies. We are in fact, subjected to a continuous bombardment by the radiations from active matter and are fortunately quite unaware of it. Some have considered that possibly the presence of radioactive matter and ionized air in the atmosphere may play some part in physiological processes, but this is a question quite outside the scope of my address.

An examination of the electrical state of the atmosphere shows that the upper atmosphere is nearly always positively charged, so that the earth must be negatively electrified. There is consequently an electric field normal to the earth which causes a steady movement of the positive ions in the air towards the earth and a corresponding movement of negative ions upwards. The latter must tend to dissipate rapidly the positive electricity in the upper atmosphere.

There are many theories as to the origin and maintenance of the positive charge in the upper atmosphere. One very plausible hypothesis, supposes that the electrical state of the atmosphere largely results from the radioactive matter distributed throughout it. The appearance of positive electricity in the upper atmosphere is in this view due to the effect of falling rain carrying the negative charge to earth; for it is found that rain is always negatively electrified. The presence of an ionized layer of gas between the upper atmosphere and the earth tends continually to dissipate the positive charge left behind, and this ordinarily prevents the increase of positive electricity to the danger limit, when lightning discharges would pass to the earth. It thus appears probable that the insignificant amount of radioactive matter in the atmosphere plays an important role in causing and controlling the electrical state of the atmosphere.

Amount of Radium Emanation in the Atmosphere.

The amount of radium emanation in the air per cubic centimetre of its volume is extremely small but can be measured by several methods. This problem has been attacked by A. S. Eve of Montreal, who found that a cubic kilometre of the atmosphere contains an amount of emanation equivalent to that liberated from about half a gram of radium bromide in radioactive equilibrium. Assuming that the amount of emanation in the air over the land surface of the globe is about the same as in the neighbourhood of Montreal, and that on an average, this distribution is uniform over a height of ten kilometres of the atmosphere, he concluded that the total amount of radium emanation in the atmosphere was equal to that liberated from about 200 tons of radium bromide in equilibrium. It is probable that the amount of radium emanation over the sea is less than that over the land, and is mainly conveyed there by winds from the land, but there is still some uncertainty on that important question.

As I mentioned before, it is extremely improbable that much solid radium in the form of fine particles exists in the air, so that for the supply of emanation to the atmosphere we must look to some external source. We shall now discuss the evidence which leads us to believe that the supply of emanation to the atmosphere is kept up by its steady escape from the surface crust of the earth. ✶

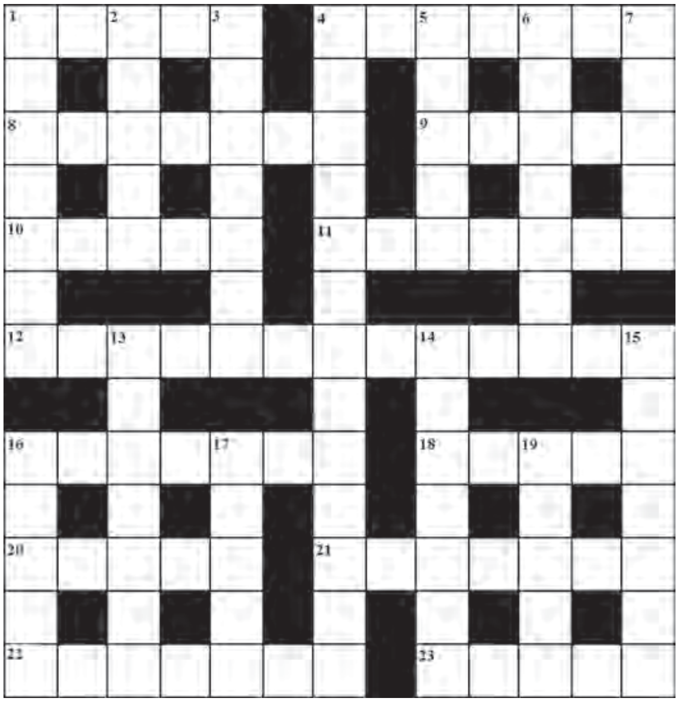
[See https://en.wikipedia.org/wiki/Ernest_Rutherford,

Ernest Rutherford held a professorship at McGill University, Montréal, at the time of this paper.]

[This article is continued as Part 2 in the October 2026 *Journal*.]

Astrocryptic

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



ACROSS

1. Tin and aluminum not really detected on Mars (5)
4. Obsessive compulsive bad actor holed up on a dwarf (7)
8. Figure seen brightest in the reticle (7)
9. Roundabout way travelled by a ball, it follows (5)
10. Astrological trine resolved to be like Krypton (5)
11. NY blade runners were an aid to Moon landings (7)
12. Organic acid appears after whirling in great space beyond M31 (13)
16. Media detective found a gap in the ring (7)
18. Ants return with nothing missing in an empty gutter like the Sun (1,4)
20. I hear a reply straight from the fox's mouth (5)
21. Ten Latin dances anti-sunward from Halley (3,4)
22. Ilium warriors safely preceding Jupiter (7)
23. Planetary occultations reported by some macabre Italian (5)

DOWN

1. Back in the clinic, Rick learns about the compasses (7)
2. Remorseful woman nominally 71 in the belt (5)
3. Somehow bolster your image of NGC 6357 (7)
4. Raves about conservatives after hot stars seen in these places (13)
5. Refractive glass atop a queen (5)
6. Country Ernest and alien with time for a great comet (7)
7. Going prices to see eastern star twinkling (5)
13. Found duffer's lost tee around Saturn (7)
14. Bengali horsing around home on the autumn diamond (7)
15. Fish head seen round the start of Thanksgiving (7)
16. Derisive laugh heard in court when a star map was produced (5)
17. Lunar terrain observed by Ms. Mitchell (5)
19. Man from Mars eating car in reverse seen by solar observatory (5)

Answers to previous puzzle

Across: **1** THEBE (anag); **4** STARMUS (star(mu)s); **8** ORTHO (hid); **9** PEGASUS (PE+anag); **10** BIPOLAR (2 def); **11** EMILY (anag); **12** ROMAN NUMERALS (anag); **15** COROT (anag-D); **16** ERIDANI (anag); **18** MINTAKA (mint+aka); **20** CARME (anag); **21** CHRISTY (Christ+Y); **22** SWANS (3 def)

Down: **1** T COR BOR (anag); **2** ESTOP (hid); **3** EXOPLANET (ex+o+plan+ET); **4** SUPERNUMERARY (2 def); **5** AFG (2 def); **6** MUSCIDA (Musc(ID)a); **7** SISSY (hid); **11** EYEPIECES (anag (spicyEEEE); **13** MARINER (2 def); **14** SPIDERS (2 def); **15** COMIC (chromic-hr); **17** ATRIA (hid); **19** AAS (2 def)

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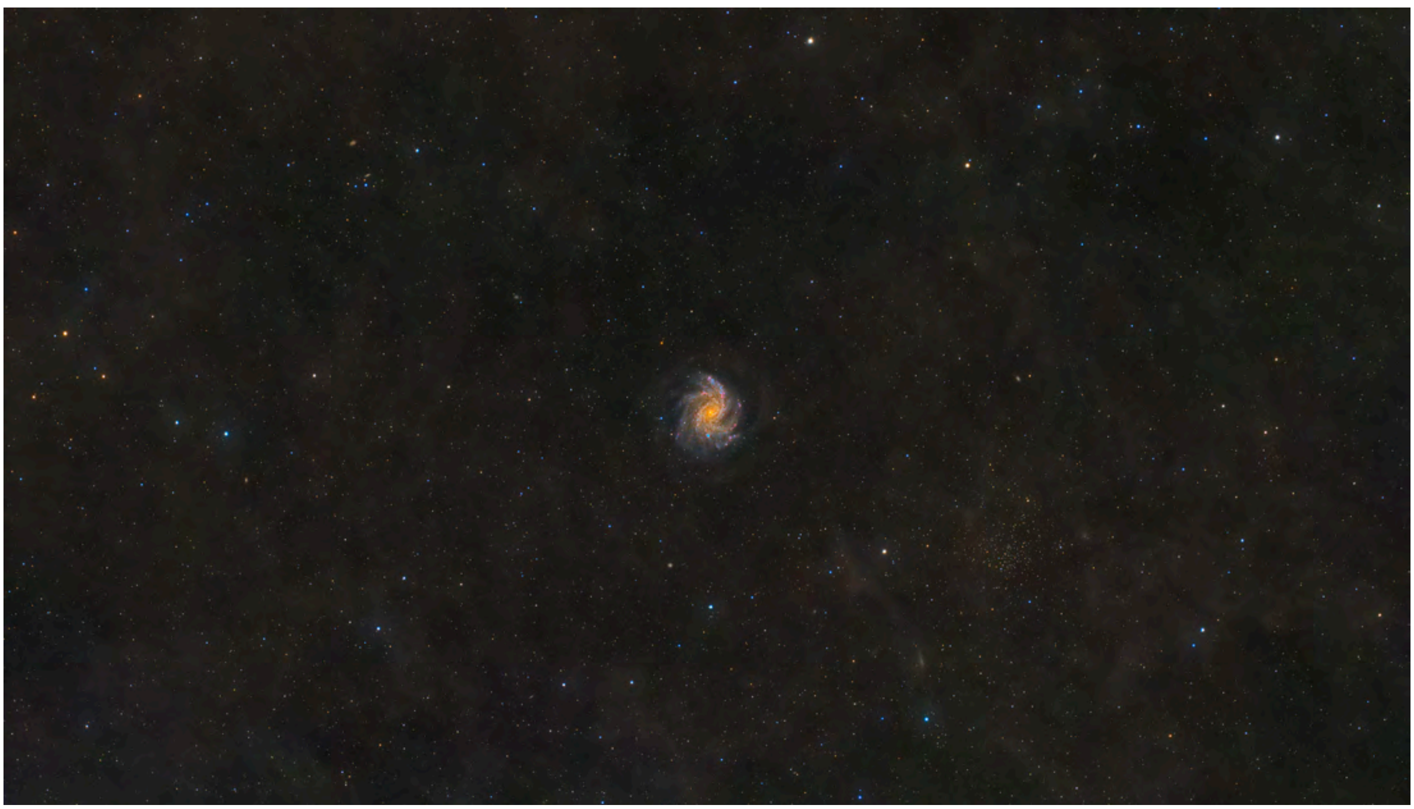
Values

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

Great Images

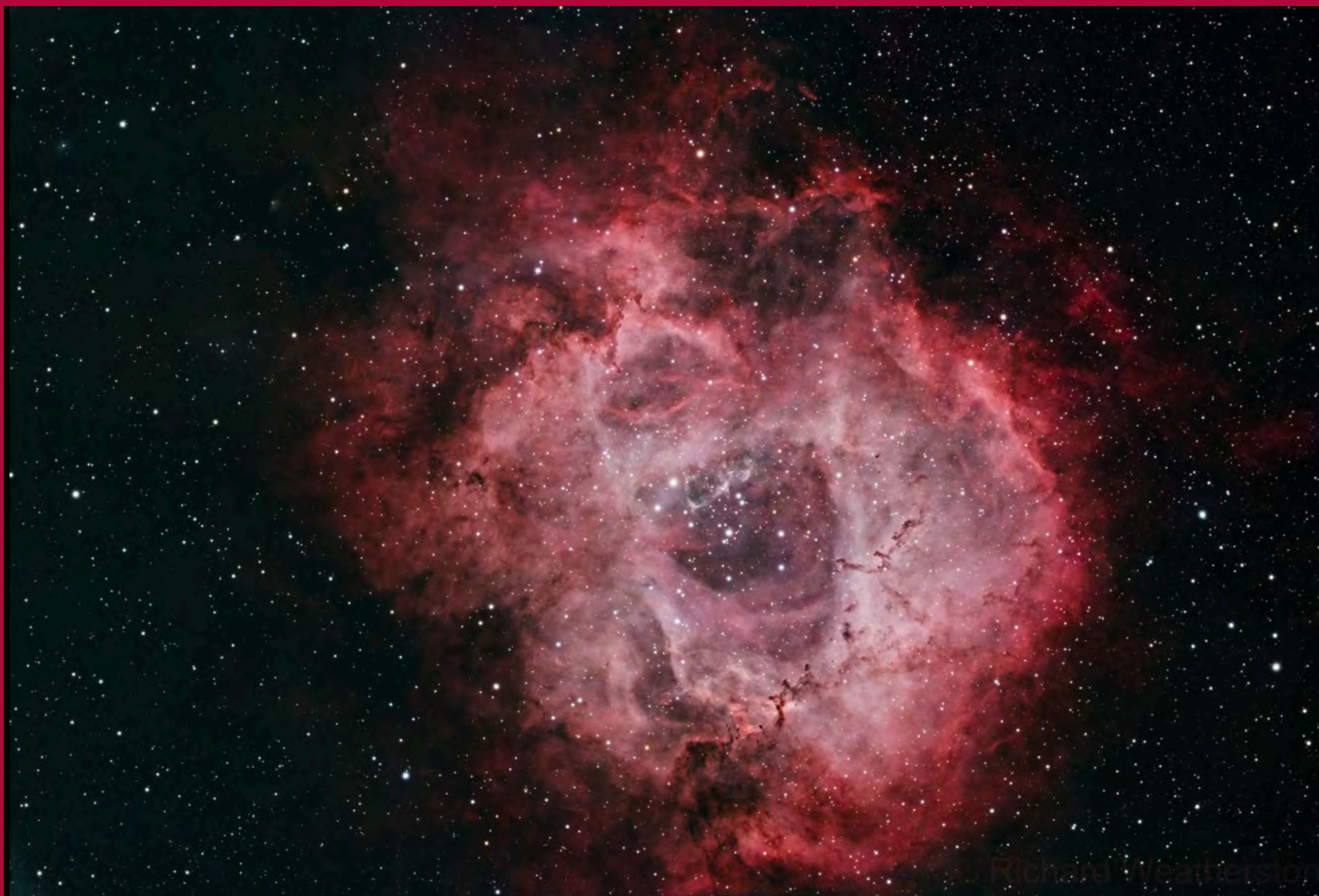
By Michele Rainville



Michele Rainville writes: NGC 6946 (Fireworks Galaxy) is known for its unusually high supernova rate and patchy, star-forming spiral arms. The galaxy is framed wide to emphasize the vastness of space and the sense of scale and wonder it evokes. I also intentionally keep the surrounding dust to a minimum to draw attention to the beautiful starfield.

This was a traveller project over several months to gather a total of 11 hours of data from the same location in Alton, Ontario. (MRASC darkish sky observing/imaging star party(s))

Gear: ZWO FF65, ASI2600MC Pro on an iOptron GEM28, ASIAir Plus with EAF, WO UniGuide 32 with ASI120MM Mini, and an Astronomik 2" UV/IR-cut L3 filter in a ZWO M48 drawer.



Journal

Richard Weatherston obtained this image of the Rosette Nebula (Caldwell 49), from his home in Sutton, Ontario. He used a Starfield ED102 scope and a ZWO ASI2600MC DUO camera on a Celestron Advanced VX mount. Processed 1h 51 min of data with Adobe Lightroom Mobile, PixInsight, and ZWO ASIAIR.