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Journal

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PROMOTING ASTRONOMY IN CANADA

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Inside this issue:

Majestic Magellanic Cloud

Great Images

by Janice Mannering

The Pleiades are a winter favourite, and Janice Mannering captures their magnificence in this image. Janice used a Canon T5i with a 200 mm L series lens and an iOptron SkyGuider Pro Mount. She used Deep Sky Stacker and Star Tools to process.

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Royal Astronomical Society of Canada

Société Royale d'Astronomie du Canada

contents / table des matières

Feature Articles / Articles de fond

Columns / Rubriques

Departments / Départements

The Large Magellanic Cloud shot by the Kerry-Ann Lecky Hepburn. For this image, Kerry-Ann collected 65 x 1 minute frames as well as dark and flat frames with her unmodified Canon 6D and used one of her favourite lenses, the Canon 100-mm macro lens at ƒ/2.8, ISO 1600. The frames were then stacked in Pixinsight, and post-processed in Photoshop and Lightroom.

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

by Chris Gainor, Ph.D.
(cgainor@shaw.ca)

Canada, as we all know, is an experiment in federalism, bringing together people of different backgrounds living over vast expanses. I also consider The Royal Astronomical Society of Canada to be its own experiment in federalism.

The RASC is a national society and also a federation of 28 Centres across this country, along with a good number of unattached members. Although the RASC got its start 150 years ago in Toronto as a simple astronomy club, for most of its history it has consisted of a number of Centres under a national umbrella.

Until five years ago, the national Society was governed by a National Council composed of representatives from every Centre. That system worked very well for the RASC, but the federal government chose to pass legislation with the aim of increasing accountability for non-profit organizations. Although this legislation arose out of concerns about other organizations, the RASC had no choice but to change its governance structure.

Today, we have a Board of Directors that is accountable to every member of the Society, and we retain our National Council and its Centre representatives in an advisory role. Both the Board and the Council have tried to ensure that the voices of our Centres continue to be heard in the running of the national Society.

At the 2018 General Assembly in Calgary, National Council focused on how to revitalize itself. This fall National Council will be putting flesh on the bones of the plan that emerged in Calgary that envisions a Council operating with more freedom in relation to the Board and meeting more often.

I imagine it will take some time for everyone to adjust to a more vigorous National Council. I welcome this change. Like most of my fellow Board members, I have served the RASC at the Centre level before moving on to the national level.

Much of the work the Society does directly benefits the Centres and the people who run them, including collecting dues, managing membership records, and providing insurance for Centre events.

We are always looking for new ways to help out our Centres. Our Executive Director Randy Attwood has called on his vast experience at the Centre level to create a manual designed to help Centre executives do their jobs.

We in the RASC know we can do better. At the Calgary General Assembly, for example, we were reminded that many of our friends in Québec could be better served by the Society.

Today I continue to attend as many membership and Council meetings as I can at my home Centre in Victoria, and I take part in other Centre activities such as public outreach events.

I always enjoy visiting Centres other than my own. These visits help me keep in touch with what is going on around the country, and I find that I always learn something that will benefit other Centres, I usually get some good tips about astronomy as well.

Both the RASC and Canada are works in progress. Most importantly, they both exist because together they are much greater than the sum of their parts. ✶

News Notes / En Manchette

Compiled by Jay Anderson

No tariffs on this aluminum

Astronomers using the Atacama Large Millimetre/submillimetre Array (ALMA) in Chile and the Northern Extended Millimetre Array (NOEMA) in France have made the first definitive detection of a radioactive molecule in interstellar space: an isotope of aluminum. The team, led by Tomasz Kamiński (Harvard-Smithsonian Center for Astrophysics, Cambridge, USA), used the ALMA and NOEMA to detect a source of the radioactive isotope aluminium-26.

The observations reveal that the isotope was dispersed into space after the collision of two stars that left behind a remnant known as CK Vulpeculae, which is about 2000 light-years from Earth. This is the first time that a direct observation has been made of this element from a known source. Previous identifications of the isotope have come from the detection of gamma rays, but their precise origin had been unknown.

CK Vulpeculae was discovered in 1670 by the French astronomer Anthelme Voituret, appearing as a naked-eye, bright, red, new star. It was extensively observed by the French astronomer Jean Dominique Cassini and the Polish mapmaker and astronomer Johannes Hevelius. For many years, it was believed to be a nova and was given the designation Nova Vulpeculae 1670. The star faded quickly and now requires large telescopes to see the remains of the merger, a dim star surrounded by a halo of glowing material that is flowing away from it. In March 2015, CK Vulpeculae was identified as the remnant of stellar merger.

After the initial event was observed, 348 years later, the remains of this explosive stellar merger have led to the clear and convincing signature of aluminium-26. This is the first unstable radioactive molecule definitively detected outside of the Solar System. Unstable isotopes have an excess of nuclear energy and eventually decay into a stable form.

"This first observation of this isotope in a star-like object is also important in the broader context of galactic chemical evolution," notes Kamiński. "This is the first time an active producer of the radioactive nuclide aluminum-26 has been directly identified."

Kamiński and his team detected the unique spectral signature of molecules made up of aluminum-26 and fluorine (^{26}AlF) in the debris surrounding CK Vulpeculae. As these molecules spin and tumble through space, they emit a distinctive fingerprint of millimetre-wavelength light, a process known as rotational transition. Astronomers consider this the "gold standard" for detections of molecules.

Like all other properties of a quantum particle, angular momentum in a rotating molecule can only take on certain

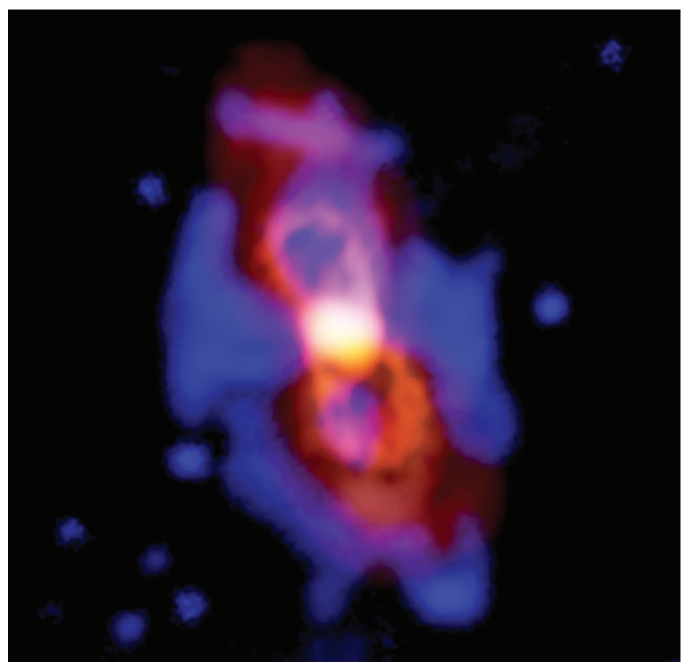

Figure 1 — Composite image of CK Vulpeculae, the remains of a double-star collision. This impact launched radioactive molecules into space, as seen in the orange double-lobe structure at the centre. This is an ALMA image of 27-aluminum monofluoride, but the rare isotropic version of AlF resides in the same region. The red, diffuse image is an ALMA image of the broader dust in the region. The blue is optical data from the Gemini observatory. Image: ALMA (ESO/NAOJ/NRAO), T. Kamiski; Gemini, NOAO/AURA/NSF; NRAO/AUI/NSF, B. Saxton

discrete values, each one corresponding to particular energy state. When a particle loses angular momentum, it transitions to a lower rotational energy state and the excess energy is emitted to space.

Rotational transitions are important in physics due to the unique spectral lines that result. Because there is a net loss of energy during a transition, electromagnetic radiation of a particular frequency must be emitted. This emitted radiation forms spectral lines at a characteristic frequency that then can be detected with a spectrometer.

The observation of this particular isotope provides fresh insights into the merger process that created CK Vulpeculae. It also demonstrates that the deep, dense, inner layers of a star, where heavy elements and radioactive isotopes are forged, can be churned up and cast into space by stellar collisions.

"We are observing the guts of a star torn apart three centuries ago by a collision," remarked Kamiński.

The astronomers also determined that the two merged stars were of relatively low mass, one being a red-giant star with a mass somewhere between 0.8 and 2.5 times that of our Sun.

Aluminium-26 will decay to become more stable and in this process one of the protons in the nucleus decays into a neutron. During this process, the excited nucleus emits a photon with very high energy, which we observe as a gamma ray.

Previously, detections of gamma-ray emission have shown that around two solar masses of aluminium-26 are present across the Milky Way, but the process that created the radioactive atoms was unknown. Furthermore, owing to the way gamma rays are detected, their precise origin was also largely unknown. With these new measurements, astronomers have definitively detected for the first time an unstable radioisotope in a molecule outside of our Solar System.

At the same time, however, the team have concluded that the production of aluminium-26 by objects similar to CK Vulpeculae is unlikely to be the major source of aluminium-26 in the Milky Way. The mass of aluminium-26 in CK Vulpeculae is roughly a quarter of the mass of Pluto, and given that these events are so rare, it is highly unlikely that they are the sole producers of the isotope in the Milky Way Galaxy. This leaves the door open for further studies into these radioactive molecules.

Prepared with material provided by ESO.

Astronomers find exoplanet twins

Doppelgänger: in German folklore, a wraith or apparition of a living person.

Scientists, using the Gemini telescope, have imaged a new planet, and it appears nearly identical to one of the best studied gas-giant planets. But this doppelgänger differs in one very important way: its origin. As Trent Dupuy, astronomer at the Gemini Observatory and lead author of the study noted, "We have found a gas-giant planet that is a virtual twin of a previously known planet, but it looks like the two objects formed in different ways"

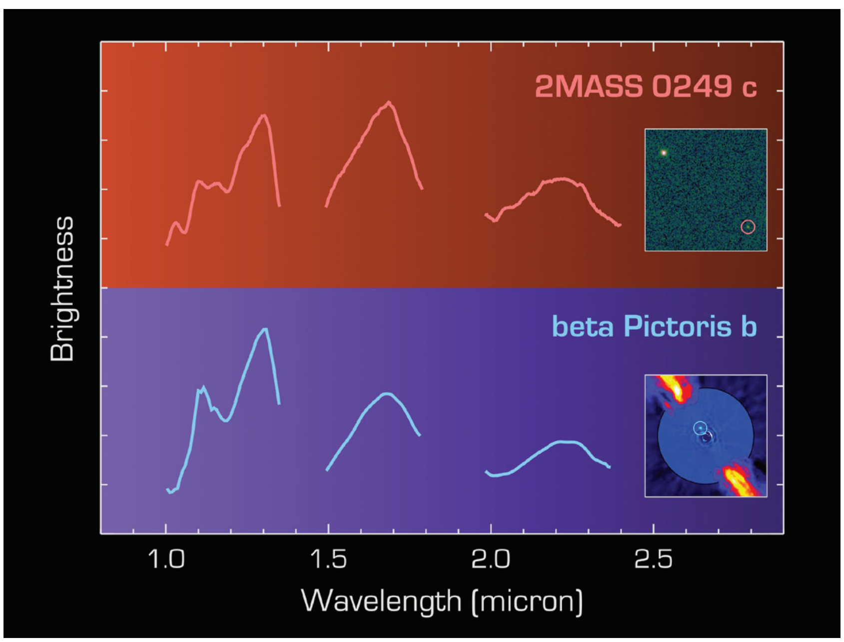

Figure 2 — The infrared spectra of 2MASS 0249 c (top) and beta Pictoris b (bottom) are very similar, as expected for two objects of comparable mass that formed in the same stellar nursery. Unlike 2MASS 0249 c, beta Pictoris b orbits much closer to its massive host star and is embedded in a bright circumstellar disk. The insets show images of the two systems. Image: T. Dupuy, ESO/A.-M. LaGrange et al.

Emerging from stellar nurseries of gas and dust, stars are born like kittens in a litter, in bunches and inevitably wandering away from their birthplace. These litters comprise stars that vary greatly, ranging from tiny runts incapable of generating their own energy (called brown dwarfs) to massive stars that end their lives with supernova explosions. In the midst of this turmoil, planets form around these new stars. And once the stellar nursery exhausts its gas, the stars (with their planets) leave their birthplace and freely wander the Milky Way.

Because of this exodus, astronomers believe there should be planets born at the same time from the same stellar nursery, but now are orbiting stars that have moved far away from each other over the eons, like long-lost siblings.

"To date, exoplanets found by direct imaging have basically been individuals, each distinct from the other in their appearance and age. Finding two exoplanets with almost identical appearances and yet having formed so differently opens a new window for understanding these objects," said Michael Liu, astronomer at the University of Hawaii Institute for Astronomy, and a collaborator on this work.

Dupuy, Liu, and their collaborators have now identified the first case of such a planetary doppelgänger. One object has long been known: the 13-Jupiter-mass planet beta Pictoris b, one of the first planets discovered by direct imaging, back in 2009. The new object, dubbed 2MASS 0249 c, has the same mass, brightness, and spectrum as beta Pictoris b. The systems belong to the beta Pictoris moving group, a widely dispersed set of stars named for its famous planet-hosting star.

After discovering this object with the Canada-France-Hawaii Telescope (CFHT), Dupuy and collaborators then determined that 2MASS 0249 c and beta Pictoris b were born in the same stellar nursery. On the surface, this makes the two objects not just lookalikes but genuine siblings.

However, the planets orbit vastly different types of stars. The host for beta Pictoris b is a star 10 times brighter than the Sun, while 2MASS 0249 c orbits a pair of brown dwarfs that are 2000 times fainter than the Sun. Furthermore, beta Pictoris b is relatively close to its host, about 9 astronomical units (AU), while 2MASS 0249 c is 2000 AU from its binary host.

These drastically different arrangements suggest that the planets' upbringings were not at all alike. The traditional picture of gas-giant formation, where planets start as small rocky cores around their host star and grow by accumulating gas from the star's disk, likely created beta Pictoris b. In contrast, the host of 2MASS 0249 c did not have enough of a disk to make a gas giant, so the planet likely formed by directly accumulating gas from the original stellar nursery.

"2MASS 0249 c and beta Pictoris b show us that nature has more than one way to make very similar looking exoplanets," says Kaitlin Kratter, astronomer at the University of Arizona and a collaborator on this work. "beta Pictoris b probably formed like we think most gas giants do, starting from tiny dust grains. In contrast, 2MASS 0249 c looks like an underweight brown dwarf that formed from the collapse of a gas cloud. They're both considered exoplanets, but 2MASS 0249 c illustrates that such a simple classification can obscure a complicated reality."

The team first identified 2MASS 0249 c using images from CFHT; repeated observations revealed this object is orbiting at a large distance from its host. Later observations using W.M. Keck Observatory's Near-Infrared Camera, second generation (NIRC2), and laser guide-star adaptive optics determined that the host is actually a closely separated pair of brown dwarfs.

Altogether, 2MASS J0249–0557ABc is a bound triple system with an 11.6 $M_{Jupiter}$ object separated by 1950 AU from a relatively close pair of 48 $M_{Jupiter}$ and 44 $M_{Jupiter}$ objects.

"We were surprised to learn that this doppelgänger planet is orbiting a binary," said Dupuy. "It's the first brown dwarf binary in the beta Pictoris moving group, and one of only a handful of brown dwarf binaries known among all the young moving groups."

Follow-up spectroscopy of 2MASS 0249 c with the NASA Infrared Telescope Facility and the Astrophysical Research Consortium 3.5-metre Telescope at Apache Point Observatory demonstrated that it shares a remarkable resemblance to beta Pictoris b.

The 2MASS 0249 system is an appealing target for future studies. Most directly imaged planets are very close to their host star(s), inhibiting detailed studies of the planets due to the bright light from the star(s). In contrast, the very wide separation of 2MASS 0249 c from its host binary will make measurements of properties like its surface weather and composition much easier, leading to a better understanding of the characteristics and origins of gas-giant planets. This pair of directly imaged objects provides a unique opportunity to measure atmospheric composition, variability, and rotation across different pathways of planetary assembly.

Prepared with material provided by the W.M. Keck Observatory

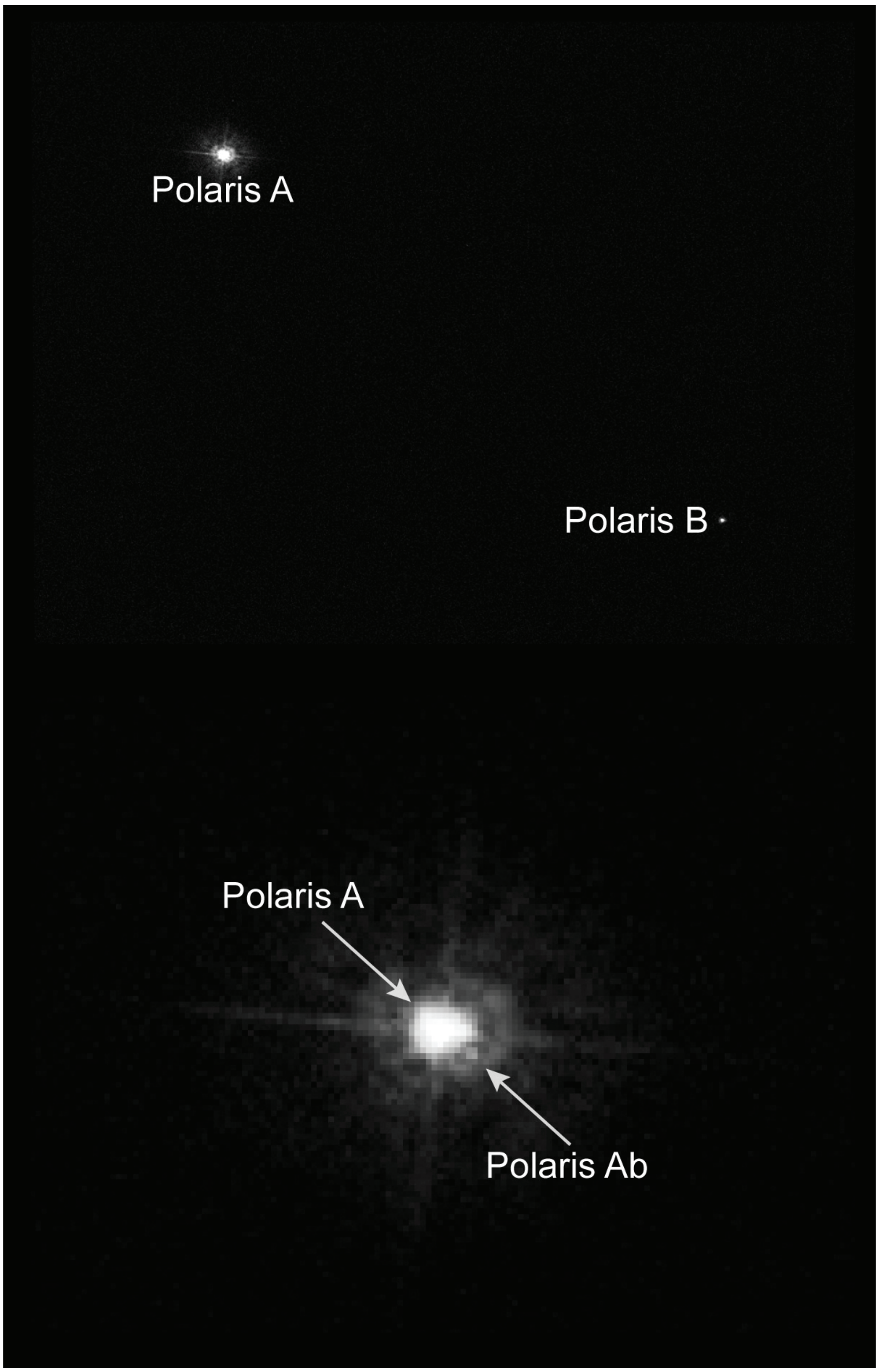

Figure 3 — This sequence of images from the **Hubble Space Telescope** *shows that the North Star really is a triple star system. For the first time, the close companion of Polaris has been seen directly. Image: NASA, ESA, N. Evans (Harvard-Smithsonian CfA), and H. Bond (STScI)*

A refined distance to Polaris

It may be the most important star in the sky, but Polaris and its companions have been a bit of a mystery, most particularly, the distance to our North Pole marker. Now, a research team— principal investigators Research Assistant Professor Scott Engle, Ph.D., and Professor of Astronomy and Astrophysics Edward Guinan, Ph.D., in Villanova's Department of Astrophysics and Planetary Science, along with Petr Harmanec, Dr.Sc., from the Astronomical Institute at Charles University, Prague, Czech Republic—has uncovered the long-hidden physical properties of the North Star.

Until the latest measurements, scientists' estimates of the star's distance from the Earth ranged from 322 to 520 light-years, which made determining its physical makeup difficult. But, equipped with a precise distance measurement recently made by the European Space Agency's (ESA) *Gaia* Mission, the team, has been able to better determine Polaris's radius, intrinsic brightness, age, and mass.

"The previous large uncertainty in the distance to Polaris was a real impediment to pinning down the properties of our nearest (and dearest) Cepheid," said Guinan. "The Gaia Mission measured its distance to better than one-half percent. Working with a precise distance measurement opens up new paths for research into the structure and evolution of Polaris and other Cepheids.

Our study of Polaris provides a clearer understanding of Cepheid variable stars as a class," continued Guinan. "Cepheids are fundamentally important for determining the distances to galaxies and the expansion rate of the universe. All but a few are too far away to determine their fundamental physical properties with the precision now provided by Polaris."

Polaris is our nearest classical Cepheid variable star, one of a rare and important class of very luminous supergiant stars that pulsate. The relation between intrinsic brightness (luminosity) and pulsation period permits Cepheids to be used as "standard candles" for measuring the distances to galaxies both near and far.

Polaris is a triple-star system with one distant companion, Polaris B (which is easily visible in small telescopes), and one very close, Polaris Ab. The North Star itself, Polaris A, was too bright for its parallax to be measured by the sensitive cameras on board the *Gaia* spacecraft. Instead, the research team focused on measuring the distance to Polaris B, calculating a distance of 447 +/- 1.6 light-years, in the middle of the range of previous estimates. The intrinsic brightness of Polaris B is a little higher than expected for its F3 V spectral type, suggesting that it too may have a close companion.

Cepheid variables are high-luminosity supergiant stars that lie in a particular region of the Hertzsprung-Russell diagram (a graph of temperature versus luminosity that traces out the evolution of stars). When stars reach that part of the H-R diagram (the "instability strip") in their evolution, they begin to pulsate with a period that depends on their luminosity, and so they become reference points for the determination of galaxy distance. Cepheid variables may cross back and forth across the instability strip in the H-R diagram several times before evolving toward older white-dwarf status. In doing so, they may pulsate in a number of frequencies, ranging from a single fundamental period to one or more of several related overtones.

The new results allow Polaris A's radius to be set at 46.0 times that of the Sun and the research team identified it as most likely a first-overtone, "first-crossing" Cepheid variable. The new results also gives Polaris a mass of 6.4–6.7 that of the Sun and an age of ≈55–65 Myr. ✶

Compiled in part with information provided by Villanova University

Feature Articles / Articles de fond

In Memoriam: Ian Halliday (1928–2018)

by Peter Brown, Western University

Ian Halliday, RASC National President (1989-1993), *Journal* Editor (1980-1982), and internationally recognized authority on meteors/fireballs, passed away 2018 June 18 in Ottawa. Ian was born in Lloydminster, Saskatchewan, and did his undergraduate work at the University of Toronto where he graduated with a Bachelor of Arts (Astronomy option) in 1949. He completed his Masters also from the University of Toronto where his thesis topic "The variable spectrum of the star HD218393" reflected his early research interest in the general area of astronomical spectroscopy. His 1952 Ph.D. on "A study of stellar luminosities from stellar spectra" cemented this research focus, which continued later when he joined the Stellar Physics Division of the Dominion Observatory in 1954, eventually becoming a Senior Scientific Officer.

Shortly after the Second World War, Ian became involved with a major program of study to use meteors as probes of the upper atmosphere, which was initiated by Fred Whipple at Harvard. As part of this work, the head of the Stellar Physics Division at the Dominion Observatory, Peter Millman, arranged for construction of two meteor stations in northern Alberta at Meanook and Newbrook. These stations, equipped with advanced spectral and wide-field photographic cameras, would become the centrepiece of a new program of meteor observations established in conjunction with Harvard to determine properties of the upper atmosphere and chemistry of meteoroids.

As a new addition to the staff at the Dominion Observatory in 1952, Ian became heavily involved in the interpretation and reduction of data from these new meteor observatories, particularly the spectroscopic meteor data, given his prior background in stellar spectroscopy. In 1955, when Peter Millman moved from the Dominion Observatory to the National Research Council, Ian took charge of the meteor measurement program at the Dominion Observatory. Many of his earliest publications in the meteor field were in this *Journal* related to data collected at Meanook and Newbrook. Some of the major findings published by Ian included the first identification of the auroral green line in meteor spectra, as well as observational constraints on the physics of coasting gas and dust behind small meteoroids.

Beginning in the early 1960s, Ian's research focus continued to expand and became more interdisciplinary, an unusual combination in the astronomical world at the time. In particular, together with other Dominion Observatory staff members, he investigated a suspected impact crater, West Hawk Lake in eastern Manitoba, starting with a gravity survey on winter ice, followed by two winter core-drilling operations. The results confirmed the impact origin of this ancient structure, now a popular vacation lake. This work signalled a shift in Ian's overall interests away from smaller meteoroids and toward larger objects, in particular fireballs and meteorite falls.

By the late 1960s, first as a member of the Dominion Observatory staff and then in 1970 as a Senior Research Scientist at the Herzberg Institute of Astrophysics within the National Research Council of Canada, Ian was leading a group planning a network of 12 automated camera stations in the Canadian prairies for fireball observation and meteorite recovery. This network was similar to two existing networks in central Europe and the midwestern United States. Known as MORP (Meteorite Observation and Recovery Project), it became operational about 1970 and was in routine operation for 15 years. A major success was the recovery of the Innisfree meteorite in 1977 in Alberta, only the third meteorite with a reliable orbit. Six fragments were visible in the late stages of flight and all six were recovered, permitting valuable checks on existing theories. Of special note is that the first piece recovered of Innisfree was found by Ian. This was a particularly

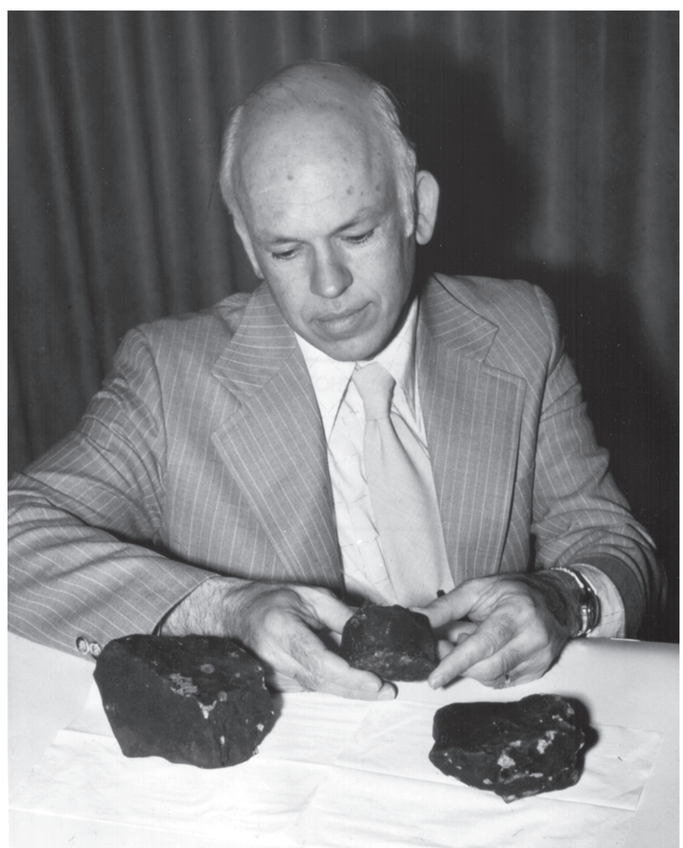

Figure 1 — Dr. Ian Halliday examining several fragments of the Innisfree meteorite, shortly after their recovery.

Figure 2 — Dr. Ian Halliday (right) receiving the National Research Council Associate Committee on Meteorites official recovery certificate for the Innisfree meteorite from Dr. Peter Millman (left).

satisfying outcome of his more than a decade of hard work and planning related to MORP, with the recovery having occurred almost exactly as planned in the original MORP proposal.

MORP proved to be a major scientific enterprise both in terms of results and operational scope. Based on thousands of hours of photographic records over a period of 11 years, the number of meteorite-producing fireball candidates in a known area of clear sky was recorded. Mass estimates were compared to theory, with Innisfree providing a particularly useful check on the theory at the time. Of note is the comparatively high value of the luminous efficiency derived from Ian's analysis of the Innisfree fall, of order ~5% averaged for the entire flight. This was an order of magnitude higher than values accepted at the time, but in good agreement with modern work. Using the Innisfree validated meteoroid mass scale, Ian went on to derive influx rates of multi-kg objects entering the atmosphere and estimating the survival fraction for meteorites. Detailed light curves and other data were published for more than 250 fireballs, and the statistics were studied with respect to cometary or asteroidal sources and other parameters. The MORP fireball survey and the associated flux of objects in the decimetre to metre range remain definitive values in the field today, decades after Ian's work was published. No comparably calibrated fireball survey has been able to match the thoroughness of his MORP analysis.

Other significant findings from the MORP survey included evidence for the existence of meteorite streams, based on the remarkable orbital similarity between the orbit for Innisfree and a similarly behaved fireball that fell near Ridgedale, Saskatchewan, in 1980. This paired event led Ian to search for other streams in fireball orbital data and to the suggestion that at least four orbital groupings were detectable in MORP data, though this remains a controversial conclusion today.

Although his experience observing comets was very limited, NASA invited Ian to join the Steering Group of the International Halley Watch in 1981. When a permanent Chair of the Group was to be elected in 1985, in order to avoid any claims of bias in awarding funds to American universities, NASA required that the position should not go to a U.S. astronomer and Ian was chosen for this role. Sixteen meetings were held between 1981 and 1993, about half in Europe and half in the U.S.A.

I did not personally know Ian very well. In later years we exchanged correspondence related to contemporary topics in the meteor field, with Ian often providing very detailed summaries and insightful comments drawing on decades of experience, which I greatly appreciated. We also co-authored a book chapter on meteorite flux to the Earth's surface in 2006, 16 years after his formal retirement. My most vivid memory of Ian is his kindness and patience in the early 1980s answering my questions related to meteors over the phone during long conversations. In particular, as the first astronomer I had ever spoken with in person, Ian provided a concise recipe for how to become an astronomer: enroll in a physics or astrophysics undergraduate program at the closest major university, then find a supervisor who studies the things you are interested in and get a graduate degree wherever that person is located. It was advice I would follow in later years, and I will never forget the honour of having Ian present the RASC Gold Medal to me at the 2001 general assembly, 50 years after he received the same award and in no small measure a direct result of his instructions some two decades earlier. His wisdom, good humour, patience and kind nature will be missed in the scientific community and beyond. ✶

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Societies

Royal Astronomical Society of Canada. Member since 1949: 1960–61, President, Ottawa Centre; 1964-69, assistant editor, *Journal* of the RASC; 1970–75, editor; 1980–82, National President; 1989–93, Honorary President.

American Astronomical Society. Member since 1954.

International Astronomical Union. Member since 1961: 1976–79, President, Commission 22, Meteors and interplanetary dust.

Meteoritical Society. Member since 1963: 1968–72, member of Council.

Canadian Astronomical Society. Member since 1971.

Planetary Society. Member since 1986.

International Halley Watch. Member 1981–93: 1985–93, Chair, Steering Group.

Awards and Honours

1949, Royal Astronomical Society of Canada Gold Medal.

1974, RASC Service Award.

1976, Medal of Merit, Poland, for service as Secretary, Canadian Committee for the 500th Anniversary of Copernicus.

1977, Queen's Silver Jubilee Medal.

1979, Elected Fellow of the Royal Society of Canada.

1989, Minor planet named (3944) Halliday.

CFHT Chronicles

In Search of Other Worlds...

by Mary Beth Laychak

This summer, astronomers using CFHT made two interesting announcements. While on the surface the discoveries seem very different, both provide interesting insights into planet formation and distant star systems.

Let's start with everyone's favourite visitor from another star system, 'Oumuamua. The interstellar object 'Oumuamua was discovered back on 2017 October 19, but the puzzle of its true nature has taken months to unravel and may never be fully solved.

Rewinding to last fall, a team of astronomers led by Karen Meech from the University of Hawaii used CFHT, UKIRT, the W.M. Keck Observatory, Gemini South, and ESO's Very Large Telescope to observe a unique objected discovered by Pan-STARRS1 on Maui. Meaning "scout from the distant past" in Hawaiian, 'Oumuamua was originally classified as an interstellar asteroid. The asteroid classification led to some consternation on the part of planetary scientists. Current understanding of planetary formation predicts many more interstellar comets than interstellar asteroids. 'Oumuamua did not show evidence of gas emission or a dusty environment in the original observations. Without these cometary signatures, it was deemed an asteroid.

"The CFHT data was absolutely critical for understanding the light curve, for our initial understanding of the orbit and determining that this objects was more like an asteroid and not a comet," noted Richard Wainscoat, an astronomer at the University of Hawaii's Institute for Astronomy and member of the discovery team, in the original news announcement.

Following the initial discovery observations with Pan-STARRS, a team of astronomers led by Marco Micheli of ESA's SSA-NEO Coordination Centre, and Karen Meech of the University of Hawai'i Institute for Astronomy, continued to make high-precision measurements of the object and its position using many ground-based facilities like CFHT, as well as the *Hubble Space Telescope*. The final images were taken with *Hubble* in January, before the object became too faint to observe as it sped away on its outbound orbit.

However, as Meech and her team continued to monitor 'Oumuamua, observations began to immerge that contradicted the asteroid label.

The first clue: its trajectory. Extensive follow-up observations by CFHT, the European Space Agency's (ESA) Optical Ground Station telescope in Tenerife, Canary Islands, and other telescopes around the world have helped pin it down.

'Oumuamua was first spotted about a month after its closest approach to the Sun, which took it within the orbit of Mercury. Unlike any asteroid or comet observed before, this new object sped past the Sun, approaching from "above" the plane of the planets on a highly inclined orbit, moving fast enough (113,942 kilometres per hour as of 2018 July 1) to escape the Sun's gravitational pull and eventually depart our Solar System.

Contrary to their expectations, the team found that the object was not following the anticipated trajectory if only the gravity of the Sun and the planets were determining its path.

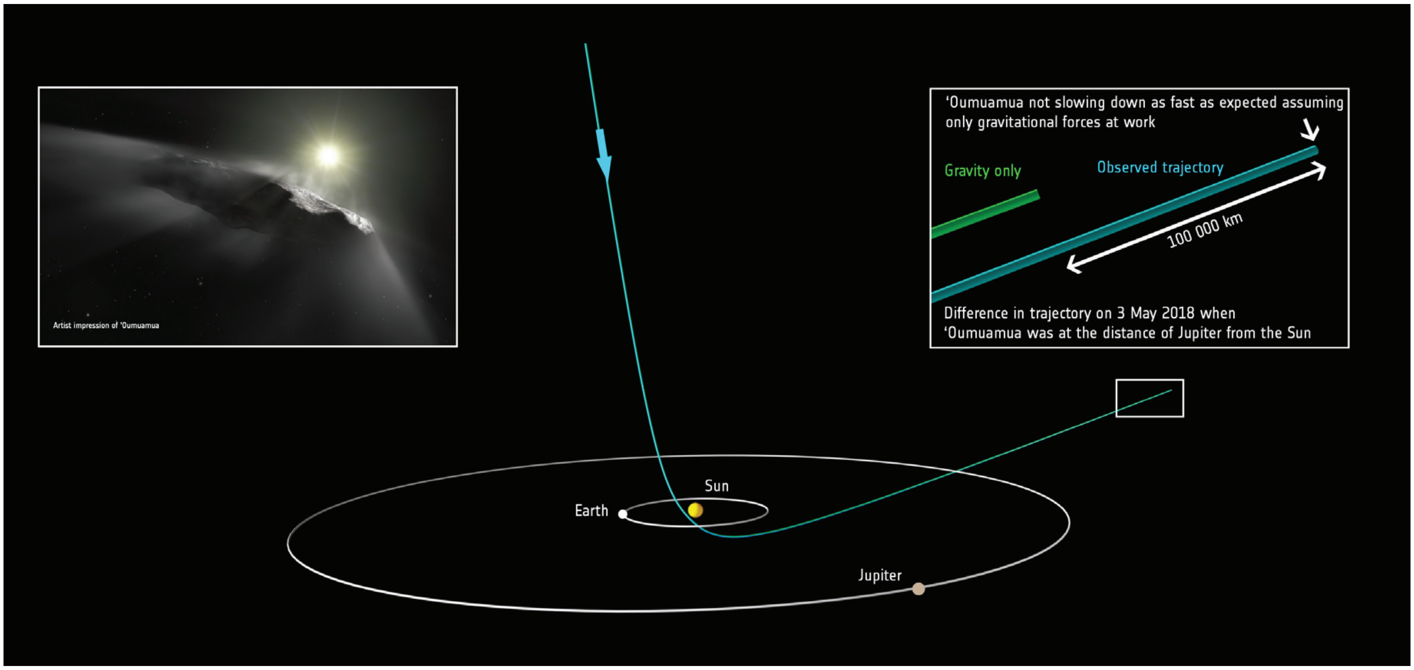

Figure 1 — This diagram shows the orbit of the interstellar object 'Oumuamua as it passes through the Solar System. It shows the predicted path of 'Oumuamua and the new course, taking the new measured velocity of the object into account.

'Oumuamua passed the distance of Jupiter's orbit in early May 2018 and will pass Saturn's orbit January 2019. It will reach a distance corresponding to Uranus' orbit in August 2020 and of Neptune in late June 2024. In late 2025 'Oumuamua will reach the outer edge of the Kuiper Belt, and then the heliopause—the edge of the Solar System—in November 2038. Credit: ESA

"Unexpectedly, we found that 'Oumuamua was not slowing down as much as it should have due to just gravitational forces," says Marco, lead author of the paper reporting the team's findings, published in the journal *Nature*. What could be causing this curious behaviour?

Rigorous analysis ruled out a range of possible influences, such as radiation pressure or thermal effects from the Sun, or interaction with the Sun's solar wind. Other, less likely scenarios, such as a collision with another body, or 'Oumuamua being two separate, loosely held-together objects, were also discarded.

Comets contain ices that sublimate, or turn directly from a solid to a gas when warmed by the Sun. This process drags out dust from the comet's surface to create a fuzzy "atmosphere" and sometimes a tail. The release of gas pressure at different locations and times can have the effect of pushing the comet slightly off course compared with the expected path if only gravitational forces were at play.

"Thanks to the high quality of the observations we were able to characterize the direction and magnitude of the non-gravitational perturbation, which behaves the same way as comet outgassing," says Davide Farnocchia of NASA's Jet Propulsion Laboratory.

The team has not detected any dusty material or chemical signatures that would typically characterize a comet, even in the deepest images from ESO's Very Large Telescope, *Hubble* and the Gemini South telescope. " 'Oumuamua is small—no more than a half a mile long—and it could have been releasing a small amount of relatively large dust for it to have escaped detection," said Meech. "To really understand 'Oumuamua we would need to send a space probe to it. This is actually possible—but it would be very expensive and take a long time to get there, so it isn't practical this time. We just have to be ready for the next one."

"It was extremely surprising that 'Oumuamua first appeared as an asteroid, given that we expect interstellar comets should be far more abundant, so we have at least solved that particular puzzle," says Olivier Hainaut of the European Southern Observatory. "It is still a tiny and weird object that is not behaving like a typical comet, but our results certainly lean towards it being a comet and not an asteroid after all."

Because of its small size and faintness, current observations of 'Oumuamua do not provide all the information astronomers need to determine important aspects of the comet's surface. "When 'Oumuamua was discovered, the astronomy community gathered as much data as possible, but ultimately, the object was just not visible long enough to answer all our questions," says Ken Chambers from Pan-STARRS. "With Pan-STARRS monitoring the skies, we hope to discover more 'Oumuamua-like objects in the future and begin to answer the really interesting questions about this class of objects."

Dr. Meech recently gave a TED talk on 'Oumuamau: www.ted.com/talks/karen_j_meech_the_story_of_oumuamua_the_first_visitor_from_another_star_system

Doppelgänger

When it comes to extrasolar planets, appearances can be deceiving. Astronomers have imaged a new planet, and it appears nearly identical to one of the best-studied gas-giant planets. But this doppelgänger differs in one very important way: its origin.

"We have found a gas-giant planet that is a virtual twin of a previously known planet, but it looks like the two objects formed in different ways," said Trent Dupuy, astronomer at the Gemini Observatory and leader of the study.

Emerging from stellar nurseries of gas and dust, stars are born like kittens in a litter, in bunches and inevitably wandering away from their birthplace. These litters comprise stars that vary greatly, ranging from tiny runts incapable of generating their own energy (called brown dwarfs) to massive stars that end their lives with supernova explosions. In the midst of this turmoil, planets form around these new stars. And once the stellar nursery exhausts its gas, the stars (with their planets) leave their birthplace and freely wander the galaxy. Because of this exodus, astronomers believe there should be planets born at the same time from the same stellar nursery, but orbiting stars that have moved far away from each other over the eons, like long-lost siblings.

"To date, exoplanets found by direct imaging have basically been individuals, each distinct from the other in their appearance and age. Finding two exoplanets with almost identical appearances and yet having formed so differently opens a new window for understanding these objects," said Michael Liu, astronomer at the University of Hawai'i Institute for Astronomy, and a collaborator on this work.

Dupuy, Liu, and their collaborators have identified the first case of such a planetary doppelgänger. One object has long been known: the 13-Jupiter-mass planet beta Pictoris b, one of the first planets discovered by direct imaging, back in 2009. The new object, dubbed 2MASS 0249 c, has the same mass, brightness, and spectrum as beta Pictoris b.

After discovering this object with the Canada-France-Hawaii Telescope (CFHT), Dupuy and collaborators then determined that 2MASS 0249 c and beta Pictoris b were born in the same stellar nursery. On the surface, this makes the two objects not just lookalikes but genuine siblings.

However, the planets have vastly different living situations, namely the types of stars they orbit. The host for beta Pictoris b is a star 10 times brighter than the Sun, while 2MASS 0249 c orbits a pair of brown dwarfs that are 2000 times fainter than

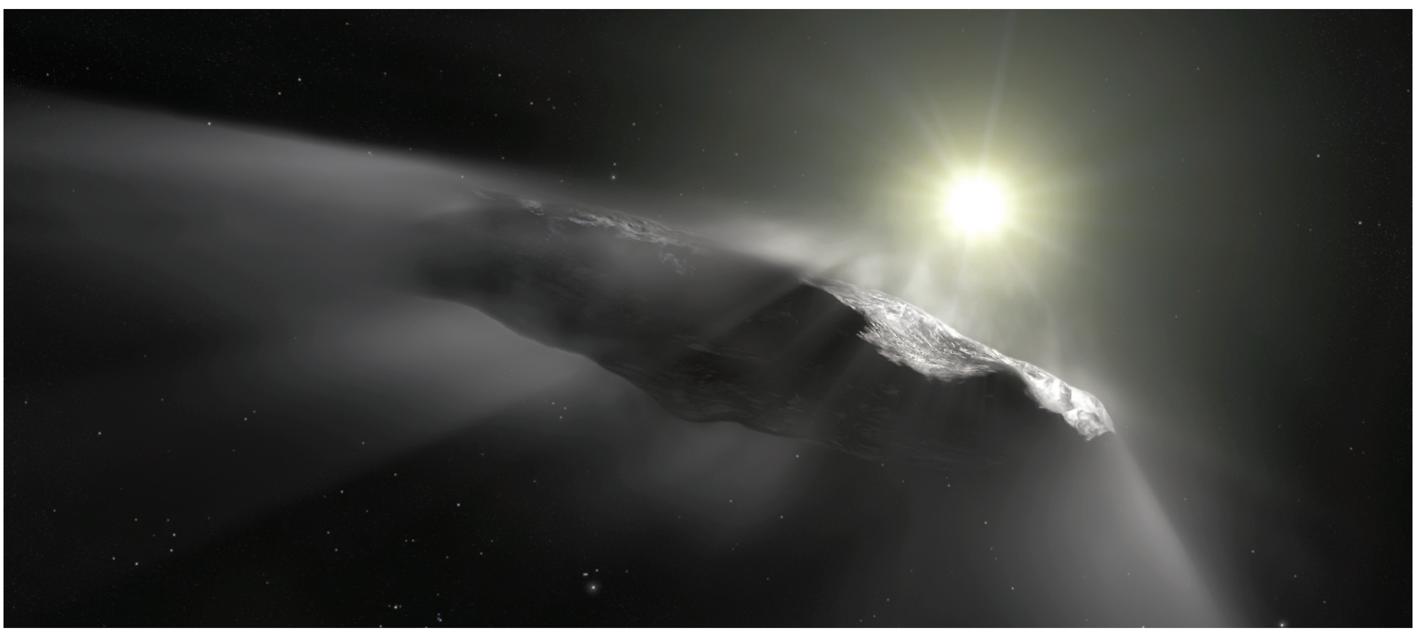

Figure 2 — This artist's impression shows the first interstellar object discovered in the Solar System, 'Oumuamua. Observations made with the NASA/ESA Hubble Space Telescope *and others show that the object is moving faster than predicted while leaving the Solar System.*

Researchers assume that venting material from its surface due to solar heating is responsible for this behaviour. This outgassing can be seen in this artist's impression as a subtle cloud being ejected from the side of the object facing the Sun.

As outgassing is a behaviour typical for comets, the team thinks that `Oumuamua's previous classification as an interstellar asteroid has to be corrected.

Credit: ESA/Hubble, NASA, ESO, M. Kornmesser

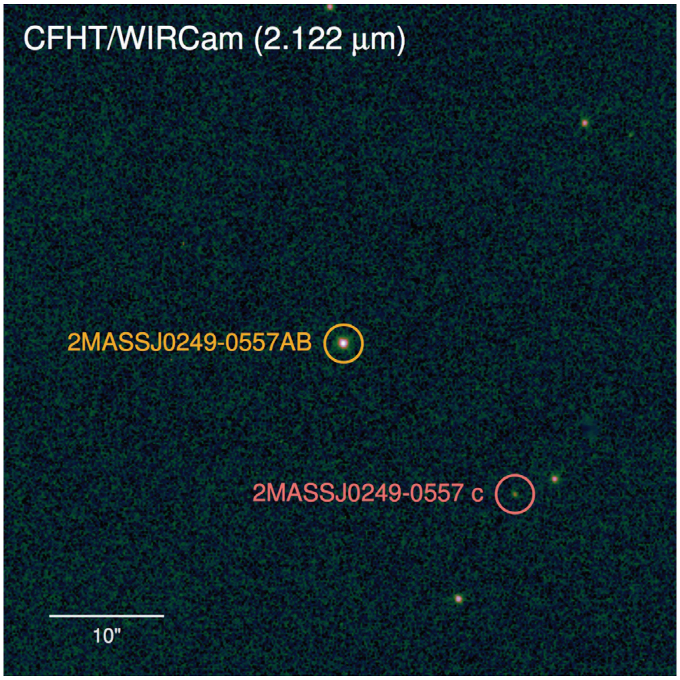

Figure 3 — Direct Wircam image of the 2MASS 0249 system taken with CFHT's infrared camera WIRCam. 2MASS 0249c is located 2000 astronomical units from the host brown dwarfs that are unresolved in this image. Credits: T. Dupuy, M. Liu

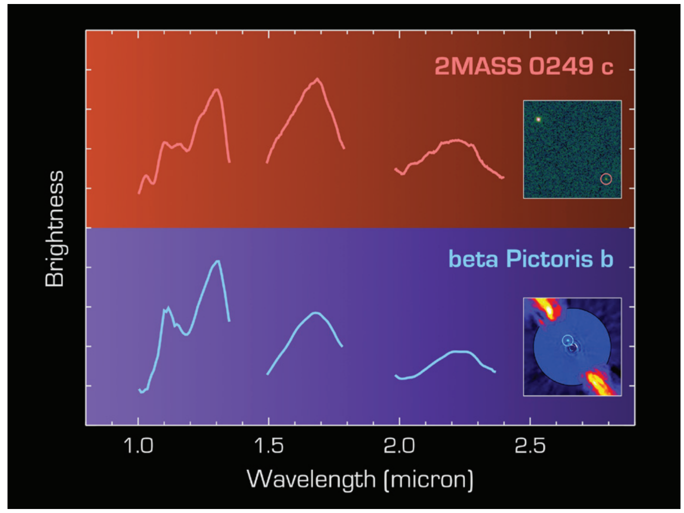

Figure 4 — The infrared spectra of 2MASS 0249c and beta Pictoris b are similar, as expected for two objects of comparable mass that formed in the same stellar nursery. Unlike 2MASS 0249c, beta Pictoris b orbits much closer to its massive host star and is imbedded in a bright circumstellar disk. Credits: T. Dupuy, ESO/A.-M. Lagrange et al.

the Sun. Furthermore, beta Pictoris b is relatively close to its host, about 9 astronomical units (AU, the distance from the Earth to the Sun), while 2MASS 0249 c is 2000 AU from its binary host.

These drastically different arrangements suggest that the planets' upbringings were not at all alike. The traditional picture of gas-giant formation, where planets start as small rocky cores around their host star and grow by accumulating gas from the star's disk, likely created beta Pictoris b. In contrast, the host of 2MASS 0249 c did not have enough of a disk to make a gas giant, so the planet likely formed by directly accumulating gas from the original stellar nursery.

"2MASS 0249 c and beta Pictoris b show us that nature has more than one way to make very similar looking exoplanets," says Kaitlin Kratter, astronomer at the University of Arizona and a collaborator on this work. "beta Pictoris b probably formed like we think most gas giants do, starting from tiny dust grains. In contrast, 2MASS 0249 c looks like an underweight brown dwarf that formed from the collapse of a gas cloud. They're both considered exoplanets, but 2MASS 0249 c illustrates that such a simple classification can obscure a complicated reality."

The team first identified 2MASS 0249 c using images from CFHT, and their repeated observations revealed this object is orbiting at a large distance from its host. The system belongs to the beta Pictoris moving group, a widely dispersed set of stars named for its famous planet-hosting star. The team's observations with the W.M. Keck Telescope determined that the host is actually a closely separated pair of brown dwarfs. So altogether, the 2MASS 0249 system comprises two brown dwarfs and one gas-giant planet. Followup spectroscopy of 2MASS 0249 c with the NASA Infrared Telescope Facility and the Astrophysical Research Consortium 3.5-metre Telescope at Apache Point demonstrated that it shares a remarkable resemblance to beta Pictoris b.

The 2MASS 0249 system is an appealing target for future studies. Most directly imaged planets are very close to their host stars, inhibiting detailed studies of the planets due to the bright light from the stars. In contrast, the very wide separation of 2MASS 0249 c from its host binary will make measurements of properties like its surface weather and composition much easier, leading to a better understanding of the characteristics and origins of gas-giant planets.

SPIRou update

SPRIou was on the telescope for another commissioning run July 27 to August 6. The team focused on using SPIRou through the CFHT queue observing tools along with continued engineering tests on the instrument. At the time of writing this column, I do not have any further updates on how the engineering went, other than everyone seems pretty happy. ✶

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

Pluto crosses the Ecliptic in 2018, for only the second time since its discovery

by Larry McNish, Calgary Centre

On 2018 October 24, Pluto will cross the Ecliptic for only the second time since it was discovered.

Pluto was discovered by Clyde Tombaugh on two images taken at Lowell Observatory on 1930 January 23 and 29.

Other than those two dates, I could not find a reference for the exact time for these two images or even whether they refer to GMT or local Lowell Observatory time, and whether the "day" started at midnight, or at noon as per Julian dates.

However, using Starry Night Pro, I was able to reproduce these discovery images (Figure 2) and determine the actual dates and times Pluto would have been in those positions as seen from Flagstaff, Arizona.

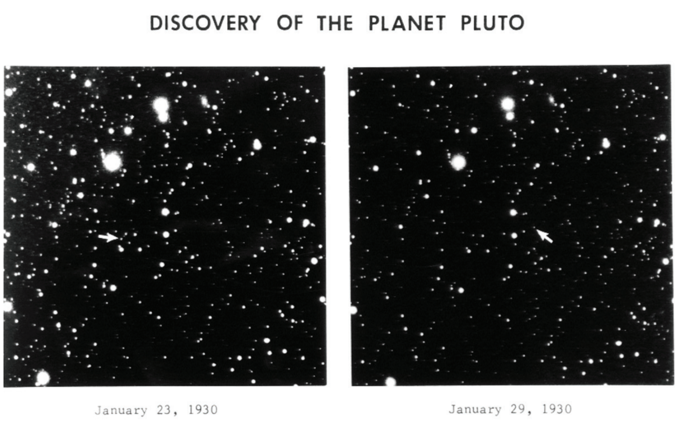

Figure 1 — Reproduction of the two main Pluto discovery photos From Wikipedia. (There were other confirming images as well.) These images correspond to an area on the sky of approximately 35.6 x 34.8 arcminutes (a little larger than the size of the Moon). The brightest (biggest) single star in the image is HIP35807. The irregular blob to the right of the brightest close pair of stars near the top of the image is NGC 2365.

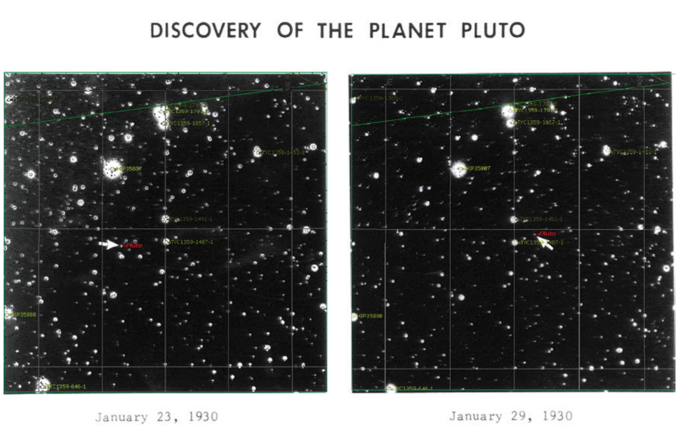

Figure 2 — The author's Starry Night Pro results overlaid on the discovery photos image.

Having proven that Starry Night Pro correctly determined the position of Pluto on those two dates, I was able to determine that the first plate was taken on 1930 January 24, at approximately 12:30 a.m. local time; the second was taken on January 29 at approximately 9:00 p.m. local time.

This confirmed that my version of Starry Night Pro was able to correctly calculate the position of Pluto 86 years ago, and in all probability can calculate its future positions accurately as well.

Pluto crosses the Ecliptic

When first photographed, Pluto was just 14.58 arcminutes below the Ecliptic (the diagonal green lines in Figure 2 above and Figure 3 below) in the constellation of Gemini at RA_{J2000} 7h 23m 01.2s and Dec_{J2000} 21° 49′ 53″ and about 41.3 arcminutes ESE of the star Wasat.

Within that year, on 1930 September 9, however, Pluto crossed the Ecliptic from the South to the North, where it has remained ever since. It reached its highest point above the ecliptic in April 1980. Now, Pluto is on its way back down in its orbit.

Pluto's path 1930 to 2018

In the intervening years, Pluto was at one time or another (sometimes more than once), in the constellations of Gemini, Cancer, Leo, Coma Berenices, Virgo, Boötes, Libra, Serpens Caput, Scorpius, Ophiuchus, Serpens Cauda, and Sagittarius.

The "loops" along Pluto's orbit in Figure 4 are caused by viewing the location of Pluto from the Sun-orbiting Earth—one loop for every Earth year during this period.

Pluto in 2018

On 2018 October 24, Pluto will cross the Ecliptic moving from the North to the South, in the constellation Sagittarius to the west of the star 50 Sgr. It will have taken Pluto 32,187 days (more than 88 years) to make the trip above the Ecliptic. Unfortunately, the Moon will be nearly full, making it difficult to photograph the 14th-magnitude planet world on this special occasion.

The event is so rare that the next time it crosses the Ecliptic (from South to North in Gemini again) is on 2178 December 11, completing one orbit from 1930 September 9, in 90,674 days or 248.25 years.

So, October 24 is the only chance to see a Pluto-Ecliptic crossing for the next 162 years.

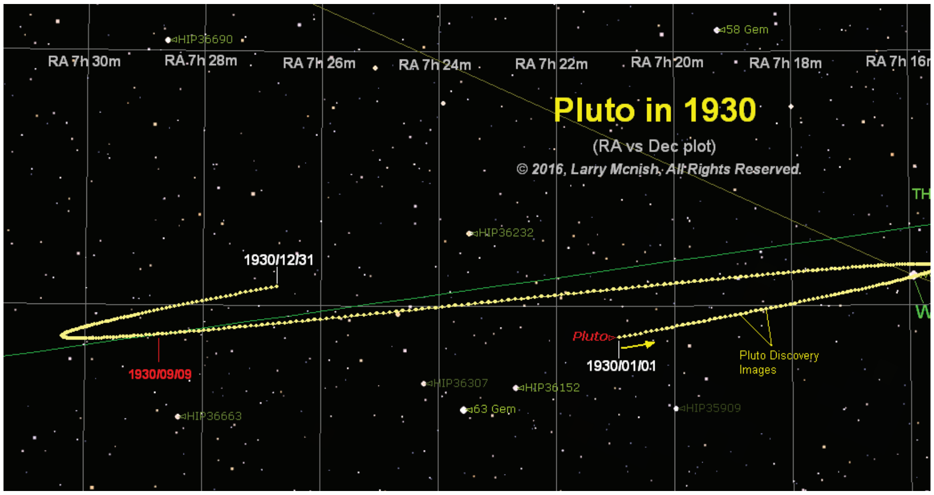

Figure 3 — Pluto's path in 1930 via Starry Night Pro.

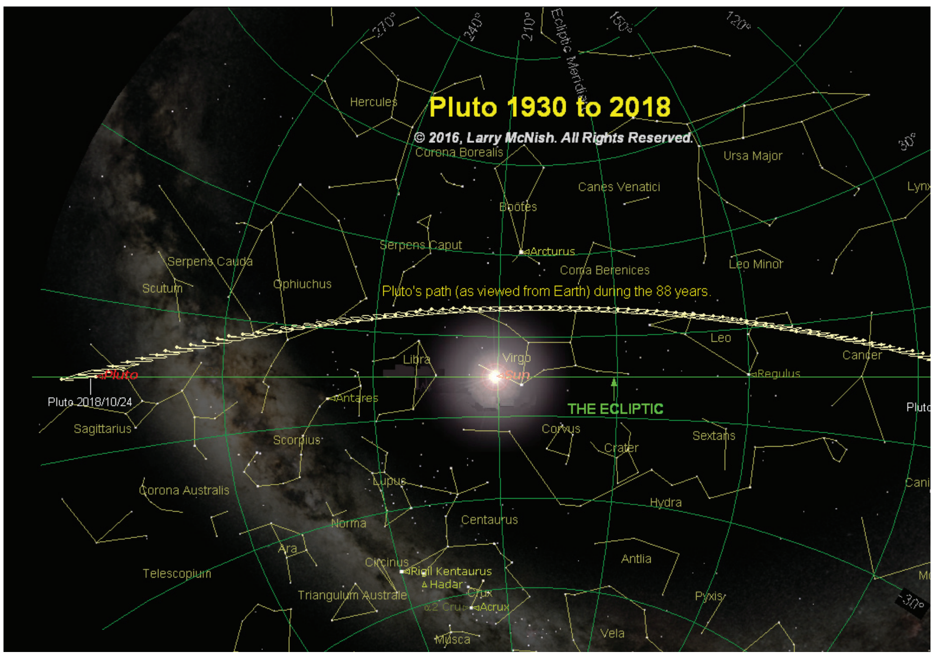

Figure 4 — Pluto's path above the Ecliptic September 1930 to October 2018 via Starry Night Pro.

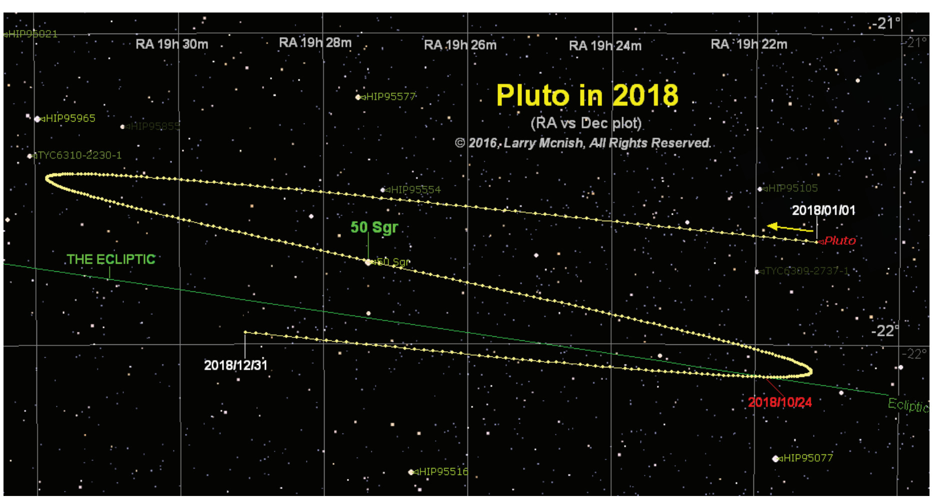

Figure 5 — Pluto's path during 2018 via Starry Night Pro

Other anomalies in the Pluto discovery images

The two individual discovery images gathered from Wikipedia can't be overlaid and compared easily because:

- the centre point of view is slightly different
- the rotation of the images is slightly different
- the image scales are slightly different in both horizontal and vertical distances
- the brightness of the stars differ

However, an animated GIF is the best way of simulating what Tombaugh would have seen through his blink comparator. I created an animation accounting for most of the problems above which can be seen here. calgary.rasc.ca/images/Pluto_animation_new.gif

What's really interesting is that when the two images are compared, there are at least three other objects of interest that change. These are shown in my "difference" image (Figure 6).

First, there is a "blob" (number 1) moving in the upper left. It has a similar shape in both images, but the position is significantly different. It's highly unlikely to be identical but transposed blemishes on the two different original photographs. It could possibly have been a blemish on the scanner glass or lens used to convert the photos to digital images if the photos to be scanned were not aligned exactly the same way before scanning and the results were cropped out for comparison. This misalignment could also explain the different rotations observed in the images.

Although there are many stars that appear on the longer exposure and disappear on the shorter exposure, there are two "dots" that appear to be a small object moving to the upper left as well. The distance moved is consid-

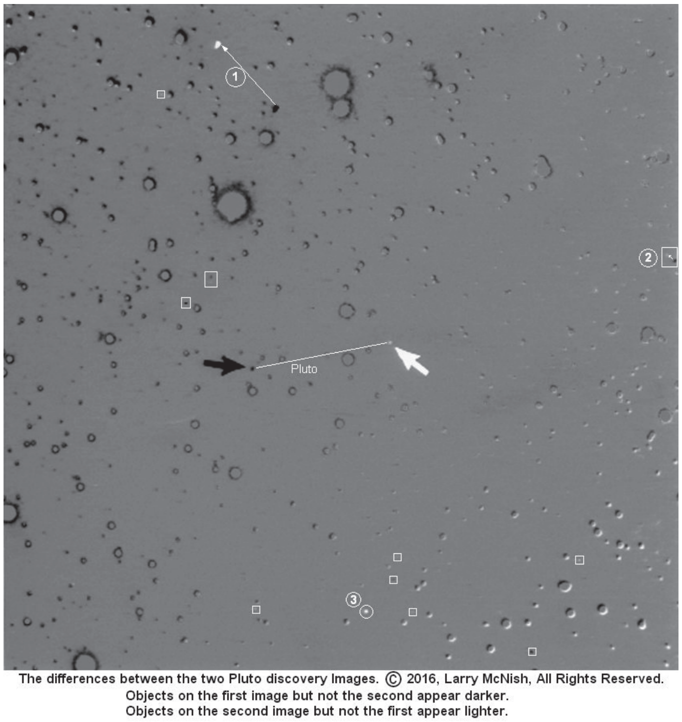

Figure 6 — The differences between the two discovery images.

erably less than the blob's (number 2) indicating that it was not caused in a similar manner. Since Pluto appears at about 14th magnitude, these dots are fainter than Pluto.

Then there is a small but significant star-like image (brighter than Pluto seen as number 3) that appears on the second image, but not in the first. There is no corresponding star "disappearance" on the first image.

And finally, there are a number of other faint objects that move or appear on the images. Those appearing on the second (shorter exposure) are boxed and appear white in the difference image. Those appearing on the first (longer exposure) are boxed and appear dark in the difference image.

Were they satellites? No. It would be 27 years before the first artificial Earth satellite, *Sputnik*, reached space.

Okay, so perhaps it was a weather balloon? Again, the answer is no. The photos were taken six days apart, not six minutes.

Was there the chance they were comets or asteroids? In an effort to determine this using Starry Night Pro, I set it to display all 857 of its comets and 1,000 asteroids on-screen, but none were in the vicinity of the discovery images on those dates. However, my version of Starry Night Pro may not have algorithms or time-dependent parameters for comets and asteroids as accurate as those for Pluto (see the beginning of this article), meaning that running the comet and asteroid orbits "backward" over 86 years could produce incorrect positions. So, this still could be a possibility.

As for forgeries, this is very doubtful. The source for the Wikipedia images was apparently The Planetary Society, whose images show the same anomalies. I believe the originals are in the Lowell Observatory Archives, so someone could check the validity of the digital images.

The Earth and Moon transit of the Sun during Pluto's 2018 Opposition

A notable event also occurred about three months before during Pluto's ecliptic crossing: the transit of Earth and Moon across the Sun.

If one had been standing on Pluto—and had a good telescope—when it was at opposition on 2018 July 12, he or she would have seen the Earth and the Moon transit the Sun.

It's been a remarkable year in Pluto's voyage. ✶

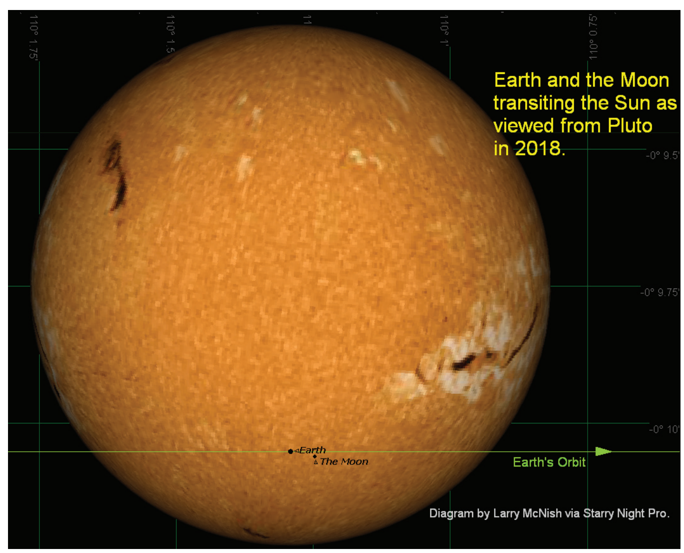

Figure 7 — The midpoint of the Earth-Moon transit as viewed from Pluto 2018/07/12.

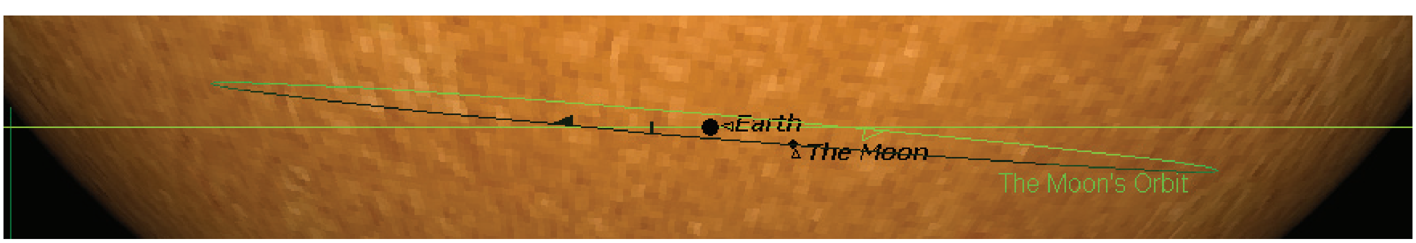

Figure 8 — The size of the Moon's orbit compared to the size of the Sun.

Binary Universe

Expand Your Brain

by Blake Nancarrow, Toronto Centre
(blaken@computer-ease.com)

My interest in astronomy goes back so far that I cannot clearly remember early moments. For fun I continue to reconstruct a timeline in my blog, and Blogger has let me date stamp entries as far back as 1970. Back then I was collecting the little colourful Red Rose tea box cards for my Brooke Bond booklet, *The Space Age*. The summer of 1977 contained a notable milestone after a visit to the H.R. MacMillan Planetarium in Vancouver: the purchase of my first star atlas. I recall while in high school, in my spare time, I collected and listed new facts on planets, moons, asteroids, and stars.

When I started using my Super Polaris Celestron 8-inch SCT in 1991, I had to apply my knowledge of the stars and constellations in a practical way. During set-up, of course, I needed to polar align the equatorial mount. During viewing, I had to manually move or star hop (before I knew the term) with bright objects acting as signposts on way to the dim or small targets. Now, with the iOptron GOTOSTAR system, I need to accurately aim at two or three named stars before my observing session.

Over the years, I think I have come to know the sky fairly well and, while difficult to quantify exactly, I can correctly identify about 100 named stars and about 50 constellations. Long I wished for something to help me proactively learn these objects. And if I'm ever fortunate enough to go below the equator, I'll need assistance getting comfortable with the southern celestial sphere. I would love to master all the official 88 constellations as per the International Astronomical Union.

Years ago, I actually considered building a product like this myself to speed my learning. I mused on authoring a website with interactive sky images. I tested some online quiz building tools. I even considered drilling with old-school flash cards. In the end, I never made anything that I felt was effective and I never found a good online testing tool (unlike Henrik Theiling's website for learning Greek characters).

Recently, while perusing the Google Play Store for science and astronomy games, I stumbled upon *Constellation Mind* for Android. It sounded intriguing, so I quickly installed the free ad-supported app.

play.google.com/store/search?q=newbraveconstellation

It is a simple application that can help you learn the constellations and then test your knowledge.

The main screen shows the celestial sphere is divided into three bands: the northern region, the equatorial constellations, and the southern sky. You start by choosing your region of interest (Figure 1).

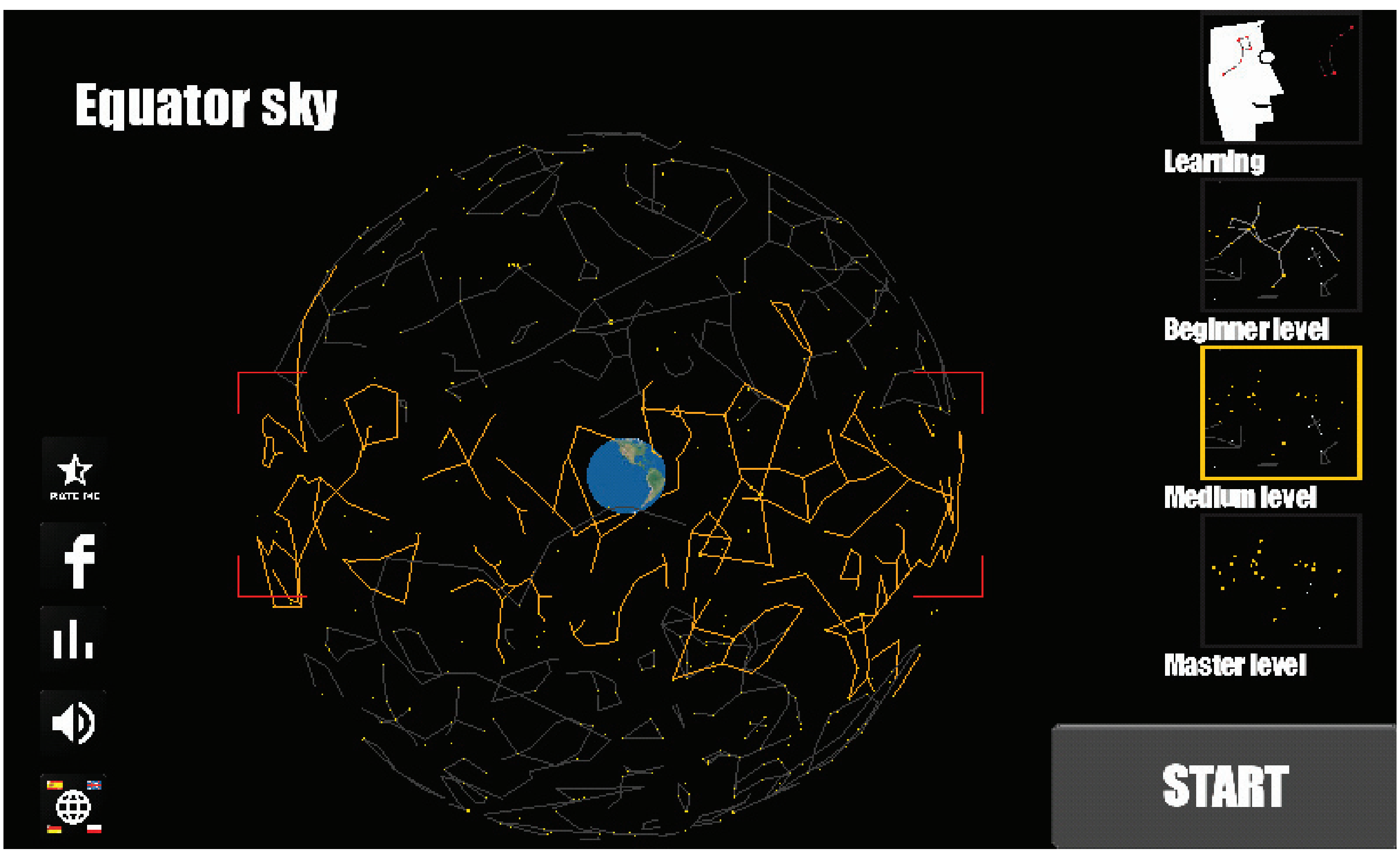

Figure 1 — The main screen with the equatorial region of the celestial sphere selected.

Whether you are very new to astronomy, or rusty, you can activate training mode by tapping the Learning button (with the caricature of a head). The app runs through a batch of constellations with the name below. The relative star magnitudes are shown in the typical way with brighter stars marked with a larger disk.

A constellation can be shown in different ways. By default, the app emphasizes the stars in orange, and draws fairly standard stick figure lines for the constellation in question (Figure 2). Also, the neighbouring constellation figures are shown with dimmer lines. Using the buttons on the right, you can change the display mode, removing some or all of the stick figure lines. This comes into play later during testing.

To gauge your knowledge, once again from the main screen, you choose a part of the sky for testing. Then you choose the difficulty level.

The drills have you recognize a constellation and respond to multiple-choice questions (Figure 3). There are no time limits.

If you answer incorrectly, you are given one additional opportunity to select the correct answer from the original five presented. Each stage has thresholds: the first is after about 50 percent of the questions, then 75 percent, and finally all. A gold star is awarded at each threshold. Three stars indicates a perfect test result.

In beginner mode, the app draws stick figure lines for you to identify the constellation in question. The lines connect some of the main stars. As well, nearby constellations are shown with their lines. Often, you will be able to guess at an unfamiliar constellation by its surroundings. When you test yourself at the intermediate level, the stars are highlighted and connected as before, but the nearby constellation lines are not shown. Now you must recognize the constellation in a more isolated way. When you graduate to the master level, there are no lines drawn anywhere; you must identify the constellation by only stars in the simulated sky—not unlike how we experience the real night sky.

Tests cannot be paused per se: that is, you should not back up to the main screen in the app, otherwise you'll lose your current progress. Neither can questions be skipped; however, I was able to switch out of the app on my Android and return later, and things were right where I left them.

I found these drills good. If I made a point of not looking at the multiple choices listed, it challenged me. I quickly mastered the northern constellations. I didn't do as well with the equatorial targets, particularly the low ones like Pyxis and Antlia.

In a number of cases, I couldn't recognize the constellation in question due to orientation. It is remarkable how we get used to seeing a pattern in a particular way. How many times has the experienced observer encountered this under the night sky? Certainly, I've been "turned around" many times (typically in the winter). All that said, I found if I rotated my device I could often spot a familiar arrangement of stars. This is possible as this app runs in landscape mode only and stays locked in the original orientation.

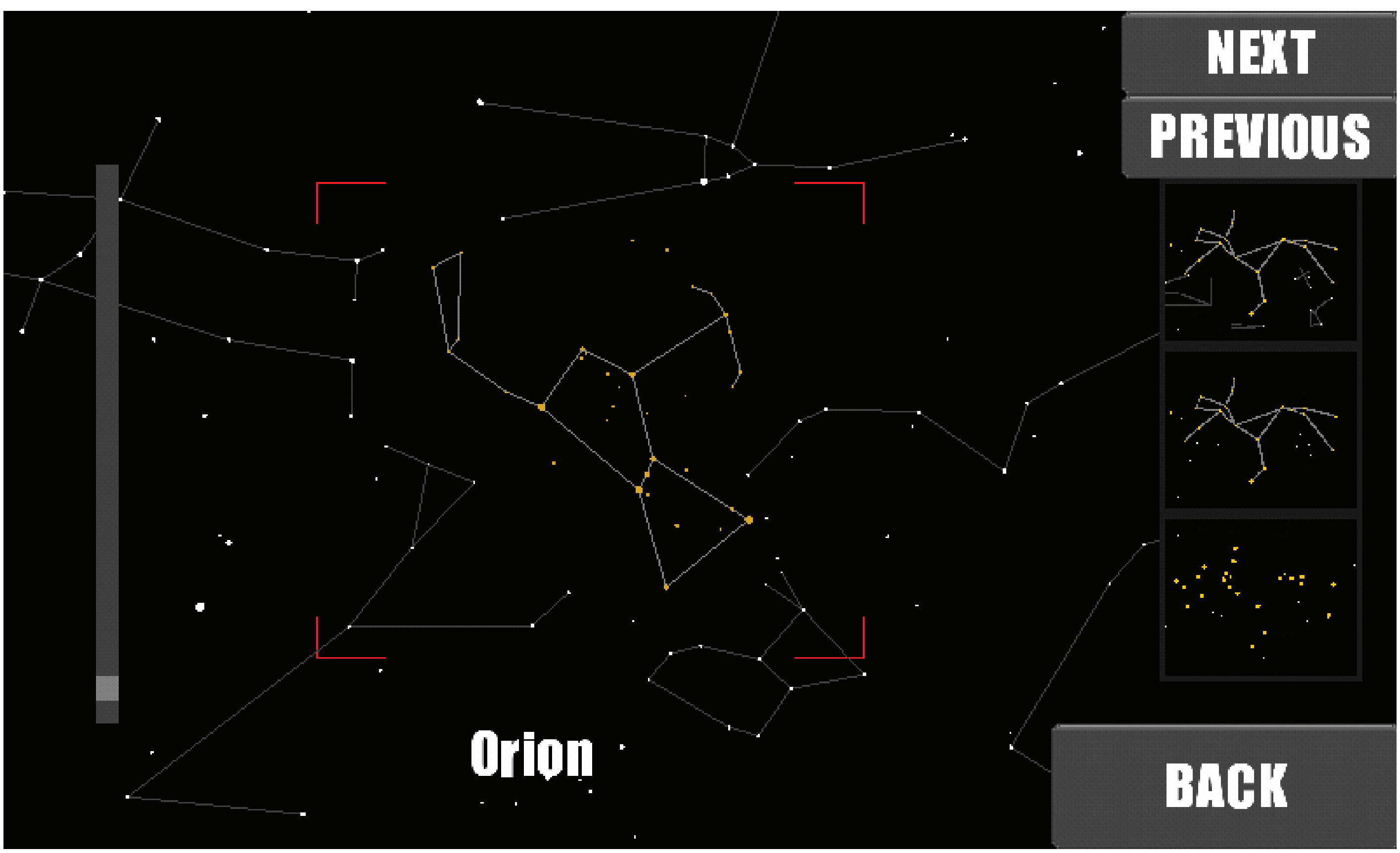

Figure 2 — Learning mode shows a constellation with or without the stick figures.

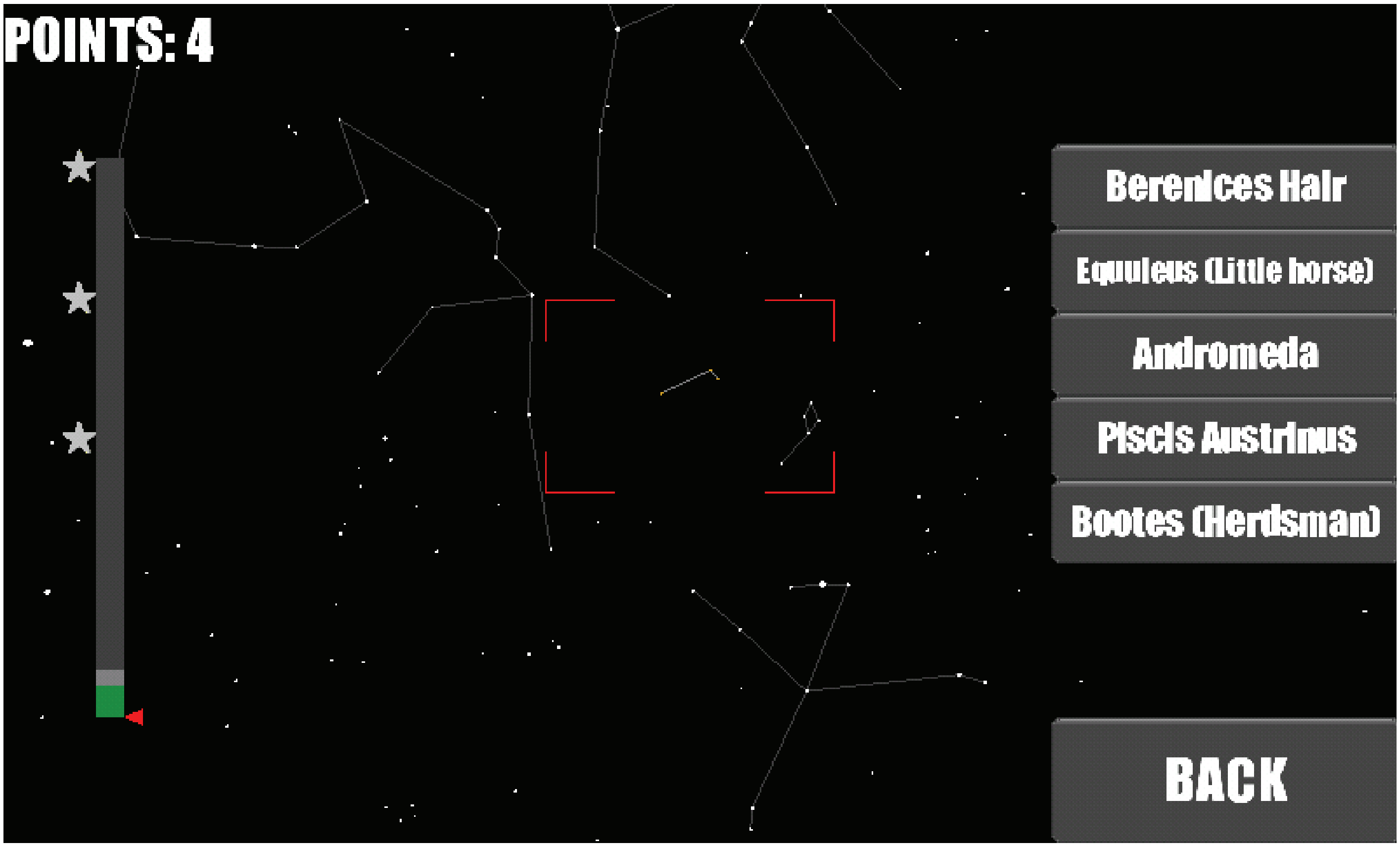

Figure 3 — Testing one's recognition ability with a multiple-choice question.

Curious wording is used for some of the constellations. I had no trouble with this as I am familiar with some of the history and background of constellations, but I wonder what impact this might have on someone quite new to the hobby. Will they know what "Giraffe" means? Or "Northern Crown?" And while a Western terminology is noted parenthetically for many constellations, e.g. Boötes (Herdsman), others have nothing, e.g. Pyxis.

On the main screen there are small buttons to rate the app, connect to Facebook, select a language, and toggle the sound. The bar-chart icon lets you examine your "profile," which reveals your test results over time.

The developers acknowledge questions and remarks raised in the Review section of the Google store page. I put some questions to them and they responded very quickly. They liked my idea of a red-light mode, so the app could be effectively used below a canopy of distant suns. When I asked if scores could be reset quickly, they guided me to the existing option within the app. Others have asked about star-name testing and the developers have taken that to heart, promising this feature in a future release. But it sounds like they are, they, like many of us, are amateur astronomers with busy lives and they do this for the love of the hobby when they can find some spare time.

The app was updated fairly recently, in May 2018. The version I tested was 2.2.

In conclusion, if you are looking for a quick and easy way to learn some or all the constellations in the night sky, try out *Constellation Mind*. The app can help you load constellations into your brain by the stick figure, the neighbouring constellations, and by the star patterns. Later, you can use the app to measure your new knowledge with a battery of tests.

Bits and Bytes

Back in June of this year, I was contacted by Gordon Telepun of Foxwood Astronomy. He's the owner of the Solar Eclipse Timer app that many of us put to work August 2017 for accurate timing of the total solar eclipse proper and related events. He informed me that he was testing his app for the 2024 event that will, like last year's, cross over much of North America. In fact, he was on the Canadian side of Niagara Falls to preview the duration of totality there. His updated app said 3½ minutes. He's added data for the 2019, 2020, and 2023 eclipses. He is redoing the voice recordings, including adding reminders to watch for planets, and looking at ways to make it more useful for people off the centreline. He's also added a percent obscuration calculation. I look forward to using this good app in the future. ✶

Blake's interest in astronomy waxed and waned for a number of years but joining the RASC in 2007 changed all that. He volunteers in education and public outreach, supervises at the Toronto Centre Carr Astronomical Observatory, sits on the David Dunlap Observatory committee, and is a member of the national observing committee. In daylight, Blake works in the IT industry.

2018 General Assembly

Compiled by Nicole Mortillaro

This year, RASC members were treated to a special 150th celebration of our esteemed society hosted by Calgary Centre.

Former Canadian astronaut Dr. Robert Thirst kicked off the General Assembly, hosted at the University of Calgary and held at the Red and White Club. The amazing list of speakers included the Planetary Society's Emily Lakdawalla, as well as Dr. Tanya Harrison, Director of Research for Arizona State University, Dr. Fereshteh Rajabi and our own Society's Alan Dyer and Randall Rosenfeld.

Events also included a tour of the Cretaceous/Tertiary Boundary, a Tyrrell Museum and Badlands tour (and of course the Star Trek museum!), a Canadian Rocky Mountains Martian analogues tour and the First Nations Cairn Site tour.

Congratulations to Calgary Centre for hosting an amazing and fun-filled General Assembly on our Society's 150th anniversary!

Figure 1 — Outgoing president Colin Haig introduces Emily Lakdawalla.

Figure 2 — Guests await a delicious dinner.

Figure 3 — A Calgary Stampede breakfast.

More on page 208

Figure 1 — Sharon Morsink writes: Noctilucent clouds over Edmonton, 3 a.m., 2018 June 25. My bedroom has a north-facing balcony, so on the occasions when I wake up in the middle of the night, I take a peek out the window. Sometimes I'm rewarded with aurora, and sometimes noctilucent clouds. This was an exceptionally bright display, with lots of interesting structure easily seen in the west (left) part of the sky. Out of frame to the east are the bright lights of downtown Edmonton and the Ice District. I could also see faint NLC above the bright lights of downtown.

Shot with a Canon 70D camera and a Sigma 18–250-mm, ƒ/3.5-6.3 lens with the polarizing filter accidentally left on. This shot was ISO 100, 18 mm, ƒ/3.5, 6-second exposure. The photo was lightly tweaked using Lightroom.

Figure 2 — Sheila Wiwchar writes: First sighting of the NLC on June 11 from Winnipeg, Manitoba. The brightest display of these electric blue clouds I have seen! Taken about 11 p.m. using a Canon 70d at ISO 800, ƒ/4.5 for 2 secs.

Journal *Editor-in-Chief Nicole Mortillaro took this image during the Thebacha & Wood Buffalo Dark Sky Festival on the night of Aug. 25–26 during a mild geomagnetic storm. Nicole used a Canon 5d Mark III at ISO 1600 for 18 seconds.*

Ann Tekatch imaged this view from Lion's Head, Ontario, using a Canon 5D at ISO 6400, 30 seconds, f/4 and at 24 mm focal length.

2018 General Assembly

Continued from page 205

Figure 4 — (Top) Award recipients (left to right): Brian Lucas, Peter Broughton, Richard Huziak, Nicole Mortillaro, Mike Moghadam, Richard Christie, and Colleen O'Hare.

Figure 5 — (Right) David Foot and Alan Dyer reveal Canada Post's new stamp featuring Alan's aurora image.

Figure 6 — (Bottom Right) New President Chris Gainor and outgoing President Colin Haig unveil another Canada Post image by Matt Quinn.

Figures 6 — (Below) Dr. Tanya Harrison, also known as "Tanya of Mars", presents to RASC members.

Observing Tips

Hooked on Astronomy

by Melody Hamilton, RASC Halifax Centre
melynnham@gmail.com

[Note from Dave Chapman, RASC Observing Committee Chair: This is the seventh in a series of articles contributed by RASC members on observing, edited by me. Melody Hamilton got hooked on astronomy later in life than most of us, and this is her story. In a short time, she has become the most "certified" RASC observer. In part, she attributes this to living in a rural site with dark skies and an observatory, but I know that she is dedicated and meticulous about her observing. Melody was the first person to complete Explore the Moon in its draft stages and her endorsement persuaded me to offer it as an RASC observing program. For future columns I am looking for practical content contributed by active observers—please email me at observing@rasc.ca with your ideas.]

The very first hint that astronomy would play a major part in my retirement came when my husband Bruce and I became grandparents for the first time. Rug hooking was a favourite hobby, so designing and hooking a mat for my new grandson was a must! Teddy bears and nursery rhyme characters are cute and fun to hook, but children outgrow this quite quickly. So, what to put in my design—something he would grow into rather than grow out of. The year was 2009, the International Year of Astronomy, so I decided to put the Solar System in my design. As I hooked, I Googled each planet and discovered there were many wonders in the night sky! Sadly, I finished hooking the mat, but what to do with my newfound interest in astronomy? Early in 2010, I Googled "amateur astronomy Annapolis Valley" and found a link to the Minas Astronomy Group in Avonport, N.S. Bruce and I attended our first meeting the following week. Dr. Roy Bishop was the speaker. He took all those present on a tour of Saturn, its moons, and ring system, all through the eyes of the *Cassini* orbiter. There we were—hooked on astronomy!

We began our journey "looking up" with a single pair of 10x50 binoculars, advice given to us by [former RASC President] Mary Lou Whitehorne. Another set of binoculars rapidly followed (have you ever watched two toddlers with one new toy?). Within a few months, there was an observatory in our backyard with a Celestron 11-inch Schmidt-Cassegrain telescope on the pier. By the end of that first year, we were RASC members. For the next 18 months, we enjoyed finding the constellations, learning the names of their brightest stars, and observing some deep-sky objects. Our interests diverged, Bruce into astrophotography, me into visual observing.

The beginner observing program Explore the Universe appealed to me (www.rasc.ca/explore-universe). Armed with binoculars and my new 120-mm Sky-Watcher refractor, I began. Page 4 of *Explore the Universe* included Kemble's Cascade, a target I became aware of early on. Frequently, I ended an evening of observing with an appreciation of this lovely cascade of stars. By then, I was attempting to sketch my observations—to one side, there appeared to be a small group of 3 or 4 stars, I couldn't really tell with binoculars, so I decided to leave that part until last when I would set up my

Figure 1 — The hooked rug made by the author for her first grandson, Emil. This unique design contains all categories of objects in the Solar System: the Sun, all the planets, the Moon, ring systems, dwarf planets, and small Solar System bodies (a comet and a few minor planets, including classic asteroids and trans-Neptunian objects).

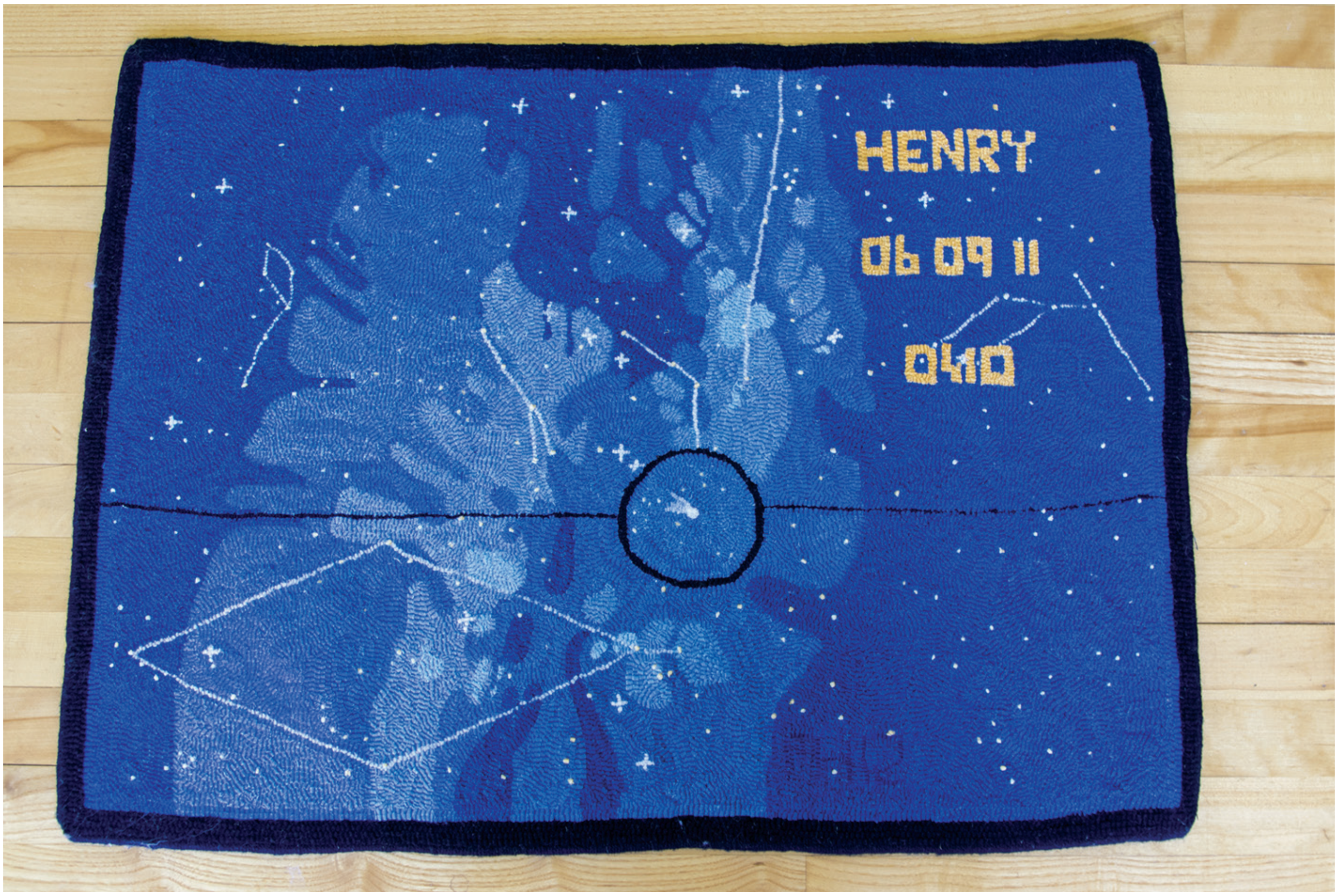

Figure 2 — The hooked rug made by the author for her second grandson, Henry. The unique design depicts comet C/2009 P1 (Garradd) passing between Cygnus and Aquila in the late summer of 2011, at the time Henry was born.

Figure 3 — The Wharf Road Observatory (shared by the author with her husband Bruce) near Annapolis Royal, Nova Scotia. Note stations for astrophotography and visual observing. WRO has its own Clear Sky Chart!

Sky-Watcher. The cascade of stars above and below that group of stars went easily into my sketch. Now to take a closer look at that small group of stars. Using the telescope, I could see a cluster of stars! Wanting to see even more, I used the C11 for greater magnification—what I discovered that night was the beautiful open cluster NGC 1502. How had I missed it when I had observed this cascade many times before? It's because on this night I was "putting my observations down on paper." Through the process of sketching, I had taken a little more time to observe these stars. What a very personal and exciting discovery that was!

An observing routine began to take shape: make an observing list, find my targets, sketch, and record. Sketching does take a little more time, but you are rewarded with improved concentration, strengthened memory, and sharpened visual acuity. At sea level, where we live, I can place 2, 3, or sometimes 4 stars in my sketch with a single observation. Recently, however, in the Atacama Desert at 7749 feet above sea level, the concentration and short-term memory skills protested—the reverse became my reality, it took 3 or 4 observations to place one star in my sketch! This did not improve over the course of the two-week stay, I just had to work with it.

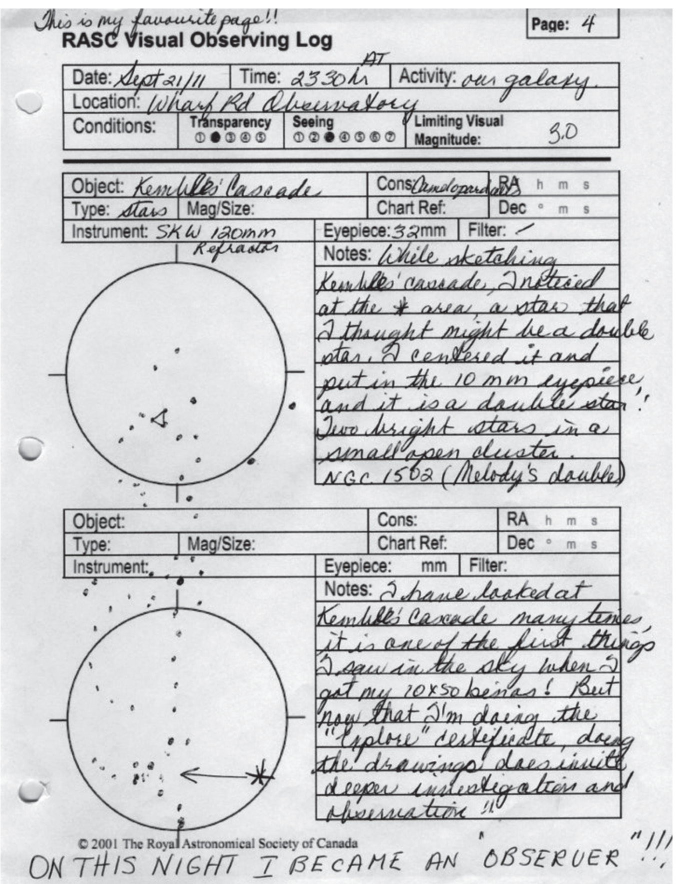

Figure 4 — A page from the author's observing logbook, showing her personal discovery of NGC 1502 near Kemble's Cascade, arguably the most interesting features in the obscure constellation Camelopardalis. [Editor's note: Melody had to devote the entire page to the observation, as it is so spread out.]

I completed Explore the Universe in 2013. The whole experience of sketching at the eyepiece changed the way I observe and laid the path through Explore the Moon (2014), Messier Catalogue (2015), Finest NGC Objects (2016), and Deep-Sky Gems (2017). Currently this path continues through the Isabel Williamson Lunar Observing Program, Deep-Sky Challenge, and the Astronomical League's Herschel 400 (see www.astroleague.org). Certificates are fun to receive, but it is the journey through the program that unlocks the treasures in the night sky!

There is an old saying that goes something like this: "If you follow in someone else's footprints, you leave no footprints of your own." I encourage you to take your own path and leave your own footprints all over the night sky. Sketching your observations is an excellent first step! ✶

Biography

Melody Hamilton is a retired nurse whose interest in astronomy began when that career ended. She has earned several RASC observing certificates, and recently enjoyed a trip to San Pedro de Atacama, Chile, to view the night skies above the Southern Hemisphere. With her husband, she enjoys their home observatory in southwestern Nova Scotia.

Dish on the Cosmos

Orphaned Planets

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

The Very Large Array in New Mexico has been observing the aurora, but not the northern lights on Earth. Other planets in our Solar System also have aurorae, but these recent observations have revealed aurora on a planet drifting through space some 20 light-years from our Solar System. The affectionately named SIMP J01365663+0933473 (hereafter SIMP J013) gives off the tell-tale polarized radio pulses that are linked to auroral activity in the Solar System. What makes this source particularly interesting is that it has a relatively low mass, estimated to be about 13 times the mass of Jupiter. This low mass means that it is more like a planet than like a star, raising questions of where the object came from?

The SIMP designation refers to a survey conducted at Observatoire du Mont-Mégantic (OMM) in Quebec. OMM specializes in designing some of the world's best cameras operating in the infrared part of the electromagnetic spectrum. Using a camera designed by researchers from Université de Montreal, the SIMP survey took repeated images of the sky over the course of several years and searched for objects that were (1) relatively bright in the infrared and (2) moving with respect to more distant stars. SIMP focused on objects that were bright in the infrared but faint in the optical, implying these objects would be cool relative to ordinary stars. In particular, the survey was searching for objects with large "proper motion" meaning they were likely nearby, where observations over the course of a few years would reveal the relative motion of these targets against the background of more distant stars. The primary focus for the survey was on a class of objects called "brown dwarfs" and SIMP sifted the skies over Québec finding several interesting objects, including the hero of this story, SIMP J013.

Brown dwarfs are frequently labelled as failed stars. An ordinary star emits the light that it produces through the nuclear fusion of hydrogen into helium taking place in the core of the star. Stars hold themselves together through gravity: all the matter in the star pulls on all the other matter, holding it in one place. The gravity is opposed by the gas pressure generated from the gas in the star being hot. The nuclear fusion at the centre of the star keeps the gas hot and giving off the starlight that we see. The key difference between an ordinary star and a brown dwarf is its mass. Brown dwarfs are less massive than regular stars. Because they are less massive, their self-gravity is not as strong as regular stars. Brown dwarfs form in a similar fashion as ordinary stars; they condense and collapse out of clouds of cold molecular gas down to smaller, denser, and hotter objects. However, brown dwarfs stop collapsing because of a force called degeneracy pressure. In contrast, regular stars stop collapsing when their interior get hot enough to ignite fusion, making them supported by thermal gas pressure. The degeneracy pressure that supports brown dwarfs arises from the rules of quantum mechanics: making the star more dense would violate the Pauli exclusion principle. Thus, the brown dwarf stops contracting simply because it cannot become any smaller.

A brown dwarf is a round object, made mostly of hydrogen and helium gas that is supported by degeneracy pressure. Jupiter is also partially supported by degeneracy pressure, so what makes brown dwarfs different from planets? Astronomers have two answers to this question. The first answer comes from the origins of the object: star-formation theory predicts brown dwarfs could form on their own within gas clouds but planets must form around a parent star. The second answer relies on deuterium, a rare, heavy isotope of hydrogen. It is easier to fuse deuterium than hydrogen. While brown dwarfs do not fuse hydrogen, they do fuse their small amount of deuterium, producing some thermal energy before becoming supported by degeneracy pressure. The minimum mass to start fusing deuterium is about 13 times the mass of Jupiter while the minimum mass to fuse hydrogen is 80 times the mass of Jupiter. Even though there are two different definitions for a brown dwarf, it is not clear whether the two defini-

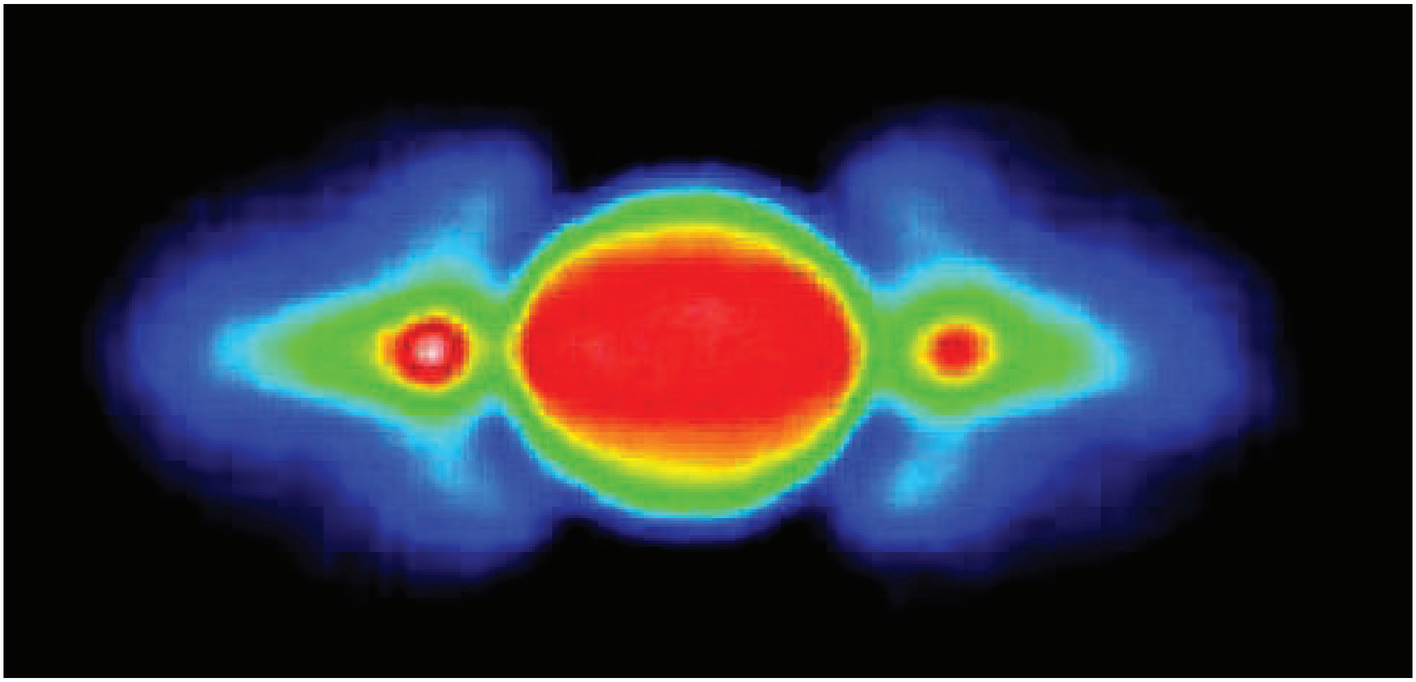

Figure 1 — Jupiter seen in radio emission at frequency of 2.3 GHz. The round shape in the middle comes from the planet itself. The extended emission to the left and right comes from a belt of high-energy particles trapped in Jupiter's magnetic field. This image shows that Jupiter-like objects can have strong radio emission associated with particles trapped in their magnetic fields. Image Credit: Australia Telescope National Facility

tions (isolated formation vs deuterium fusion) are equivalent. However, planets (less than 13 Jupiter masses) are almost certain to have been formed as part of a stellar system.

It can be difficult to determine the masses of brown dwarfs. Usually, we determine the masses of objects in astronomy by measuring the orbit of something going around the object. Brown dwarfs are faint and finding objects in orbit around them is extremely rare. Instead, we use models of how brown dwarfs cool off. Brown dwarfs start out warm from their contraction and deuterium fusion, then, like an ember pulled out of the fire, the brown dwarf cools off and becomes fainter. If we can estimate the age of a brown dwarf, we can use how it is cooling off to infer the mass. SIMP J013 was originally thought to be an old brown dwarf with a mass well above the deuterium burning threshold. However, recent studies also found it to be moving through the galaxy, showing similar proper motions as several young stars. Having similar motions is a sign that the stars formed together, so astronomers could assume SIMP J013 had a much younger age. If it was younger, it must have been hotter, which meant that it was far less massive than originally thought. The new mass estimate is now below the 13 Jupiter mass limit, making SIMP J013 likely to be a planet.

However, SIMP J013 has no parent star. At a mere 20 light-years from Earth, it is one of our nearest neighbours in the galaxy. We would easily see a regular star if SIMP J013 were in a stellar system. The most likely scenario is that SIMP J013 was formed in a binary stellar system. The orbits of planets in binary star systems can easily become unstable, ejecting the planet out into the depths of space. The planet would then float free through the galaxy, unlikely to ever pass close to another star system.

Brown dwarfs and orphaned planets can be extremely difficult to see. Because they are cool and small, they give off very little radiation, with most of the emission coming in the infrared where it is relatively difficult to detect. We could easily miss these objects in our own galatic backyard. However, SIMP J013 clearly stands out in radio emission because it has a strong magnetic field. Strong fields are a common feature of brown dwarfs and massive planets. This is because degenerate hydrogen actually becomes a metal. These objects also tend to be rapidly spinning, and these two ingredients (fast spin plus a metal core) are needed to make a strong magnetic field. When passing particles hit the magnetosphere of these objects, they trigger aurora. While we are unlikely to see the optical light from the aurora on SIMP J013, it stands out clearly in the radio. Indeed, Jupiter is incredibly bright in radio emission (Figure 1), coming from its own magnetic field. Similarly, SIMP J013 was also seen in the radio, giving off the same kind of polarized pulses that are seen coming from Jupiter's aurora. Thus, in one observation, it appears that astronomers found the first free-floating planet and made the first detection of an extrasolar planet in the radio. ✶

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

Skyward

The Universe and Mars

by David Levy, Montreal and Kingston Centres

Having lived in Arizona for 39 years, more than half my life, I enjoy looking back at some of the more interesting things that have happened. One of the nicest, a strong bond of friendship, began in January 1980, when I got a telephone call from Rik Hill. Like me, he had just relocated to Arizona to begin work running the Burrell Schmidt Telescope atop Kitt Peak. It was a telescope designed to photograph large fields of the sky. At the time, Kitt Peak National Observatory was one of the world's foremost centres of research in astronomy. There, Rik set up his big telescopic camera and began a night of taking pictures of the night sky, studying the highly energetic centres of distant galaxies that we call quasi-stellar objects, or quasars.

Figure 1 — Rik and Dolores Hill. Courtesy Rik Hill.

While Rik was working that night, I brought along my six-inch diameter reflector telescope, which I now call Minerva. At the time I used it (and still do) for visual comet hunting; being able to search for elusive comets from the top of a mountain high in southern Arizona was a thrill I'll never forget. I ended up spending many nights atop Kitt Peak, and I enjoyed them all. With his wife Dolores, Rik and I even drove out to the Riverside Telescope Maker's Conference together in the spring of 1980. As the years went by, the visits became fewer, but we always remained friends, especially when years later I had the honour of presenting to Rik the Walter Haas Award of the Association of Lunar and Planetary Observers, a prize intended to celebrate his decades of work observing other worlds in our Solar System.

In more recent years, Rik joined the Catalina Sky Survey where he used a large telescope on a different mountaintop to discover no fewer than 27 comets. Rik is now near the top of the list of people who have discovered these exciting wandering minstrels in our Solar System.

Dolores is the other half of the Hill astronomy team, and to hear it from Rik, she represents its future just as he does its past. As their daughter Alyson was growing up, Dolores began working at the University of Arizona's Lunar and Planetary Lab in meteoritics. In recent years, Dolores has been a senior research specialist doing outreach for NASA's *OSIRIS-REx* mission, which is currently on its way to the asteroid (101955) Bennu. When it gets there, it will study the small world, choose an appropriate site, touch the asteroid's surface, collect a sample, and finally return the sample to Earth. I have listened to Dolores as she delivered the keynote lecture at our astronomy club's 60th anniversary, describing how a group of scientists and engineers designed and built a spaceship, then sent it aloft to wander across the Solar System to find its target asteroid. I have also enjoyed watching Dolores lead groups of children in experiments, all specially designed to increase their awareness of how humanity explores other worlds in deep space.

Rik and Dolores do astronomy as professionals, with big telescopes and spacecraft, but they have never lost the wonder that is the key to using their own telescopes as amateur astronomers. Their friendship helped ease my first difficult year in Arizona. More important, they symbolize the idea that, while astronomy is meant to be studied, the night sky, with its myriad suns and worlds, is there for all of us to enjoy.

Mighty Mars and the Adirondacks

The summer of 2018 featured our 15th Adirondack Astronomy Retreat in the Adirondack mountains in upstate New York. It is also the last one that Wendee and I will host. Usually the dark and pristine sky from the AAR, as the retreat is known, provides brilliant walkways amongst the distant stars of the globular star cluster Messier 15, or the spiral arms of a galaxy all but lost in the vacuum of space and the mists of time.

But not this year. For the first time in 15 years, Mars, relatively nearby, shone like a big red traffic light in the sky. All night long in the sky, during this particular summer, Mars ruled the night.

The last time Mars looked this good, it was the late summer of 2003. I looked through Obadiah, my six-inch diameter refractor, and I decided that this was by far the best view I have ever had of Mars. Just before going inside, however, I used the very same eyepiece to catch a view of Mars using Pegasus, the eight-inch reflector telescope I have had since 1964.

The view through Pegasus was even better! The dark feature called Syrtis Major and its large complex of adjacent features, were razor sharp. One of the polar caps was clearly visible.

Figure 2-3 — The retreat site, one during the day, the other at night around moonrise, using a fisheye..

From that night onward, I knew that old Pegasus is optically the very best telescope I have.

Mars and I go way back. When I was a teenager I loved to imagine intelligent life there. That idea permanently left me during the summer of 1965, when the famous *New York Times* headline "Mars at Noon: No Canals," reported on the visit to Mars by the spacecraft *Mariner IV*. The idea that Mars harboured no life at all held sway until 1971, when *Mariner IX* revealed a much more complex surface there including Vales Marineris, Mars's larger-than-life version of the Grand Canyon. As years went by, and automated spacecraft actually landed there, Mars became ever more intriguing.

In 1995, an ancient meteorite from Mars, found in Antarctica, displayed vague signs of microfossils that could have given proof that once upon a time, Mars harboured life. Although that conclusion was somewhat premature, it did provide an explosion of interest in the question of Martian bacterial life. This summer a large underground lake was found beneath Mars's south pole. Since Earth has life in virtually every marine environment, it is possible, maybe even likely, that Mars offers the same conditions. With each spacecraft, each new observation, we get closer to detecting life on Mars.

In August, Wendee and I observed Mars through telescopes at our Adirondack Astronomy Retreat. Despite a planet-wide dust storm rendering most surface details invisible, I did see both the north and south polar caps as well as some contrast features. We also had unfavourable weather this year at the retreat, with only about two clear hours during the week. But we did get to see Mars. As this lovely, brilliant red planet orbits the Sun, it offers us in the Adirondacks, and readers of these words in Arizona and around the Earth, an unparalleled view of an ancient and exquisite world. ✶

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

Second light

Lightning on Jupiter from the *Juno* spacecraft

by Leslie J. Sage
(l.sage@us.nature.com)

Radio emission from lightning on Earth has been seen at frequencies from the kilohertz to gigahertz range. Previous spacecraft visiting Jupiter have found that the radio emission from lightning cuts off at kHz frequencies, which has been somewhat puzzling. The explanation could be that the lightning at Jupiter differs from that on Earth, or that the radio signals were cut off due to effects in Jupiter's ionosphere. The *Juno* spacecraft, which arrived at Jupiter on 2016 July 4, after a five-year trip, was equipped with detectors to determine precisely what the explanation is. Shannon Brown of JPL, and his collaborators from around the world, found the radio signature of lightning at 600 MHz (see the 2018 June 7 issue of *Nature*). They conclude that the lightning is not so different from earthly lightning. But rather surprisingly, the distribution of lightning shows a distinct asymmetry—it is far more prevalent in Jupiter's northern hemisphere than the southern, and most common north of 40 degrees north latitude, with a concentration around the poles. Because lightning is related to moist convection (think the towering summer thunderstorms on Earth), Brown and collaborators conclude that increased convection near the poles, carrying energy from the deep atmosphere, is most consistent with what they see.

Juno was launched from Earth in August 2011, and entered Jupiter's orbit five years later. Unlike previous missions, however, *Juno* is in a 53-day polar orbit, plunging quite close to the upper atmosphere—just 4000 km above the "surface," which is defined at the 10-bar pressure level. Its lifetime will be limited by the intense radiation associated with Jupiter's magnetosphere. So far it has completed 12 orbits, exploring the planet's gravity field, which also has a north-south asymmetry and has some inexplicable polar cyclones (see the June 6 issue of *Nature*). The mission is under the direction of Scott Bolton, of the Southwest Research Institute of San Antonio, Texas.

Radio emission from lightning on Earth is identified as "whistlers" in the kHz range, where the characteristic signal, if converted to sound, would sound like a descending whistle, and "sferics" (short for "atmospherics") in the MHz range. Previous spacecraft had identified whistlers at Jupiter, but no sferics. While the lack of sferics could be explained by the large number of free electrons in Jupiter's ionosphere, it was believed that the whistlers also would be attenuated. So an alternative explanation of "slow discharge" lightning, which would cut off radio emission at about 10 MHz, was proposed.

Juno gets 50-times closer to Jupiter than did Voyager in its flyby (and 6-times closer than Galileo's closest approach), skimming just above the atmosphere, making the lightning signal stronger at the spacecraft. *Juno* is also observing at higher frequencies than previous missions, where the ionospheric attenuation is negligible. The spacecraft spins at two revolutions per minute, and its looping path means that over the primary mission it will observe essentially all of Jupiter. The first eight orbits have covered about half the planet.

In the first eight orbits, Brown and his colleagues observed 377 sferics. Lightning is prevalent at both poles, but not seen near the equator (within +/- 6 degrees). This is consistent with the absence of lightning seen by the Galileo probe, which entered the atmosphere at 6 degrees north latitude. No lightning was observed near the great red spot, even though *Juno* passed right over it. The north-south asymmetry is seen in every pass, and so cannot be attributed to a widespread storm in a single pass. The whistlers, observed by a different instrument, showed a similar distribution to the sferics (online with *Nature Astronomy*'s website on June 6).

The lack of lightning and water vapour seen by the Galileo probe led to the conclusion that it dropped into a dry zone, and raised the possibility that the planet was depleted generally in water. That conclusion for the equator is reinforced by Brown's observations, but it is clear that water is abundant at high latitudes. He concludes that the water abundance on Jupiter is at least at the solar average, and likely more abundant.

Jupiter will be bright in the evening sky until early November. The next time you have it in your telescope, spare a thought for *Juno* and what we are learning from its mission. ✶

Leslie J. Sage is Senior Editor, Physical Sciences, for Nature Magazine *and a Research Associate in the Astronomy Department at the University of Maryland. He grew up in Burlington, Ontario, where even the bright lights of Toronto did not dim his enthusiasm for astronomy. Currently he studies molecular gas and star formation in galaxies, particularly interacting ones, but is not above looking at a humble planetary object.*

The December *Journal* deadline for submissions is 2018 October 1.

See the published schedule at

www.rasc.ca/sites/default/files/jrascschedule2018.pdf

Figure 1 — An artist's concept of lightning distribution in Jupiter's northern hemisphere incorporates a JunoCam image with artistic embellishments. (NASA/JPL-Caltech/SwRI/JunoCam)

John Percy's Universe

Naked-Eye Variable Stars, Revisited

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

I recently chanced upon an article that I published in this *Journal* almost half a century ago, on "Naked-Eye Variable Stars" (Percy 1970). Since most of you readers observe the sky on occasion, and many of you show off the sky to the public, you might want to know a bit more about the personalities of the stars you are looking at, or showing off.

At this point, my late colleague Bob Garrison, a former RASC National President and Honorary President, would point out that the *spectra* of stars reveal much about their nature and their personalities. I agree, but the study of their *variability* is an equally important tool. And, in some cases, you can observe it with your unaided eye! So here's an update, with some emphasis on some interesting and bizarre naked-eye variable stars. Depending on sky conditions and eye conditions, "naked-eye" means visual magnitude (V) of six or brighter.

The RASC *Observer's Handbook* lists the "vital statistics" of all stars brighter than V = 3.5 in "The Brightest Stars" section, and you will notice that many of them are variable or *suspected* of being so. It's difficult to measure the brightness of these stars reliably. Too many photons! That's why their variability (or not) is still uncertain. The Canada-Austria-Poland BRITE constellation of nanosatellites[(1)] was specifically designed to study the variability of the brightest stars, and is doing so very successfully.

What kind of stars are the brightest stars? Stars that are nearby and/or more luminous (powerful) are more likely to be visible and bright. It so happens that more-luminous stars are also more likely to be variable. Most stars are actually *less* luminous than the Sun, but those stars are therefore less likely to be bright, and don't appear among "The Brightest Stars." Luminous stars include hot main-sequence stars[(2)], red giants, and supergiants of all colours. "The Brightest Stars" are of these kinds, along with a few nearby, less-luminous stars, such as Sirius.

In 1970, I highlighted the most common bright "variables" (variable stars): rotating magnetic/peculiar stars, and the pulsating Beta Cephei stars and Delta Scuti stars. These are all small-amplitude variables. I mentioned the magnetic/peculiar stars in my last column (Percy 2018), and discussed the Beta Cephei stars in an earlier one (Percy 2016). As I forecast in 1970, the changing pulsation periods of these latter stars can be used to detect and measure their evolution (Neilson and Ignace 2015). My favourite Beta Cephei star is BW Vul (a bit faint for the naked eye at V = 6.64), which has an easily measurable period change, and an in-and-out pulsation amplitude of half a million km per hour! Delta Scuti stars are all small amplitude, and reasonably well understood (except by the specialists, of course). The type star of the magnetic/peculiar stars is the bright Alpha-2 CVn (V = 2.85) with a global magnetic field thousands of times stronger than Earth's.

One development since 1970 is the discovery and understanding of *non-radially pulsating (NRP)* stars. Rather than having in-and-out vibration, as most pulsating stars do, these stars have pulsation waves that go around the star, like water waves. So there are Slowly-Pulsating B-type (SPB) NRP stars that correspond to the hot Beta Cephei stars (Gamma Peg is both), and Gamma Doradus NRP stars that correspond to the cooler Delta Scuti stars (Alpha Oph is both). But these four variable-star types are all small-amplitude.

The other big change since 1970 is the large number of bright pulsating red giants (PRGs). The *General Catalogue of Variable Stars (GCVS)* lists 174 variables brighter than V = 3.5, and over 40 percent are PRGs, most of them small-amplitude. Progress in understanding bright PRGs is due in part to the efforts of my students (Percy 2015), and especially to the efforts of the visual and photoelectric photometry programs of the American Association of Variable Star Observers (AAVSO). By the way, the 174 *GCVS* variables include stars that have been brighter than V = 3.5 at some time in the past—bright novae and supernovae, for instance.

Some PRGs are large-amplitude. Omicron Cet or *Mira* ranges between magnitudes three and nine. In the "Variable Stars" section of the *Observers Handbook* there is a finding chart for this star, plus a prediction of the time of maximum, to help you observe it more easily. Betelgeuse, a pulsating red supergiant, one of the brightest and most conspicuous stars in the sky, varies between magnitudes 0.0 and +1.3, in a complex manner. There's a section on "Carbon Stars" in the *Observers Handbook.* These are stars whose atmospheres have been enriched in carbon, produced by nuclear processes inside the star, and "burped" to the surface. You will notice that all of them have variable-star names! Several of them reach naked-eye brightness; U Hya has reached V = 4.1. And they are beautifully red.

There is also a score of eclipsing binary variables among the brightest stars. In the *Observer's Handbook,* there are finding charts for two of the most conspicuous—Beta Per (Algol) and Beta Lyr. Algol is a relatively simple system, though its past evolutionary path is complicated. Beta Lyr is complicated by interactions between its two components. Observing the variability of these two stars should be on any serious observer's bucket list.

There are also bizarre eclipsing binary variables like Epsilon Aur (V = 3.0) and Zeta Aur (V = 3.7), consisting of a hot star and a cool supergiant star with orbital periods of many years.

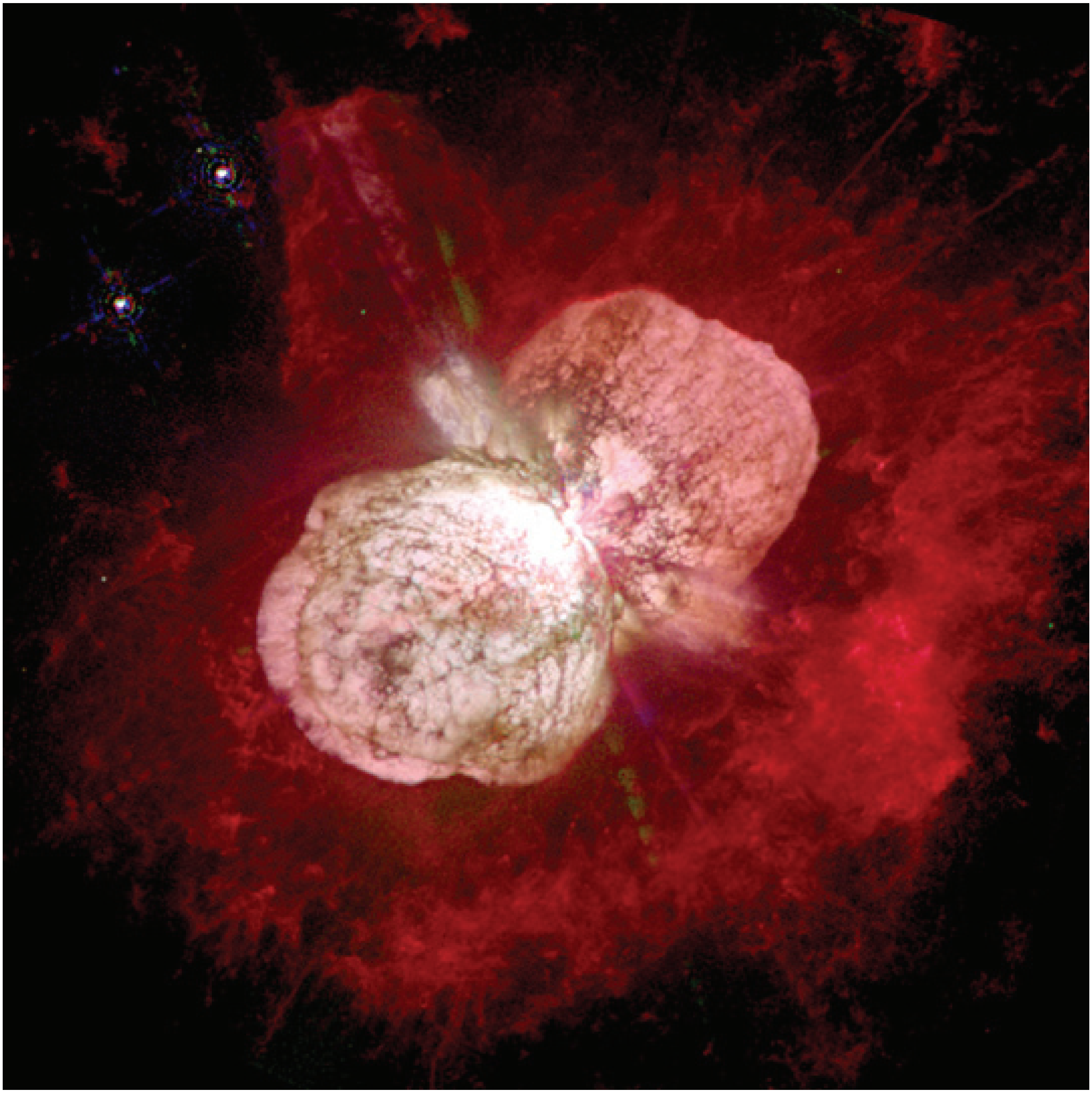

Figure 1 — Hubble Space Telescope *image of Eta Carinae, which erupted in 1837, leaving this remnant behind. Source: NASA/ESA/HST.*

A whole "citizen science" campaign was organized around the 2009–2011 eclipse of Epsilon Aur, in part because the start of the eclipse coincided with the International Year of Astronomy.

From the Common to the Rare

The variables discussed so far are a dime a dozen. *R Coronae Borealis* (V = 5.71), on the other hand, is the prototype of a small group of yellow supergiant stars that are both bizarre and rare. RY Sgr (V = 6.25) is a bright-ish example in the southern sky. There are only a few dozen of these in our whole galaxy. Unlike normal stars, they are rich in carbon and almost devoid of hydrogen, as a result of their previous evolution. And they pulsate. Every now and then, the pulsation drives off a cloud of gas and dust. When the cloud cools, the carbon condenses into soot. If the cloud is between us and the star, the star is obscured, and it fades by up to 10 magnitudes. As the cloud disperses, the star slowly reappears.

Another kind of "eruptive" star is the *Gamma Cassiopeiae* stars, named after Gamma Cas (V = 2.2). They throw off "excretion disks" (as opposed to accretion disks, which occur in forming stars and in many close binary systems) above their equators. This can cause the star to brighten or fade slightly. But its most conspicuous effect is to produce bright emission lines in the spectrum of the star. So they are also called "Be stars"—B for their high temperature, and e for their emission lines.

Wolf-Rayet stars are exceptionally hot stars that also have strong emission lines in their spectra, thought to come from an expanding envelope of gas around the star. The emission lines were discovered by Wolf and Rayet in the year of Canada's Confederation, using a visual spectroscope on a 40-cm telescope. Gamma-2 Vel (V = 1.8) is a small-amplitude variable consisting of a Wolf-Rayet star and a massive, hot main-sequence star in a 78.53-day orbit. One of the projects of the *BRITE Constellation* is to study the variability of Wolf-Rayet stars.

Then there's P Cyg (V = 4.82), a *luminous blue variable* (LBV). How luminous? Half a million times more luminous than the Sun. Its outer layers can barely resist the outward pressure of the star's radiation. Matter streams off the star in a powerful, steady wind. In 1600, the wind swelled, and the star brightened to third magnitude. Since then, it has returned to its present magnitude, but rumbled away like a dormant volcano.

The most remarkable LBV is Eta Car. In a "great eruption" in 1837, it reached magnitude –0.8, rivalling Sirius. Within a few years, it had faded by ten magnitudes but, in the last few decades, it has slowly recovered, and is now V = 4.3. Figure 1 shows a famous *Hubble Space Telescope* image of the remnants of the eruption. If you are in the Southern Hemisphere, check out both the star and the nebula. See [3] and [4] for superb images of the nebula by RASC astrophotographer and Board member, Michael Watson.

In summary: next time you look at the sky, think more deeply about what you are looking at, especially the "action in the sky"—variable stars. And I encourage you to consider contributing to astronomical research by systematically observing and measuring variable stars, as many amateur astronomers do. The place to find resources, as always, is the AAVSO (www.aavso.org). Or read my book (Percy 2007). Almost all of the stars mentioned in this article are also in *Wikipedia*. An easy star to begin observing is the prototype Cepheid Delta Cephei. There's a finding chart in the *Observer's Handbook*, and the main comparison stars are easy to find. ✶

John R. Percy FRASC is Professor Emeritus, Astronomy & Astrophysics and Science Education, University of Toronto, and a keen student of variable stars for over half a century.

Notes

1 www.brite-constellation.at

2 A main-sequence star is one that generates energy by fusing hydrogen into helium in its core. This stage makes up over 90 percent of a star's lifetime.

3 Watson, M.S.F. 2018: www.flickr.com/photos/97587627@N06/41615329630

4 Watson, M.S.F. 2018: www.flickr.com/photos/97587627@N06/43375738622

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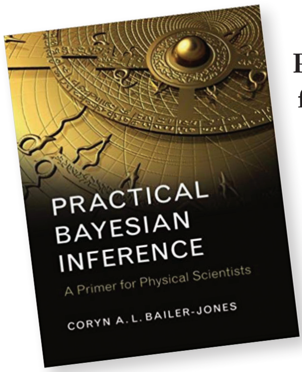
Percy, J.R. (2018), What does a giant star look like? *JRASC, 112*, 177-8.

Reviews/Critiques

by David Turner



Practical Bayesian Inference: A Primer for Physical Scientists, by Coryn A. L. Bailer-Jones, pages 295 + ix, 25 cm × 17 cm, Cambridge University Press, 2017. Price $43.95, paperback (ISBN–13: 978-1-316642-21-4).

This book is outstanding.

Over the past 20 years the progress in statistical awareness for physical scientists has been astonishing. In astronomy, for example, it has become *de rigeur* to understand and use statistics, Bayesian statistics in particular, simply because of the scale of the datasets with which we are now confronted. The awareness has been fostered by necessity and by the efforts of statistically literate scientists and the institutes in which they work. Summer schools now make great contributions at the right point in the training of young physical scientists. Such schools now abound, led by the pioneering and exemplary Penn State offering. Moreover, a free high-level computer language, R, has been developed to assist the process—see www.r-project.org—and it works on all standard platforms.

For some time, there have been good guides for physical scientists in which Bayesian methods are expounded (e.g. *Data Analysis: A Bayesian Tutorial*, D.S. Sivia with J. Skilling, 2nd ed., 2006, Oxford Science Publications). The present work, however, stands out most impressively. For a book of less than 300 pages (available in a well-priced paperback), it is remarkably comprehensive, concise as of necessity, but practical in that the worked examples may be modified to suit many problems one encounters. As a bonus, R-routines are included.

In talking Bayesian statistics, you cannot get there from here. It is essential to go through the concepts of variables, probability theory, probability distributions, errors, and uncertainty—all present here. Then we can get into parameter estimation and model fitting, with appropriate emphasis on the Bayesian Way, together with explicit contrasts with the classical frequentist methods. The development here is neat and logical.

There are gems of worked examples sprinkled throughout. The book opens with the notorious three-doors (Monty Hall) problem. Another gem, worth the book price on its own, is the fitting of lines of given form, in which the Bayesian methodology plus Markov Chain Monte Carlo (MCMC) sampling is developed for fitting a line through points, (a) given noise in one co-ordinate, (b) given noise in both co-ordinates, and (c) points with noise not known in either co-ordinate.

I have noted the pace of change in awareness and expertise in statistical methods. I wish we had reached a point at which it was not necessary to advertise books of the present type using the term "Bayesian" simply because it is the fashion. We need to know about frequentist methods as well, because sometimes Bayesian methods are not applicable. In addition, others—the pharmaceutical industry, in particular—still rely on frequentist methods, and the so-called p-values. We need self-defense. The irony is that *Practical Bayesian Inference* has it all, at the same time making it clear why Bayesian methods are vastly to be preferred when applicable. The day will come when statistical inference or methods will assume that Bayesian methodology is the norm. We might even get to a point where all statistical methods are assumed to constitute basic knowledge in the sciences, and simply refer to methods of scientific inference.

Practical Bayesian Inference is an excellent book that represents great value. It is concise and yet comprehensive on all aspects of the statistics required in the physical sciences, and does what it sets out to do extremely successfully. As advertised, it can serve as a text for senior-year science students as well as for graduate students. In addition, it is a fine first reference for all of us. I recommend it highly.

Jasper V. Wall ✶

Originally a radio astronomer trained at Queen's University (Kingston), the University of Toronto, and the Australian National University (Canberra), with experience at the Mullard Radio Astronomy Observatory, Cavendish Laboratory, Cambridge, Jasper Wall served as Head of Astrophysics at the Royal Greenwich Observatory (1986–1990; 1995–1998), Director of the Isaac Newton Group of Telescopes, La Palma, (1990–1995), and was the last Director of the Royal Greenwich Observatory (1995–1998) when it was an active scientific institution. He is currently an Adjunct Professor in the Department of Physics and Astronomy at the University of British Columbia.

2018 Awards Citations

Chant Medal

Peter Broughton

This medal is awarded, not more than once a year, to an amateur astronomer resident in Canada on the basis of the value of the work carried out in astronomy and closely allied fields of the original investigation and specifically not for the services of the Society, worthy though these may be.

Peter Broughton is an outstanding writer on the history of Canadian astronomy. He is a doyen of those working in the field, by virtue of the quality and quantity of his contributions. For the entirety of the nearly four decades during which he has published, he has done so as a RASC member. A former RASC National President (1992-1994), and holder of many other Society offices, Peter is a retired mathematics teacher (Toronto Board of Education), but an autodidact as an historian. Unlike many amateurs who venture into writing astronomical history, including some quite prominent professional astronomy writers, Peter is at home with original sources in archives, and rare book collections. He has no need to repeat what is found in every book, but, from the vantage of original research, can write about what was not previously known. It is something to which we should all aspire.

Within the Society he is chiefly known for *Looking Up: a History of the Royal Astronomical Society of Canada* (Toronto-Oxford: Dundurn Press, 1994) , the history of the RASC (incidentally, Peter's work on the source material at the National Office in preparation for writing the book led directly to the creation of the present RASC Archives). To this can be added his numerous papers published in JRASC, such as:

"Astronomy in Seventeenth-Century Canada," JRASC 75, 4 (1981, August), 175-208

"Daniel Knode Winder (1828-97), the First President of the Toronto Astronomical Club," JRASC 102, 6 (2008, December), 238-241, and "Astronomical Observations by Peter Fidler and Others in "Canada" 1790-1820," JRASC 103, 4 (2009, August), 141-151.

Many of these remain key treatments in print.

Peter has published other work, less known to most Society members, but arguably of more significance than *Looking Up*, including

"First Predicted Return of Halley's Comet," Journal for the History of Astronomy (JHA) 16 (1985), 123-132

"Arthur Storer of Maryland: His Astronomical Work and His Family Ties with Newton," JHA 19 (1988), 77-96

"Auroral Records from Canada 1769-1821," Journal of Geophysical Research 107. A8 (2002), SIA1-9

"The Accuracy and Use of Sextants and Watches in Rupert's Land in the 1790s," Annals of Science 66, 2 (2009, April), 209-229 as well as entries in both editions (2007, and 2014) of the Biographical Encyclopedia of Astronomers, ed. Thomas Hockey et al., (New York, NY: Springer), for which Peter and his collaborators won the prestigious Donald E. Osterbrock Book Prize for Historical Astronomy of the Historical Astronomy Division of the AAS in 2017.

Peter Broughton's major monograph on J.S. Plaskett (2018) is his most important achievement (https://utorontopress.com/ca/northern-star-1). It enables us to now see the first Canadian astrophysicist of world standing in the round. It is the product of over a decade of research, and its results, significant for refining the narrative of astronomy in Canada, are of interest not only to researchers here, but also to those abroad.

Peter's published work has allowed us a fuller view of the world of amateur and professional astronomy leading to the present stage of the discipline in Canada. In doing so he has enhanced the reputation of the Society. His contributions well merit the Chant medal.

Simon Newcomb Award

Nicole Mortillaro

The Simon Newcomb Award is intended to encourage members of the Royal Astronomical Society of Canada to write on the topic of astronomy for the Society or the general public, and to recognize the best published works through an annual award.

An eligible entry should be a recently published piece of writing with an astronomical theme. This could be one of a book or a portion of a book; an article in the *Journal* of the RASC a Centre newsletter, or another RASC publication; an article in a commercially published magazine; and so on. A series of articles or a history of exemplary writing would also be considered eligible.

Our nominee, Nicole Mortillaro, is one of Canada's best-known and most widely read science journalists. Her writing is both incisive and accessible, balancing a critical, analytical approach to her subject matter with a readable style. She brings complex and fascinating astronomy topics to Canadians of all ages. Well respected for her clear communication and insight into a wide range of complex scientific issues and diverse subject matter, she brings sensitivity and understanding to astronomical topics. Her work inspires curiosity and shares the excitement of scientific discovery.

In 2013, she became well-known through her work at Global News by writing, blogging, and reporting on numerous astronomy, science, and weather topics. With her move to the Canadian Broadcasting Corporation in 2016, she has become one of the nation's pre-eminent science writers, with a large national audience.

In 2010, Firefly Books published her book *Saturn: Exploring the Mystery of the Ringed Planet* based on science data and imagery from the Cassini-Huygens orbiter and space probe. It includes extraordinary mission photographs and accessible text for the general reader.

Nicole also maintains a science blog at www.nicolemortillaro.ca where she has published numerous articles ranging from exploration of our solar system to the fight to save our skies from the scourge of excess lighting.

Nicole was appointed Editor of the Journal of the Royal Astronomical Society of Canada in the summer of 2015, following several years as an assistant editor and is responsible for moving the Journal forward from issue to issue.

She has written an estimated 170 articles and many can be found on the CBC News website. A concise piece titled "Are we really headed to the moon?" features some quotations from NASA executives and excerpts from an interview with RASC Executive Director Randy Attwood.

Published September 28, 2017 it can be found at:
www.cbc.ca/news/technology/going-moon-nasa-russia-1.4309109

Nicole's November 2016 article on Science and Canada's First Nations peoples, "How science and First Nations oral tradition are converging" displays her sensitivity and understanding of complex issues, although this particular article does not relate to astronomy, it demonstrates how Nicole is bringing science to all Canadians.

Her work related to the August 15, 2017 "Total solar eclipse 2017: Read CBC's complete coverage" is another example of good science, supporting information, practical advice, and excellence in bringing astronomy to the citizens of Canada. In this multi-faceted article, and the related items she brings together material to cover where the eclipse could be experienced, how to do it safely, and explain in clear terms how it comes together. It can be found here: www.cbc.ca/news/technology/full-eclipse-compilation-1.4247285 and Ms. Mortillaro's article here: www.cbc.ca/news/technology/solar-eclipses-science-1.4242330

We heartily recommend that the Simon Newcomb Award be presented to Nicole Mortillaro. She has proven her science-writing skills and her work is well-aligned with the RASC's effort to inspire all Canadian's to learn more about their Universe. We believe her work is of the calibre of prior award winners Terence Dickenson, Dan Falk, and Ivan Semeniuk. She would be the second woman to receive the award since 1979. She has potential to reach and inspire generations of Canadians, sparking their interest in astronomy and encouraging them to protect our night skies.

Submitter: Colin Haig, RASC President
Submitter: Craig Levine, RASC Past President

Fellowship Award

Peter Jedicke

The award of Fellow of the RASC is to recognize the long-term and on-going contributions of members whose service to the Society has been exemplary and substantive for an extended period of time. Such contribution will far exceed the level required for our Service Award.

Nominees may already hold the Service Award, but it is not a prerequisite for Fellowship.

This is a major, and senior, national award. It is intended to be the Society's most senior award and the highest honour the Society can pay to a member. Candidate's service and contributions to the Society must have had a significant positive impact on the work of the Society over an extended period, and must have contributed to the Society's success in attaining its stated objectives, mission, and vision. Such contributions can be at both the Centre and National level, but at least half of the service contribution must have been rendered at the national level.

Although many of the London Centre did not meet Peter until the early 90s, it became quickly evident that Peter already possessed a long history of contribution to the RASC, a passion for the Society, and a vast knowledge of the inner workings of the RASC at both the National and Centre levels.

Soon after joining London Centre in 1974, Peter became a member of the Centre's Executive Council. Peter served as London Centre President from 1978-1980. During that period, Peter single-handedly chaired and organized the 1979 General Assembly in London. Peter also rewrote the London Centre Constitution and Bylaws and obtained the Centre's non-profit status that continues to this date. Peter obtained government grants which were used to run summer astronomy programs, and was instrumental in having telescope trade tariffs removed. In 1980, Peter began his long period of service to National Council as the London Centre National Representative. In the mid 80s Peter set up a speaker's exchange program with other centres in Southern Ontario. In 1986 and 1987, Peter again served as London Centre President. In 1996 Peter was appointed Honorary President of London Centre. As Honorary President, Peter continuously mentors new members, attends Executive meetings, assists in finding Guest Speakers, and performs Public Outreach at Cronyn Observatory.

Peter again acted as Chair for the 2001 General Assembly that was held at Fanshawe College in London. This resulted in yet another well-received GA, cementing London's reputation for entertaining and innovative GAs.

Peter continued his involvement with National Council, serving in various capacities until becoming National President in 2004 to 2006. While Peter was National Council

President, he visited and attended as many Centre meetings across Canada as possible. Peter continues to attend National Council meetings via Webex and is a regular attendee of General Assemblies.

In 2015-2016 Peter acted as co-chair for the 2016 General Assembly held in London, Ontario, the third London GA Peter had been involved in organizing. This particular GA was special as it was combined with the Canadian Vendor Show AstroCATS, an RASC first. As a GA organizational veteran, Peter is a sought after and willing counsel to other Centres' GA committees.

Peter has been instrumental in the Asteroid Names with a Canadian Connection program. Many Canadians and RASC members now have an asteroid named after them thanks in part to Peter's efforts.

Peter has demonstrated a life-long commitment to and passion for the RASC. Over 44 years he has tirelessly served both London Centre and the Society. Peter has put the RASC at the forefront of his life, resulting in a long-lasting, positive and measurable impact on the RASC at both the National and Centre level. His achievements and hard work speak for themselves.

There can be little doubt that Peter deserves consideration for the Fellowship Award of the Royal Astronomical Society of Canada.

Service Awards

The Service Award is a major award of the Society given to a member in recognition of outstanding service, rendered over an extended period of time (at least 10 years), where such service has had a major impact on the work of the Society and/or of a Centre of the Society.

Grant Rice – Okanagan Centre

Grant has served several years as the Okanagan Centre Secretary.

Grant was a member of the registration committee for the RASC General Assembly in 2005, was instrumental in implementing the web-based registration process, and a gracious OC representative host throughout the event.

Grant was in on the ground floor of the development of the Okanagan Observatory. The Okanagan Observatory is open to the public every Friday that weather permits, and also hosts special bookings of youth and school guests. Grant was initially involved in creating the business plan and researching the financial opportunities that might promote advancement of the project, and successful in many funding applications. For many years Grant ensured that our annual charity tax return was completed properly and on time, and has mentored other members in this task.

Grant has also used his computer skills to great purpose in the development of the security system for the remote Okanagan Observatory assets. Grant has played a role in the planning, installation and monitoring of the entire system. Grant has made numerous short-notice trips out to the observatory in order to reset or adjust the security equipment, sometimes having to snowshoe in and dig away snow for door access.

The above examples of Grant's service to the Okanagan Centre highlight the generosity he extends in offering his computer and other skills whenever they are needed. When our Centre website was undergoing a needed revitalization in 2011 by the then-President who had no experience with the internet whatsoever, Grant generously lent his expertise, time, and especially infinite patience to teach the necessary skills which made this possible.

Grant is familiar with the operation of all of the Okanagan Observatory equipment and plays an active role on our public Friday nights in operating a telescope, assisting with parking, helping at the welcome desk or giving laser-guided tours of the night sky.

It is thanks to Grant's insistence and determination that we now hold an annual Gala Dinner for our Centre. For seven years now, we have engaged a special guest speaker and gather to enjoy a meal and silent auction, with the funds raised going to the advancement of the Okanagan Observatory. Grant chaired the Gala committee for the first three years and continues to play an active role.

Very recently Grant was successful in garnering yet another donation to the observatory project for a binocular-observing station as part of the public nights. Grant is looking forward to organizing the assets and developing the binocular program, as well as sharing with our larger community.

Submitter: Guy Mackie, Okanagan Centre
Submitter: Colleen O'Hare, Okanagan Centre

Richard Christie – Okanagan Centre

Richard Christie has been an active Okanagan Centre volunteer since the Centre's inception in 1996. He has negotiated free meeting space for the Centre's three meeting groups at Okanagan College campuses in Vernon, Kelowna, and Penticton each year which contributes greatly to the financial viability of the centre. As a professional astronomer, he has been a major contact with the area's professional astronomers, and has been active in recruiting them as speakers. Each year he researches an astronomical topic outside his own research interests, and presents a talk at one of the monthly meetings.

He has been a regular volunteer at outreach activities and also at the Friday evening public nights at the Okanagan Observatory since it opened to the public in 2008. Richard assisted the Okanagan Astronomical Society before its merger with the Okanagan Centre.

Richard has been a significant member of the organizing committee at the annual Mount Kobau Star Party for many years, and he served three terms as chairman, in 2010-2012.

Richard operated the A/V equipment at the Okanagan Centre GA in 2005. He required all speakers to meet with him half a day before their presentation to ensure that their pictures and videos would seamlessly show up on the screen when they were supposed to instead of the usual speaker puzzlement when they say: "Gee, my Powerpoint always worked before!" Richard thus prevented speakers' presentations from being the usual shambles of rebooting computers and A/V equipment that we have all come to expect from Powerpoint. Because of Richard, the Okanagan GA paper sessions ran much more smoothly than at prior GAs.

He was the communication nexus for the dissemination of weather forecasts to the scores of Okanagan Centre members who travelled to far-flung sites across Oregon and Idaho for the 2017 total solar eclipse.

He was the speaker at the Centre's 2017 Gala, which is the Okanagan Observatory's major annual fundraising event.

Nationally, he has been the Okanagan Centre's National Representative on National Council since 2011. He is a member of Okanagan Centre Council's Observatory and Gala Dinner Committees.

Submitter: Alan Whitman, Okanagan Centre
Submitter: David Hawkins, Okanagan Centre

Colleen O'Hare – Okanagan Centre

Colleen O'Hare has lead astronomy outreach activities in the Okanagan Centre for 12 years, and each year she continues to arrange the exceptional number of events which won her the first Qilak Award in 2012. In 2017 she arranged 99 events (of which 76 took place, the rest being cancelled due to weather). By December 5 these events had served 4,451 guests, and she participated personally in almost all of them. Some years she has reached more like 8,000 people. She has travelled to towns several hours away to provide astronomy experiences to them.

She has served on the Okanagan Centre Council since shortly after joining the centre in 2004, including serving three terms as president and being the librarian for about a decade (she lugs books related to the main speaker's topic to the Kelowna, Vernon, and Penticton monthly meetings). She is an active member of these Okanagan Centre council committees: the Okanagan Observatory Planning Committee, the Finance Committee, the Gala Dinner Committee, and chairs the Nominating Committee.

She researches topics and is the main speaker at meetings at least once each year. She made the public service announcements for our Kelowna area meetings and events for a decade or so; composes and has printed handout materials promoting the Centre and the observatory; creates decorations and information displays to augment our tent at outreach events; frequently brings baking to meetings; and for many years has brought the coffee making supplies to Kelowna meetings.

When she was a new member Colleen did much of the organizing for the meet and greet table at the 2005 Okanagan General Assembly, acting as an enthusiastic and cheerful ambassador for our Centre.

She volunteers at the week-long Mount Kobau Star Party's registration desk each summer.

She has had an active role in the Friday evening public nights at the Okanagan Observatory since it opened in 2008. In addition, she led the SkyTheatre development (planning, construction, and volunteer organization); has helped with annual maintenance (painting, weed pulling, and crush raking); organized special observing nights at the observatory for school children, youth groups and service groups; and helped in developing the mobility-challenged bus service program. She has been the media representative for the observatory, developing leads, contributing to news releases, and taking part in televised interviews. She has contributed to the Gala Dinner (the annual observatory fund raiser) by soliciting name speakers, creating and printing admission tickets, and running merchandize and ticket sales.

Wherever astronomy volunteers are working on a project in the Okanagan Valley, Colleen O'Hare is almost always there and pitching in.

Submitter: Alan Whitman, Okanagan Centre
Submitter: Richard Christie, Okanagan Centre

Neil Sandy – Sunshine Coast Centre

Neil Sandy, a Sunshine Coast realtor, has been a member of the Royal Astronomical Society of Canada since January 1997, roughly 11 years before our Sunshine Coast Centre was founded in April 2008. Neil became one of the founding members of the Sunshine Coast Astronomy Club that was the precursor of our Centre in 2004. Our Sunshine Coast Astronomy club became the Sunshine Coast Centre of the RASC in April 2008. Neil served five years as a director on the Sunshine Coast Centre's first Board of Directors. Neil set up the Freelists email lists for our Centre and has managed these email lists ever since. Neil oversaw the Public Speaker Program for our Centre for several years and was so employed when I joined the Sunshine Coast Centre in 2013. I took the speaker program over from him in 2014, but Neil has often billeted speakers who come to the Sunshine Coast for the evening to speak at our monthly meetings at the Sunshine Coast Arts Centre at no charge to our Centre since then. Neil is always there at welcome dinners for the speaker to make the visitor welcome. Our founding President, Bill Clark, describes Neil as a "lead hand" in astronomy outreach events for our Centre. Neil has always been supportive in our Centre's public outreach events, bringing his telescopes to these events year-round, spending countless hours taking great pride and pleasure in helping the public to view the skies. When our Centre built its roll-off roof observatory at the Sechelt Airport, Neil acted as liaison with the Sechelt Airport Users Group to represent our interests. Neil has built several telescopes and taught classes on this and other astronomy subjects to Centre members. Neil is always volunteering his expertise to assist members on line. Neil Sandy has consistently been an excellent ambassador to the public for the RASC.

Submitter: Charles Ennis, National Secretary/President, Sunshine Coast Centre
Submitter: Bill Clark, Past President, Sunshine Coast Centre

Brian Lucas – Sunshine Coast Centre

Brian Lucas, a retired anesthesiologist, is one of the founding members of our Sunshine Coast Centre and is currently the Secretary on the Board of our Centre. Brian has been a member of the RASC since January 1999 and was originally with the Vancouver Centre before moving to the Sunshine Coast of BC. Brian Lucas is a passionate advocate for the abatement of light pollution and started researching the problem and advocating for solutions when he was with the Vancouver Centre. He has accumulated extensive files on this subject. Brian is currently on our Sunshine Coast Centre's Light Abatement Committee. Brian served briefly on the RASC's national Light Pollution Abatement Committee, starting back in 2008. It was Brian's extensive research that supplied our Centre with the data needed to succeed in getting the District of Sechelt to become a Dark-Sky Community, under IDA regulations. Our Centre shared Brian's files with the Yukon Centre, that used this information to win their battle with the Yukon Territory and Whitehorse to get the correct colour temperature street lighting. Brian has spent countless hours researching this subject and seeking out problem lighting and solutions on the Sunshine Coast. Brian came up with an idea that turned into a very successful fund-raising venture for our Centre (and others across Canada): reloadable shopping cards. These are plastic cards for a particular store (in our case, the IGA supermarket) which you load with credit and then use to purchase your items. It doesn't cost you any extra, but for every purchase, the store donates four percent of the total. This project brought in $2,000 a year in our Centre's first year.

Submitter Charles A. Ennis, National Secretary/President, Sunshine Coast Centre
Submitter: Michael Bradley, Vice President, Sunshine Coast Centre

Qilak Award

The Qilak Award / Prix Qilak is intended to recognize individual Canadian residents, or teams of residents, who have made an outstanding contribution, during a particular time period, either to the public understanding and appreciation of astronomy in Canada, or to informal astronomy education in Canada, and to promote such activities among the members of the sponsoring organizations.

The awards do not recognize achievement in formal astronomy education or achievement by a person or team of persons in the performance of their regular duties in their job or profession.

RASC – Mike Moghadam, Ottawa

CASCA – Dr. Rob Thacker, St. Mary's University, Halifax

FAAQ – Daniel Brousseau, Sherbrooke

Mike Moghadam has been an RASC member since 2003, most of it with the Ottawa Centre. During that time Mike has served as Outreach Coordinator (2009–2011), Meeting Chair (2014–2015) and currently as Vice President (2017–2018). Through this entire period there has not been a time when Mike was not actively involved in trying to promote the RASC and educate as many people as possible about the night sky. In his roles as Meeting Chair and Vice President, Mike's focus and motivation is outreach.

During his time as Outreach Coordinator, Mike organized and promoted our monthly public star parties that run from May through October. He worked with the City to obtain an easily accessible, secure, relatively dark site to host the events. He publicized them and built them to the point where we routinely had 250 people attending regularly. For a while he even tried to have a second event running in the opposite (east) end of the City to accommodate those who were not prepared to make the longer drive to the outreaches of the west end.

Responding to the numerous requests from various community groups for astronomy events was something Mike seemed to particularly enjoy. Girl Guide, Brownie, Boy Scout and Cub groups were a regular with Mike. Events that he could not personally lead, he would delegate to a team of volunteers he had trained.

Mike developed and ran a school program where we would send volunteers into the area schools to encourage an awareness and appreciation of the night sky.

From 2009 onward, Mike has been organizing our Astronomy Day events, which draw 1,000 to 2,500 people depending on the weather. Ottawa Centre currently holds its meeting at the Aviation and Space Museum. Previously they were held at the Museum of Science and Technology. These institutions regular host events that have an astronomy connection, and we are called on to support them. Mike always finds new and fresh ways to provide that support.

As Meeting Chair, Mike worked very hard at bringing in speakers that would draw the general public to our meetings. He would usually pair this speaker with one of the many excellent speakers from the Ottawa Centre to demonstrate to value we have to offer to these "guests." In an auditorium with seating for about 300, and a typical attendance of 125, we would have standing room only at these events. It resulted in a marked increase in our membership.

Mike has always had an eye for spotting potential volunteers and a manner that encourages them. During his term as Meeting Chair he spotted a young teenager in our midst. She had created an Astronomy themed cook book (with things like Asteroid Chunk cookies). Mike helped her with a presentation and she sold the cook book to raise money for a local charity. With Mike's continued support and encouragement, she went on to be our Meeting Chair in 2017—at the age of just 17! Her involvement led to an upsurge in young people joining our greying group and becoming actively involved. We now have another teenager (15) who has given a presentation at the meeting, published an article in our newsletter and is now our Outreach co-chair.

The result of all this is that Mike's efforts have reached and influenced thousands of people a year. This alone would qualify Mike Moghadam to receive this award but the above only scratches the surface of the many things he has done and continues to do to promote our beloved pastime. Mike has worked at least as hard during the times he was not "officially" responsible for Outreach. After stepping down as our Outreach Coordinator, since nobody immediately stepped forward, Mike continued to organize our summer star parties and thanks to his efforts these now average 300 to 400 people at each event. He was heavily involved in our Solar Eclipse event last summer which drew 8,000 to 10,000 people. We had 2,000 solar glasses to hand out to the public and at one set per family they were gone half an hour before we officially started. The traffic was so bad the RCMP had to close the roads leading to our event.

Mike created telescope clinics for anyone needing help with any issue with their equipment. These have been well attended by new members and non-members alike. In the lead up to the recent Ottawa GA he led several outreach events for the Kanata region of Ottawa in exchange for their support for the GA. As well he acted as volunteer coordinator for the GA. He is also actively guiding our new Outreach team.

An event that really stands out for me is the Mercury Transit event on Parliament Hill. I know how much work went into this event alone because I worked with Mike on organizing it. Over a period of several months we worked with Minister Kirsty Duncan's office to host an event on the front lawn of Parliament Hill. We had National and Local news coverage of the event that was attended by everyone from Members of Parliament, including Science Minister Duncan and Transport Minister Garneau, to tourists just visiting the Hill. We had between 3,500 and 5,000 people attend.

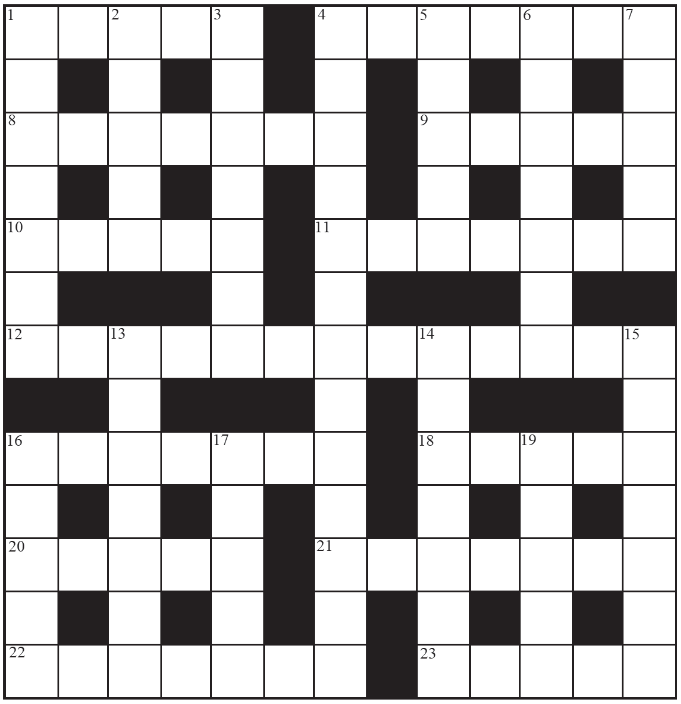
From the time Mike joined us, he has been the person we think of for any Outreach event. Outreach is in his blood. No matter what role Mike is "officially" undertaking for the Centre, his direction is always outreach. Even by conservative estimates, Mike's efforts over the past nine years have reached over 40,000 people. We feel that Mike embodies all the values and requirements of the Qilak Award and that if any other Centre has anyone who works half as tirelessly as Mike, they are indeed blessed

Submitted by:

Tim Cole, Robert Dick, Oscar Echeverri, Karen Finstad, Chris Teron, Carmen Rush, Gerry Shewan, Jim Sofia, Gordon Webster ✶

Astrocryptic

by Curt Nason



ACROSS

1. Future pole star shines in a summer rainbow (5)
4. Lane software takes us on a winding road where Mintaka transits overhead (7)
8. Nebulous new catalogue filler rewritten for Al Green (7)
9. Mopes about salts thought to be in Occator crater (5)
10. Hot moon back in a region of ancient Greece (5)
11. Perseus to Andromeda about a bad curse (7)
12. Blair vanished mysteriously in an erratic nebula (5,8)
16. Possible Bengali name for horseback (7)
18. Sandy place on the Riviera looks bright orange in a PST (5)
20. One hundred fifty are about to make a sky wish (5)
21. Faculae undergo FM transition to dark spots on a planet (7)
22. Executive Director initially caused class disruption on our list (7)
23. The Moon soars around for a period (5)

DOWN

1. Broken shingle on Hooker mounting (7)
2. Practical astronomer came right before seed spiller (5)
3. Invasion where Helios stood tall, we hear (7)
4. Hot Lips loses her head and fails miserably as bright star points (8,5)
5. Unsavoury characters on computers (5)
6. Bother to learn what an impact can do to rocks (7)
7. Primary light timer was heard to be an aimless wanderer (5)
13. Angels dance around redhead for classics eyepieces (7)
14. Little devil plays a role in how craters form (7)
15. Looking through it can you see Selene running around the gym? (3,4)
16. The rider was in the pastoral corral (5)
17. She is on the level down south (5)
19. To go in France he wrote about stellar atmospheres (5)

Answers to August's puzzle

ACROSS

1 TERRA (2 def); **4** BENNETT (ben(NE T)t); **8** AMMONIA (anag); **9** BAYER (2 def); **10** SYNODIC (anag); **11** LAIRD (2 def); **12** SPARSE (anag+E); **14** DEIMOS (anag); **18** LACUS (anag 19D); **20** PALOMAR (pal+omar); **22** MODEL (2 def); **23** REPULSE (re+anag); **24** TRANSIT (anag); **25** ERNES (an(N)ag)

DOWN

1 THARSIS (th(ArS)is); **2** ROMAN (anag); **3** AONIDES (anag); **4** BRANCH (2 def); **5** NOBEL (anag Bonestell-lets); **6** ELYSIUM (2 def); **7** TIRED (2 def); **13** ARCADIA (A(r)cadia); **15** ELLIPSE (el+lips+e); **16** SERPENS (anag); **17** SPIRIT (anag); **18** LIMIT (LI+MIT); **19** SOLIS (anag 18A); **21** MALIN (hid)

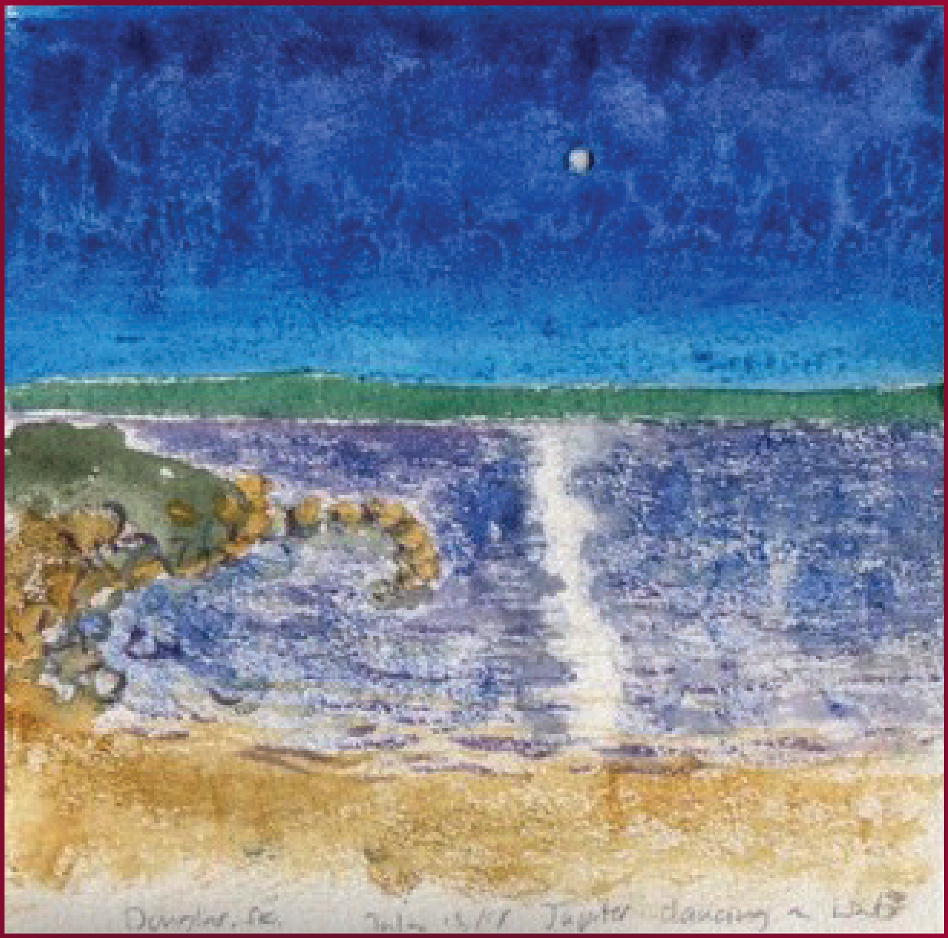
It's Not All Sirius

by Ted Dunphy

Great Images

by Kerry-Ann Lecky Hepburn

One extra treat from Kerry-Ann Lecky Hepburn. This time it's the Orion Nebula (M42). She used an AT8RC ƒ/8 and an SBIG 8300. 12x5min, 4x60sec.



Journal

Great Images

Jupiter as a hole in the sky, reflecting its own light on Lake Diefenbaker, Saskatchewan, and Venus at Dusk over Lake Diefenbaker. Kathleen Houston painted this on watercolour paper, with Windsor and Newton watercolour paints and Caran d'arche neocolor 2 water colour pencils.