The Journal of The Royal Astronomical Society of Canada

Journal

Le Journal de la Société royale d'astronomie du Canada

PROMOTING
ASTRONOMY
IN CANADA

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Number/numéro 6 [793]

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Astronomical Art
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The Royal Astronomical Society of Canada, then and now.

THE GOVERNOR GENERAL · LA GOUVERNEURE GÉNÉRALE

It is a pleasure to send greetings to amateur and professional astronomers across this country who are celebrating the 150th anniversary of the Royal Astronomical Society of Canada (RASC).

What an accomplishment, 150 years! A century and a half of discoveries and advancements.

My fellow astronauts and I owe our passion and time in space to those astronomers and scientists who looked up to the sky, defined the mechanisms that control gravitational movement and furthered our comprehension of the world we live in.

Through lectures, education and public outreach, the RASC brings the vastness of space and its complexity into focus. The Light-Pollution Abatement (LPA) Program, for example, gives an increasing number of Canadians a chance to clearly see the stars. If you know where to look, you will spot a planet or a galaxy—or even discover your own asteroid to add to an already impressive online collection.

For 150 years, the RASC has worked to inspire curiosity and enhance our understanding of the universe. As we continue to look towards space, as the current frontier at the edge of the known world, I know the RASC will continue to play an essential role and help one and all explore the cosmos, one star, one planet, one galaxy at a time.

PER ASPERA AD ASTRA!

Julie Payette

PER ASPERA Σ AD ASTRA

1 SUSSEX DRIVE · 1, PROMENADE SUSSEX
OTTAWA · CANADA · K1A 0A1 · WWW.GG.CA

Photo: Sgt Johanie Maheu, Rideau Hall

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

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Top: see page 246 for caption. Bottom: celebrants at the Calgary General Assembly, 2018.

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., Victoria Centre
(cgainor@shaw.ca)

RASC's 150th anniversary celebrations are coming to an end after a year of memorable events.

Many highlights come to mind for me. First of all, our Society obtained recognition in the form of special stamps issued in June by Canada Post and a commemorative coin created by the Royal Canadian Mint that includes a piece of a meteorite.

As a long-time stamp collector, I was thrilled to help unveil the stamps at the Calgary General Assembly along with my predecessor Colin Haig, our great astroimager Alan Dyer, and David K. Foot, an RASC member who was also on Canada Post's Stamp Advisory Committee. The anniversary coin sold out within hours of going on sale, but I was lucky to find one in a local post office for my own collection.

Much of the credit for this recognition goes to our Executive Director, Randy Attwood, who persuaded both the Mint and Canada Post to include our sesquicentennial in their 2018 programs.

We had two national star parties this year the first one in January carried live in a nationwide webcast. Members across Canada, including myself, have contributed astrophotos, sketches, and other artwork to our Imagining the Skies website.

Our RASC 150 logo has been popular and so has our RASC Mosaic, which is available for download.

My colleagues on the RASC History Committee have been busy. Committee chair Randall Rosenfeld and Board Member Heather Laird have created a great set of podcasts on our shared history in the RASC. Much of our GA was taken up with an excellent set of papers in a seminar called "A Shared Sky: The RASC 1868–2018". Those papers will be published in the near future.

For me, this year was very special, not only because I became President of the RASC. Like many other people, I enjoyed the great hospitality and terrific speakers at the Calgary GA. The opening ceremony involving local First Nations' speakers and dancers was especially memorable.

I've been able to visit a number of Centres, including the Toronto Centre where our Society began in 1868.

A special highlight for me was enjoying the magnificent beauty of Yukon when I spoke at the Northern Nights Dark Sky Festival at Kluane National Park in September. Kluane's incredible mountain scenery was even better than usual with fall colours.

Around midnight, the skies lit up with a great display of Northern Lights that was visible all over the north. I stayed up late and got my first ever photos of the Aurora Borealis, which can be found on the Imagining the Skies website. I rarely get to see the Northern Lights at home on the West Coast, but this display took me back to the time many years ago when I first joined the RASC as an adolescent at the Edmonton Centre, and where I quickly became an enthusiastic auroral observer.

I hope all of you have great memories like these of the RASC's 150th anniversary, but most importantly I hope we all enjoy clear skies and impressive sights in the years to come. ✶

News Notes / En Manchette

Compiled by Jay Anderson

Voyager 2 leaving home

NASA's *Voyager 2* probe, currently in the outer reaches of the Solar System, has detected an increase in cosmic rays that originate outside our Solar System. Launched in 1977, *Voyager 2* is a now a little less than 17.7 billion kilometres from Earth, more than 118 times the distance from Earth to the Sun.

Since launch, the probe has been travelling within the heliosphere—the vast bubble around the Sun and the planets, dominated by charged particles and magnetic fields carried by the solar wind. The solar wind creates and maintains the bubble, pushing back against the pressure of material in the interstellar medium. *Voyager 2* scientists have been watching for the spacecraft to reach the outer boundary of the heliosphere, known as the heliopause. Once *Voyager 2* exits the heliosphere, it will become the second human-made object, after *Voyager 1*, to enter interstellar space.

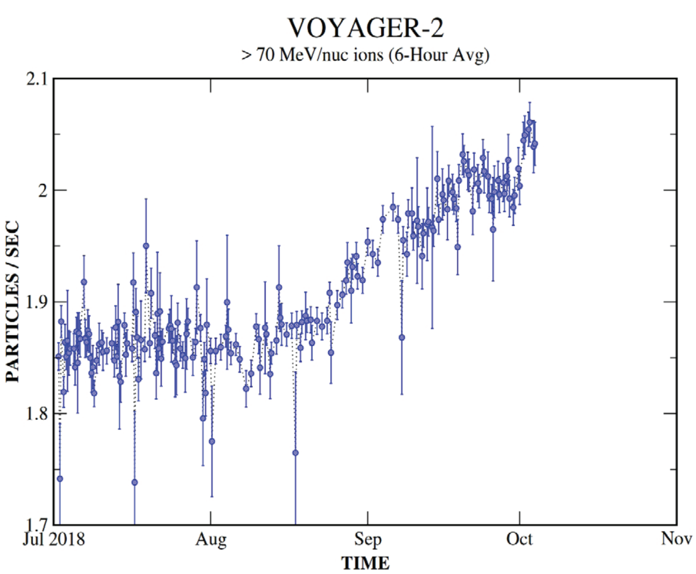

Figure 1 — A graph of high-energy particle detection rates acquired aboard the Voyager 2 *spacecraft up to early October. The PGH rate consists of >70 MeV/nuclei ions, primarily protons, and is a good indicator of the level of modulation of galactic cosmic rays. It can also respond to large solar flares.*

The outer reaches of the heliosphere is a turbulent region with a complex structure that is formed by the variable nature of the solar wind, the spiralling solar magnetic field, and the gradual impact of the interstellar medium. In the inner parts of the Solar System, the solar wind flows at supersonic speeds, but in the outer reaches, it must slow down to meet the interstellar environment. A "termination shock" forms where the solar wind becomes subsonic; beyond that point, the environment has been described as "foamy," consisting of 160-million-km-wide bubbles of twisted magnetic fields and associated ionized particles. *Voyager 2* passed the termination shock in 2007 and will not enter interstellar space until it has passed this region and has reached the heliopause.

Since late August, the Cosmic Ray Subsystem instrument on *Voyager 2* has measured about a 5-percent increase in the rate of cosmic rays hitting the spacecraft compared to early August (Figure 1). The probe's Low-Energy Charged Particle instrument has detected a similar increase in higher-energy cosmic rays. Cosmic rays are fast-moving particles that originate outside the Solar System. Some interstellar cosmic rays are blocked by the heliosphere, so mission planners expect that *Voyager 2* will measure an increase in the rate of cosmic rays as it approaches and crosses the boundary of the heliosphere.

In May 2012, *Voyager 1* experienced a similar increase in the rate of cosmic rays, about three months before it crossed the heliopause and entered interstellar space.

However, *Voyager* team members note that the increase in cosmic rays is not a definitive sign that the probe is about to cross the heliopause. *Voyager 2* is in a different location in the heliosheath—the outer region of the heliosphere—than *Voyager 1* had been, and possible differences in these locations means *Voyager 2* may experience a different exit timeline than *Voyager 1*.

"We're seeing a change in the environment around *Voyager 2*, there's no doubt about that," said *Voyager* Project Scientist Ed

Stone, based at Caltech in Pasadena. "We're going to learn a lot in the coming months, but we still don't know when we'll reach the heliopause. We're not there yet—that's one thing I can say with confidence."

The *New Horizons* spacecraft, now on its way to explore a tiny body in the Kuiper Belt, is expected to reach a similar distance from the Sun in about 2040. *New Horizons* is travelling more slowly than the *Voyager* spacecraft.

Compiled in part with material provided by the Jet Propulsion Laboratory, Pasadena.

Another member of the outer Solar System

A new dwarf planet has been discovered in the outer reaches of our planetary system at a distance of about 80 astronomical units (AU), two-and-a-half times farther than Pluto.

The new object is on a very elongated orbit and never comes closer to the Sun (perihelion) than about 65 AU. Only two other dwarf planets, 2012 VP113 and Sedna, at 80 and 76 AU respectively have more-distant perihelia than 2015 TG387. Interestingly, the new dwarf has an orbital semi-major axis much larger than 2012 VP113 and Sedna's, reaching all the way out to about 2,300 AU. 2015 TG387 is one of the few known objects that never comes close enough to the Solar System's giant planets to have significant gravitational interactions with them.

Scott Sheppard of the Carnegie Institute for Science, Chad Trujillo of Northern Arizona University, and David Tholen of the University of Hawaii discovered the new object, which has an orbit that lends support to the presence of an even-farther-out, super-Earth-sized "Planet X."

"These so-called Inner Oort Cloud objects like 2015 TG387, 2012 VP113, and Sedna are isolated from most of the Solar System's known mass, which makes them immensely interesting," Sheppard explained. "They can be used as probes to understand what is happening at the edge of our Solar System."

The object with the most-distant orbit at perihelion, 2012 VP113, was also discovered by Sheppard and Trujillo, who announced that find in 2014. The discovery of 2012 VP113 led the two to notice similarities of the orbits of several extremely distant Solar System objects, and they proposed the presence of an unknown planet several times larger than Earth—sometimes called Planet X or Planet 9—orbiting the Sun well beyond Pluto at hundreds of AUs.

"We think there could be thousands of small bodies like 2015 TG387 out on the Solar System's fringes, but their distance makes finding them very difficult," Tholen said. "Currently we would only detect 2015 TG387 when it is near its closest approach to the Sun. For some 99 percent of its 40,000-year orbit, it would be too faint to see."

The object was discovered as part of the team's ongoing hunt for unknown dwarf planets and Planet X. It is the largest and deepest survey ever conducted for distant Solar System objects.

"These distant objects are like breadcrumbs leading us to Planet X. The more of them we can find, the better we can understand the outer Solar System and the possible planet that we think is shaping their orbits—a discovery that would redefine our knowledge of the Solar System's evolution," Sheppard added.

It took the team a few years of observations to obtain a good orbit for 2015 TG387 because it moves so slowly and has such a long orbital period. They first observed 2015 TG387 in

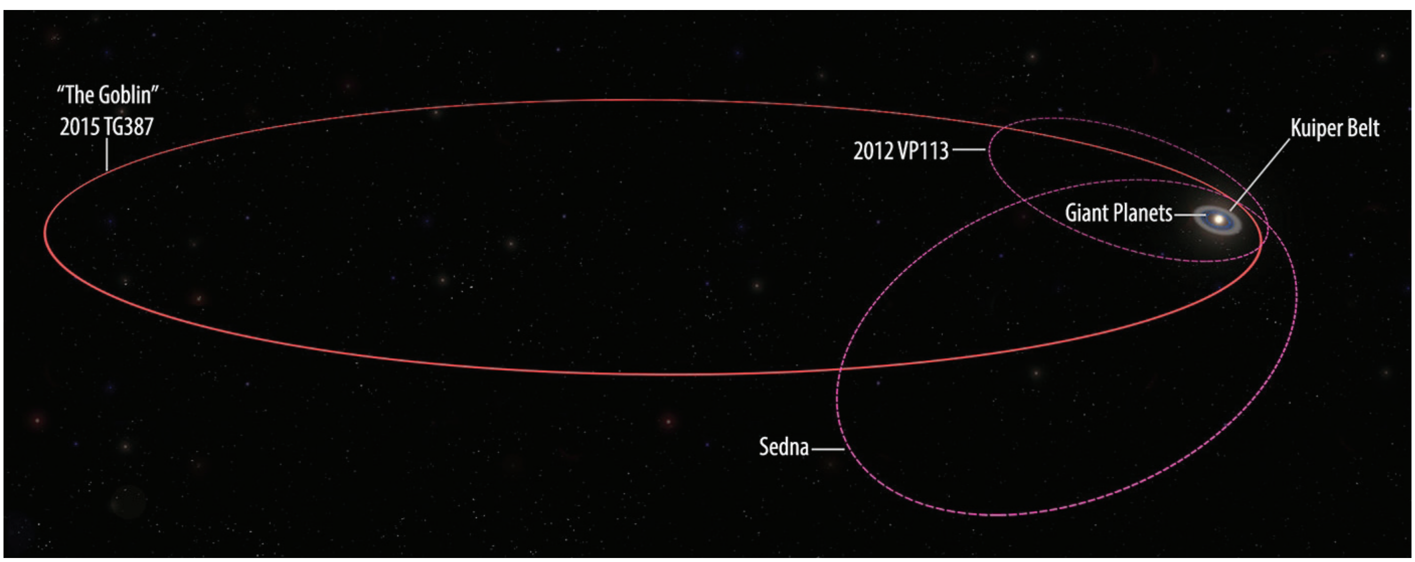

Figure 2 — The orbits of the new extreme dwarf planet 2015 TG387 and its fellow Inner Oort Cloud objects 2012 VP113 and Sedna as compared with the rest of the Solar System. 2015 TG387 was nicknamed "The Goblin" by the discoverers, as its provisional designation contains TG and the object was first seen near Halloween. Credit: Roberto Molar Candanosa and Scott Sheppard, courtesy of Carnegie Institution for Science.

October 2015 using the Japanese Subaru 8-metre telescope located atop Mauna Kea in Hawaii. Follow-up observations at the Magellan Telescope at Carnegie's Las Campanas Observatory in Chile and the Discovery Channel Telescope in Arizona were obtained in 2015, 2016, 2017, and 2018 to determine 2015 TG387's orbit.

2015 TG387 is likely on the small end of being a dwarf planet since it has a diameter near 300 kilometres. The location in the sky where 2015 TG387 reaches perihelion is similar to 2012 VP113, Sedna, and most other known extremely distant trans-Neptunian objects, suggesting that something is pushing them into similar types of orbits.

Trujillo and University of Oklahoma's Nathan Kaib ran computer simulations to determine how different hypothetical Planet X orbits would affect the orbit of 2015 TG387. The simulations included a Super-Earth-mass planet at several hundred AU on an elongated orbit as proposed by Caltech's Konstantin Batygin and Michael Brown in 2016. Most of the simulations showed that not only was 2015 TG387's orbit stable for the age of the Solar System, but it was actually shepherded by Planet X's gravity, which keeps the smaller 2015 TG387 away from the massive planet. This gravitational shepherding could explain why the most-distant objects in our Solar System have similar orbits. These orbits keep them from ever approaching the proposed planet too closely. Pluto has a similar orbit so that it never gets too close to Neptune even though their orbits cross.

"What makes this result really interesting is that Planet X seems to affect 2015 TG387 the same way as all the other extremely distant Solar System objects. These simulations do not prove that there's another massive planet in our Solar System, but they are further evidence that something big could be out there," Trujillo concludes.

Compiled with material provided by the Carnegie Institute.

Nova Vulpeculae 1670 gets new identity

Using the Atacama Large Millimeter/submillimeter Array (ALMA) in Chile, a team of European, South African, and American astronomers have found evidence that a white dwarf (the remains of a sun-like star at the end of its life) and a brown dwarf (a failed star without sufficient mass to sustain thermonuclear fusion) collided in a short-lived blaze of glory that was witnessed on Earth in 1670 as Nova Cygni—"a new star below the head of the Swan." It appeared abruptly as a star as bright as those in the Big Dipper, that gradually faded, reappeared, and finally disappeared from view.

When the object was identified in modern observations, it was realized that it did not fit the profile of a classical nova. Reconstructed light curves in 1985 showed two peaks brighter than third magnitude, in 1670 and 1671—an extremely unlikely behaviour for a nova. In addition, the expansion velocity of the remnant is implausibly slow. This nova was

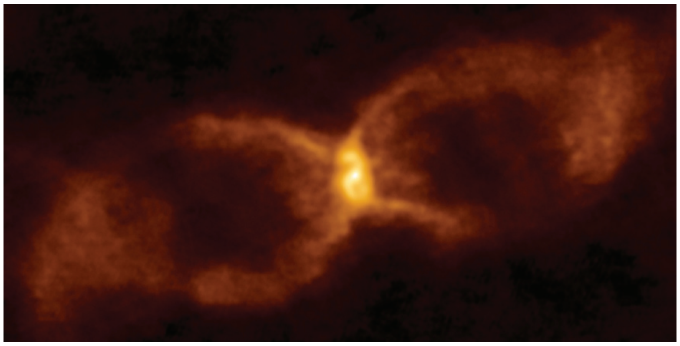

Figure 3 — ALMA image of CK Vulpeculae. New research indicates that this hourglass-like object is the result of a collision between a brown dwarf and a white dwarf. Credit: ALMA (ESO/NAOJ/NRAO)/S. P. S. Eyres

long referred to as "Nova Vulpeculae 1670," and later became known as CK Vulpeculae. In recent years, astronomers studying the remains of this cosmic event initially proposed that it was triggered by the merging of two main-sequence stars on the same evolutionary path as our Sun.

Nye Evans, Professor of Astrophysics at Keele University and co-author in the *Monthly Notices of the Royal Astronomical Society*, explains: "CK Vulpeculae has in the past been regarded as the oldest 'old nova.' However, the observations of CK Vulpeculae I have made over the years using telescopes on the ground and in space convinced me that this was no nova. Everyone knew what it wasn't—but nobody knew what it was."

By studying the debris from this explosion, which today appears as dual rings of dust and gas resembling an hourglass with a compact central object, the research team concluded that CK Vulpeculae is the result of the merger of a brown dwarf with a white dwarf. By studying the light from two distant stars as they shine through the dusty remains of the merger, the researchers were able to detect the telltale signature of the element lithium, which is easily destroyed in stellar interiors.

Dr. Stewart Eyres, deputy dean of the Faculty of Computing, Engineering and Science at the University of South Wales and lead author on the paper, says, "The material in the hourglass contains the element lithium, normally easily destroyed in stellar interiors. The presence of lithium, together with unusual isotopic ratios of the elements C, N, O, indicate that an astronomically small amount of material, in the form of a brown dwarf star, crashed onto the surface of a white dwarf in 1670, leading to thermonuclear burning, an eruption that led to the brightening seen by the Carthusian monk Anthelme and the astronomer Hevelius, and in the hourglass we see today."

Professor Sumner Starrfield, Regents' Professor of Astrophysics at Arizona State University says, "The white dwarf would have been about 10 times more massive than the brown dwarf, so as the brown dwarf spiralled into the white dwarf, it would have been ripped apart by the intense tidal forces exerted by the white dwarf. When these two objects collided, they spilled out a cocktail of molecules and unusual element isotopes. These organic molecules, which we could detect with ALMA, expanded measurably into the surrounding environment, providing compelling evidence of the true origin of this blast. This is the first time such an event has been conclusively identified. Intriguingly, the hourglass is also rich in organic molecules such as formaldehyde (H_2CO), methanol (CH_3OH) and methanamide (NH_2CHO). These molecules would not survive in an environment undergoing nuclear fusion and must have been produced in the debris from the explosion. This lends further support to the conclusion that a brown dwarf met its demise in a star-on-star collision with a white dwarf."

Since most star systems in the Milky Way are binary, Professor Starrfield noted: "Such collisions are probably not rare, and this material will eventually become part of a new planetary system, implying that they may already contain the building-blocks of organic molecules as they are forming."

Compiled in part with material provided by Keele University.

Gamma-ray astronomy steps to higher energy

For the first time, an international collaboration of scientists has detected high-energy gamma radiation coming from the outermost regions of an unusual star system within our own galaxy. The source is a microquasar known as SS 433—a binary system about 1,500 light-years from Earth containing a supergiant star that is overflowing its Roche lobe and

Figure 4 — The High-Altitude Water Cherenkov Gamma-Ray Observatory (HAWC) is a detector designed to look at gamma-ray emission coming from astronomical objects such as supernova remnants, quasars, and rotating dense stars called pulsars. Located roughly 4,115 metres above sea level near the Sierra Negra volcano in Mexico, the detector is composed of more than 300 tanks of water, each about 7.5 metres in diameter. Image credit: Jordan Goodman/University of Maryland.

transferring matter onto either a black hole or neutron-star companion. Two jets of ionized matter with a velocity of approximately 0.26*c* (where *c* is the speed of light in a vacuum) extend from the binary, perpendicular to the line of sight, and terminate inside W50, a supernova remnant that is being distorted by the jets. SS 433 differs from other microquasars (small-scale versions of quasars that are present within our own galaxy) in that the accretion of material onto the compact object is believed to be unusually large (known as super-Eddington).

The Eddington limit to stellar accretion occurs when the radiation generated by the infalling material is sufficient to overcome the gravitational pull. At this point, the star forms an outflowing stellar wind that limits the rate of accretion. Super-Eddington accretion occurs when, for some reason, the infall is not totally restricted such as when material falls beyond the event horizon in a black hole without radiating energy.

The lobes of W50 in which the jets terminate, about 40 parsecs from the central source, are the regions from which radio and X-ray emission consistent with electron synchrotron emission in a magnetic field have been observed.

The research team gathered data from the High-Altitude Water Cherenkov Gamma-Ray Observatory (HAWC), is a detector designed to look at gamma-ray emissions coming from astronomical objects such as supernova remnants, quasars, and rotating dense stars called pulsars. Located more than 4,100 above sea level near the Sierra Negra volcano in Mexico, HAWC is perfectly situated to catch the fast-moving rain of particles. The detector is composed of more than 300 tanks of water, each of which is about seven metres in diameter. When the particles strike the water, they are movin fast enough to produce a shock wave of blue light called Cherenkov radiation. Special cameras in the tanks detect this light, allowing scientists to determine the origin of the gamma rays.

"SS 433 is right in our neighbourhood and so, using HAWC's unique wide field of view, we were able to resolve both microquasar particle acceleration sites," said Jordan Goodman, a Distinguished University Professor at the University of Maryland and U.S. lead investigator and spokesperson for the HAWC collaboration. "By combining our observations with multi-wavelength and multi-messenger data from other telescopes, we can improve our understanding of particle acceleration in SS 433 and its giant, extragalactic cousins, called quasars." ✶

Compiled in part with information provided by Villanova University.

Out of This World: Art inspired by all things Astronomical

by R.A. Rosenfeld (RASC Archivist)
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Abstract

Cultural Connections, one of the core programs of the RASC's sesquicentennial, encourages partnerships between the RASC and other cultural institutions to celebrate the role of astronomy across cultural divides. One recent example was mounted by the Propeller Gallery, in collaboration with the RASC Archives, which offered professional artists' responses to astronomical themes in August 2018 to mark our 150th year. That show is described here.

Origins

Representation of astronomical phenomena through art (or what we now see as "art") has been part of human expression for eons, in the service of cultic, aesthetic, or scientific ends. The contemporary appeal and popularity of astronomical art still has the power to pleasantly surprise those with decades of experience in promoting astronomy, given that society may appear at times more and more removed from direct experience of the natural world, and ambivalent about science. The stuff of astronomy is almost magical in its broad appeal. Little advocacy is necessary to make the case for astronomy as a base for imaginative cultural expression, as it seems to effectively make the case for itself. Astronomy, often called *the* visual science, offers an almost endless store of evocative, powerful, and adaptable imagery.

It may have been with that partly in mind that one of the members of the RASC 2018 Working Group, Paul Delaney, offered to contact a colleague at York University, Dr. Robin Kingsburgh, a professional artist and a trained astrophysicist, to see if she was interested in developing a RASC 2018 Cultural Connections project (Cultural Connections—resources). The original idea of organizing a show in Toronto to mark the RASC's sesquicentennial is due to Professor Delaney's initiative, and the greatest role in shaping and effecting what became "Out of This World: Art inspired by all things astronomical" is Dr. Kingsburgh's. As "magical" as scientific images of the cosmos appear to be, exhibitions of astronomically inspired art don't just miraculously drop from heaven. They are deliberate acts of creation.

Figure 1a — Front of exhibition card for Out of This World: Art inspired by all things astronomical*, designed by Tony Saad. This side features RASC member John Goldie's* Paraselene *drawing from 1892.*

Figure 1b — Back of exhibition card for Out of This World: Art inspired by all things astronomical*, designed by Tony Saad. This side lists the artists in the show, and their work.*

Evolution

Viewed from the outside, the dispatch, competence, and collegiality that marked the processes of design and implementation of "Out of This World: Art inspired by all things astronomical" was striking and could serve as a model for how such projects might best be realized. There are lessons for the amateur astronomical community here.

Figure 2. Out of This World: Art inspired by all things astronomical installed at Propeller Gallery. Photograph courtesy of R.A. Rosenfeld.

The Propeller Gallery proved a perfect partner for the RASC Archives in staging a Cultural Connections project for the Society's sesquicentennial. The gallery (also known as the Propeller Centre for the Visual Arts) defines itself as "a member-run gallery supporting innovative, sustainable programming, and providing community building, networking, and partnership opportunities," all aptly epitomized by its motto "Artists Empowering Artists" (Propeller Gallery: Mission Statement). It was one of the first galleries to be established (1996) in the "Gallery District" on Queen Street West in Toronto, in proximity to the Drake Hotel, and "the last-remaining artist-run gallery in the district" (Propeller Gallery: Mission Statement). Dr. Kingsburgh and her colleagues in the arts community offered the RASC an opportunity to reach out to a cultural sector it rarely touches and show a presence in an area of the city it seldom frequents. This was a collaborative outreach opportunity too good to pass up.

The stages in mounting the show are laid out in the following text timeline:

– 2017 September 18: Prof. Delaney emails Dr. Kingsburgh and the RASC Archivist to inquire how we ought to proceed

– 2017 October 14: Dr. Kingsburgh emails the above, and some of her colleagues at The Propeller Gallery with choices for the show run, and suggested associated "astronomy and art" activities

– 2018 April 26: Emails from Dr. Kingsburgh with the confirmed dates for the show, July 4 to 22, and from Prof. Delaney with the offer to ciruclate invitations to RASC Toronto Centre members to raise interest in participating in a public star party in conjunction with the show

– *ca*. 2018 April 30: Dr. Kingsburgh convenes a Jury for the show (her, Prof. Delaney, artists Dr. David Giffin, Tony Saad, and the RASC Archivist), and a call to artists is drafted

– *ca*. 2018 May 5: The final version of the call to artists is approved, and distributed to the art community Canada-wide through e-platforms (Akimbo, huutaart), with a submission deadline of June 7

– 2018 June 9: Judging of submissions

– *ca*. 2018 June 12: Notices of acceptance, and rejection, are sent from the gallery

– *ca*. 2018 June 14 to 18: Design and approval of the card for the show (the designer is Tony Saad, and the card features John Goldie's 1892 March 19 paraselene drawing from the RASC Archives; Figure 1 a–b)

– *ca*. 2018 June 24: 500 of the cards are printed for distribution

– 2018 July 2 and 3: Artists' works are dropped off at the gallery

– 2018 July 3 and 4: The show is installed

– 2018 July 4: The show starts

– 2018 July 5: Evening opening, with reception and live astronomy-themed music

Figure 3 — Detail of Giuseppe Morano, Spacetime (the fabric of the Universe). *Photograph courtesy of R.A. Rosenfeld.*

Figure 4 — Sarah Moreau, Stargazer 2018. Photograph courtesy of R.A. Rosenfeld.

– 2018 July 14: Afternoon panel "Understanding Astronomical Images" (Prof. Delaney, Dr. David Griffin, Dr. Kingsburgh, Tony Saad moderator, & the RASC Archivist)

– 2018 July 21: Artists' talks, and star party in Lisgar park (next to gallery)

– 2018 July 22: Final day of the show; artists collect their work

Natural Selection

The response from the arts community to the call for submissions was very positive. Submissions were received from 40 artists from as far away as Montréal, totalling 54 different art works (not counting the historical observational art selected from the Society's Archives). Less inspiring was the response of the members of the RASC to the invitation to submit art—including astrophotography—to the show. Only one RASC member responded. As it happens, one of Dan Falk's landscape astrophotos was jury selected for the exhibit. Where was everyone else?

The works represented a wide variety of media: tempera, watercolour, oil, acrylic, graphite, charcoal, traditional photographic prints, metallic prints, 3D prints, performance art, video, cardboard, wood, glass, plastics, copper alloys and other metals, papers, textiles, LEDs, fibre-optics, sound, and combinations of these. The subject matter ranged from details of astromaterials based closely on research imagery and its close mimesis (*e.g.* details of astromaterials in reflected light; rocky and gaseous planetary surfaces), to the direct recording of phenomena (*e.g.* eclipses; solar trails over successive days), to visualizations of computer models of phenomena, and views from non-terrestrial vantage points (*e.g.* twilight on Mars), to more speculative and interior treatments (*e.g.* performatively writing the constellations on the body; dark matter; the experience of the space-time continuum).

Styles represented run the gamut from varieties of realism to species of abstraction.

Out of the works submitted, the jury selected 37 pieces to form a balanced and effective exhibit. To those 37 contemporary works were added 5 historical observational images curated from the RASC Archives, bringing the number of works on display up to 42.

Display

Robin and her Propeller Gallery colleagues had the show installed in about a day, apparently an average time-period for hanging an exposition of this size. To one from another cultural world, their speed was commendable—and impressive.

Figure 5 — Linda-Marlena Bucholtz Ross, Armillary*. Photograph courtesy of R.A. Rosenfeld.*

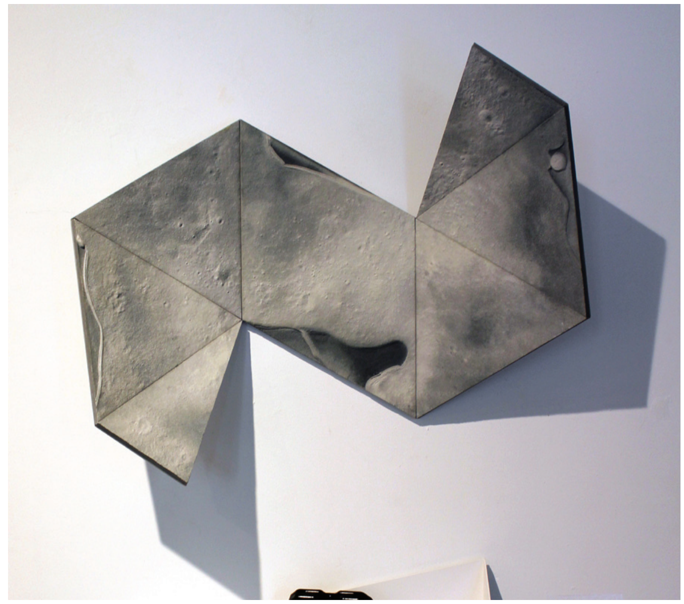

Figure 6. Neeko Paluzzi, Moon*. Photograph courtesy of R.A. Rosenfeld.*

A general sense of "Out of This World: Art inspired by all things astronomical" when installed can be grasped from Figure 2 (but no two-dimensional still photo can capture the full effect of being physically present in a gallery face-to-face with the artwork; it is analogous to the difference between looking at a photograph of the Milky Way, and being out at a dark-sky site and experiencing our galaxy live under the canopy of the night).

The range of media of the work in the show was mentioned earlier. Most were fairly traditional, with two exceptions: Giuseppe Morano's *Spacetime (the fabric of the Universe)*, an installation (Figure 3), and Sarah Moreau's *Stargazer 2018*, performance art captured through videography (Figure 4). It is only fair to observe that both media have been practised for decades, although they are rarely part of the amateur astronomer's experience of astronomically inspired art. The first invited an immersive experience through contemplating walls of numbers, and the second featured the artists inscribing/writing the traditional western constellations on herself. Both were certainly effective, not the least because they invited active engagement from the viewer and could be unsettling.

Two acrylics, Michelle Letarte's *N66 NGC 346* & *Crab Nebula*, were done in memory of one of the RASC's former National Presidents, Prof. Robert Garrison (1936-2017).

Rather than present *all* the work in the show, the author has chosen to concentrate on those particularly appealing to him.

There were several sculptural works, such as David Cumming's humourous take on *Newton's First Telescope*, Chris Harms' *Sat.10001*, and Nancy Lalicon's *Two Stars and a Comet*. Outstanding among them were Linda-Marlena Bucholtz Ross's *Armillary* (Figure 5), and Neeko Paluzzi's *Moon* (Figure 6).

France McNeil's *Voyage dans la lune* (Figure 7) is a clever invocation of Georges Méliès's *Le Voyage dans la Lune* (1902), considered by some to be the first science-fiction film (Le Voyage Dans la Lune (1902), The Public Domain Review; Boron 2011).

For this author, who is easily won over by virtuosity, the visual highlight of the show was Dr. Diana Hamer's acrylics, *Central Force Problem*, *Corralling Baryons* & *Cosmic Horseshoe* (Figures 8 to 10). These canvasses feature beautifully drawn equations as integral parts of the compositions (more graphically pleasing ones would be hard to find), along with imaginatively intelligent renderings of the scientific imagery.

The RASC was represented by five works from our Archives (Figure 11); Andrew Elvins' *Phases of Venus* (1868, quite possibly the oldest observational sketch associated with the Society), A.F. Miller's *Occultation of Saturn by the Moon* (1883), *Mars* (1884, a double sketch), *Jupiter* (1885, featuring shadow transits of Ganymede and Callisto), and John Goldie's *Paraselene* (1892). These works, while they were the physically smallest on display, nonetheless attracted considerable attention from gallery goers.

Rather than show the originals, hand-produced copies of the RASC artifacts were commissioned for display in their stead. There were several reasons for this decision. The drawings are still in the Album of the Toronto Astronomical and Physical Society where Andrew Elvins glued them in the 1890s, so removing them for display would have done violence to their codicological context. Even if the historical astrosketches weren't imbedded in the 1890's album, placing them on display would put them at risk of being stolen. The acknowledgement

Figure 7 — France McNeil, Voyage dans la lune. *Photograph courtesy of R.A. Rosenfeld.*

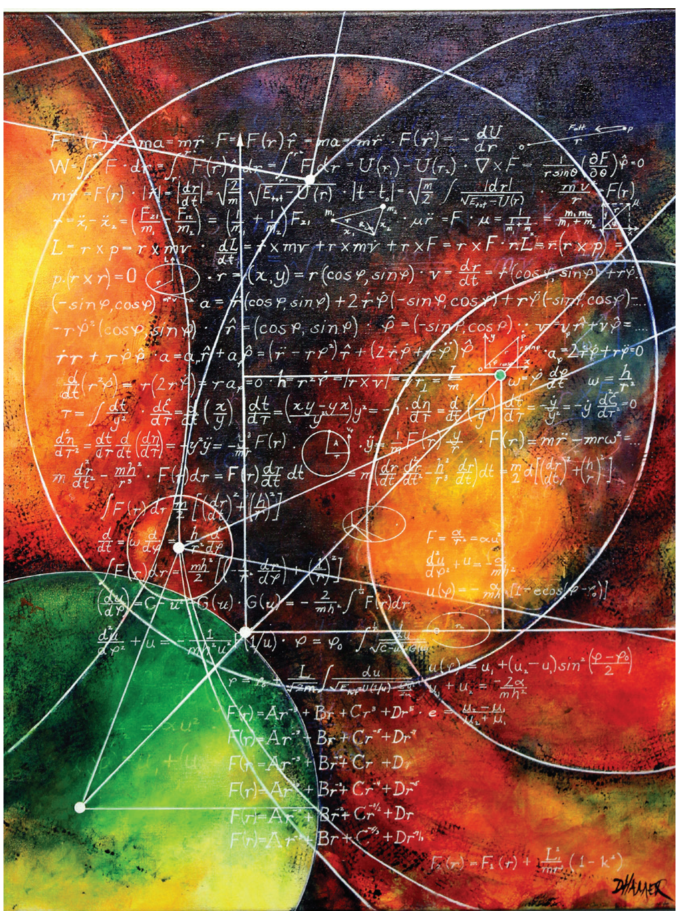

Figure 8 — Diana Hamer, Central Force Problem. *Photograph courtesy of R.A. Rosenfeld.*

of such a possibility is not meant to impugn the care exercised by the Propeller Gallery, but all galleries face this problem. In the event museum-quality copies should be stolen or damaged, it is inconvenient and a loss, but it is not an irreparable one, which it would be if it befell the originals. Fortunately, an anonymous donor covered the costs associated with the production of the facsimiles. The same donor also subsidized the RASC's participation in *Out of This World*, covering the costs of the Society's participation in the show.

Synthesis & Cooperation

As is common with themed art shows, several events were planned to afford those involved with the show, from participating artists to attending audiences, opportunities to broaden and deepen their experience of art and astronomy through the focus of the exhibit.

The first was the opening evening reception on July 5, which allowed a first view of the show in its entirety, and a convenient occasion for informal discussions of art, astronomy, and the RASC at 150 among those present. An added feature was live music on astronomical themes, as an aural counterpart to what was on the walls.

On the afternoon of July 14, the panel on "Understanding Astronomical Images" took place. Artist and jury member Tony Saad performed the role of moderator, and the panellists were Prof. Paul Delaney, Dr. David Griffin, Dr. Kingsburgh, and the RASC Archivist. Questions discussed included "What are the historical dimensions of imaging the cosmos?"; "What is false colour?"; "How do we know when the instrument we are using adds artefacts?"; "Why do we visualize data—especially data outside the visible portion of the electromagnetic spectrum, and why is this important?"; "Are astroimages overly romanticized through colour selection?". The panel was very well attended, attesting to the lively interest in astronomical imagery as art and science among the non-astronomical public.

The final event took place on July 21. It consisted of artists' talks, where they explained their approaches to imagining and imaging the cosmos. This was to happen in conjunction with a planned star party in Lisgar Park (next to the gallery), but unfortunately the weather proved uncooperative. Most Toronto Centre members were busy with other EPO events in any event. As some of the artists expressed the wish to have some astronomical equipment present for the occasion (the sort that an amateur astrosketcher or astrophotographer might use today), the Society's Archivist obligingly transported a "built-like-a-tank" Stellarvue OTA, M2 mount, and tripod to the gallery, entirely by means of public transport. He won't soon forget that experience!

Figure 9 — Diana Hamer, Corralling Baryons. *Photograph courtesy of R.A. Rosenfeld.*

Figure 10 — Diana Hamer, Cosmic Horseshoe. *Photograph courtesy of R.A. Rosenfeld.*

Outcomes

According to the Propeller members, "Out of This World: Art inspired by all things astronomical" was a very successful show. It well fulfilled the goals of the RASC 150 Cultural Connections program, as a "creative partnership between an astronomical group and an arts organization," to "introduce aspects of astronomy to new audiences." Through the show, the Society's existence was made known in a significant geographical area of the city where it had previously been absent, and to a cultural sector to whom it has been largely invisible. Connections between some RASC members and the arts community in Toronto were forged, or already existing links were strengthened. Members of the arts community were invited to make use of the materials of astronomy, and many of them accepted the invitation. If the numbers can be taken as representative, judging by the count and quality of the submissions to the show, a considerable number of people outside the astronomical community were happy to devote personal thought, effort, and expense to helping us mark our 150th anniversary. That is encouraging.

Less encouraging, and wholly counterintuitive was the RASC's local response to the opportunity represented by "Out of This World: Art inspired by all things astronomical", both as member participants, and as audience. If non-astronomers are willing to devote their talents to celebrating the RASC as part of the fabric of Canadian society, one would expect that the RASC would want to meet them halfway, through experiencing their perspectives on the Universe using materials common to us all, as we celebrate our sesquicentennial. It is admittedly not EPO we are accustomed to do. As a Society we have not been as ready to re-envision our possibilities as we might be. Will we afford ourselves the space to learn to do so to ensure that there will be a next sesquicentennial for us to celebrate? Or a bicentennial before then? Only time will tell. ✶

Acknowledgements

This research has made use of NASA's Astrophysics Data System. Thanks are due to the anonymous donor who made the RASC's participation as a collaborator in "Out of This World: Art inspired by all things astronomical" possible.

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(consulted 2018 September 1)

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(consulted October 7)

Propeller Gallery: Mission Statement
www.propellerctr.com/mission-statement-and-history.html
(consulted 2018 August 29)

Stargazer 2018, Sarah Moreau
www.sarah-moreau.com/#/stargazer
(consulted 2018 October 7)

Endnotes

1. For a broad survey see Boitani 2012. A recent re-examination of some of the most significant claims for the earliest origins of this practice may be found in the collection edited by Bahn 2010, supplemented with Lorblanchet & Bahn 2017.
2. For an amusing use, see Rubin 1996, xii.
3. The author's perception may be due to the cumulative effect of time d i l a t i o n experienced during Council meetings. There is no adequate explanation for this well-known effect.
4. The artist's statement is as follows: "*Stargazer is a video performance piece in which the artist connects the moles on her body with marker, reciting the constellations they resemble. Originally used to relate stories of beliefs, experiences, creation, and mythology, constellations represent navigation and identity. Stargazer draws comparisons between the markings, history, and beauty of the female body and that of the night sky;*" Stargazer 2018, Sarah Moreau.
5. Not to say that it won't be necessary one day, if the materials of which the album is composed continue to disintegrate, due to high acid levels in the paper. The album was a gift from a member, as recorded in the minutes for the 14th meeting of the Society in 1892: "*On behalf of Mr. Charles P. Sparling, Mr. Elvins presented to the Society a large and handsomely bound album, suitably inscribed and intended to receive the Astronomical drawings, plates and views belonging to the Society. Mr. Elvins said he had inserted various plates and original sketches, and would be glad to receive from members others to be thus preserved. Mr. Sparling was heartily thanked for his timely and valuable gift;*" TAPS 1893, 68-69.
6. Modest funding for the Cultural Connections program of RASC 150 was included in the submitted sesquicentennial budget for 2018, but, while *Out of This World* was being developed, the then Finance Committee unexpectedly withdrew the funding for Cultural Connections without an explanation. The private donor thought it important enough that the Society carry through with the project, that he stepped in to see that the Society could indeed fully participate in this collaboration marking its sesquicentennial.

Figure 11 — Museum quality reproductions of observational art from the RASC Archives: upper left Alan F. Miller, Jupiter *(1885, featuring shadow transits of Ganymede and Calisto); upper right Andrew Elvins,* Phases of Venus *(1868); middle John Goldie,* Paraselene *(1892); lower left Miller,* Mars *(1884); and lower right Miller,* Occultation of Saturn by the Moon *(1883). Photograph courtesy of R.A. Rosenfeld.*

Some thoughts about WWI and the RASC

by Peter Broughton

Early in 1918, the Society's Secretary, John R. Collins, wrote in the annual report that "many of our members are serving the allied cause overseas and several have fallen." How many, I wondered, and who were they? No RASC honour roll seems to exist, so I attempted to investigate using two tools: a list of about 400 active RASC members and their addresses published in the *Journal* 8 (1914) i-xx, and a website listing the personnel records of the Canadian Expeditionary Force (www.bac-lac.gc.ca/eng/discover/military-heritage/first-world-war/personnel-records/Pages/Search.aspx). It was not a difficult task to go through the members' names searching for matches on the website. As a result of this process, I was able to identify 25 members of our Society who served, including one who died in the War—John Lockhart Godwin (see Figure 1). So far as I know, his sacrifice has never been recognized by the Society. I may have overlooked some others for whom correlation was not possible. Moreover, the database does not include references for those who served with the Royal Canadian Navy, the armed forces of Britain or other countries, or individuals who served in Canada with local militia units. Nonetheless, given the fact that about one in three adult males in Canada enlisted or were conscripted, I expected to find many more than 25 matches. Even bearing in mind the maxim that absence of evidence is not evidence of absence, it is difficult to support the secretary's statement implying that several members gave their lives.

One reason why RASC members (overwhelmingly male) seemed to sign up in proportionately smaller numbers than the general population may be have been their age—usually men over 45 years old were considered unfit for service overseas. Finding the ages of even a random sample of the RASC

JOHN LOCKHART GODWIN
ARTS, 1906-07
Born at Lethbridge, Alta., September 20th, 1889. Appointed Lieutenant in the Canadian Field Artillery, March 11th, 1915. Transferred to the 1st Divisional Ammunition Column, thence to Trench Mortar Battery No. 46. Served in France. Killed in action in Belgium, July 8th, 1916.

Figure 1 — RASC members in 1914 who are known to have served in the Canadian Expeditionary Force in World War I. (Photo from "McGill Honour Roll, 1914–1918," McGill University, Montreal, 1926)

Twenty-five of the RASC members who then served In WWI

George G. Aitken (1885 –), Chief Geographer for BC. Enlisted January 1916

John H. Burnham (1860 –), barrister. Enlisted December 1915

Robert Bussell (1879 –), telegrapher. Enlisted February 1916

John W. Campbell (1889 – 1955), mathematician. Enlisted July 1917

Arthur W. Currie (1875 – 1933), real estate agent. Enlisted September 1914

Gordon Geddie (1887 –), Loan company manager. Enlisted March 1916

Lachlan Gilchrist (1875 – 1962), physicist. Enlisted November 1916

Arthur C. B. Gray (1890 –), assistant at Gonzales Obs.. Enlisted January 1916

J Henry Horning (1892–1978), future teacher and principal. Enlisted May 1915

Clifford B. Keenleyside (1865 –), financier. Enlisted October 1916

Lorence V. Kerr (1884 –), broker. Enlisted June 1915

Philip S. Langton (1895 –), clerk. Enlisted December 1915

Albert P. Miller (1880 –), civil engineer. Enlisted November 1914

Arthur G. Mumford (1885 –), surveyor. Enlisted April 1917

Douglas H. Nelles (1881 –), engineer & surveyor. Enlisted October 1916

John W. Odell (1866 –), teacher. Enlisted 1914

Andrew J. Oliver (1862 –), manufacturer. Enlisted September 1915

T. Harold Parker (1886 –), astronomer, DO. Enlisted October 1915

Walter Parry (1879 –), financial agent. Enlisted February 1915

George R. Sample (1889 –), conductor. Enlisted June 1916

Frank C. Swannell (1880 –), surveyor. Enlisted February 1915

Arthur H. Swinburn (1887 –), civil servant, DO. Enlisted May 1917

Robert G. H. Tait (1886 –), bookkeeper. Enlisted June 1916

Frederic Wollaston (1872 –), engineer and surveyor. Enlisted January 1917

Figure 2 — Victoria Centre member, General Sir Arthur Currie, in 1917. (Adapted from LAC MIKAN 3404794)

Figure 3 — Bert Topham in his WWI uniform. Note the bullet hole in his belt. (RASC Archives: Topham WWI - 0003)

members in 1914 would be difficult if not impossible, but I would not be surprised if the majority of members were more than 45 years old. Collins may have been thinking of the sons of members when he wrote that several had fallen. Here is just one interesting case in point: Among the members of Guelph Centre in 1914 was "Lt. Col. McCrea [sic], Janefield St." Knowing that the famous soldier, doctor, and poet, John McCrae came from Guelph, my heart skipped a beat when I saw this record. However, as I learned from Bev Dietrich, a former curator at the Guelph museums and an acknowledged expert on the McCraes, John McCrae, later famous for his poem "In Flanders Fields" had not yet been promoted to the rank of Lt. Col. in 1914 and had been living in Montreal since 1901 when he returned from the Boer War. The RASC member was John's father, Lt. Col. David McCrae (1845–1930), a prominent resident of Guelph in 1914 and a member of the militia, but obviously too old for active duty and so not included in Figure 1. (See www.wellingtonadvertiser.com/comments/columns.cfm?articleID=1000001581 for more details.) David was an original member of the Guelph Centre in 1911 and a member of their council during the war years. Though there is no indication that John McCrae was ever an RASC member, Bev Dietrich did point out to me that he was a good friend of Dr. Oskar Klotz, son of Otto Klotz, Canada's chief astronomer from 1917 to 1923.

One name that is listed in Figure 1, and which is almost as familiar to Canadians today as McCrae, is Victoria Centre member, Colonel Arthur Currie, as he was identified in the RASC membership roll. Before the War's end, he would become General Sir Arthur Currie, Commander in Chief of the Canadian forces, and a key player in the eventual success of the Allies (see Figure 2). I could find only one other occasion during his life when his name appeared in the RASC *Journal*, when C.A. Chant spoke to the Montreal Centre in January 1923 about his eclipse expedition to Australia the previous year. Currie, by then principal of McGill University, was among a "gastronomic galaxy" entertaining Chant at dinner.

Of course, there were many who served in the Canadian armed forces during World War I and later became RASC members. I will single out only two—a professional and an amateur astronomer. Joseph Pearce interrupted his studies at the University of Toronto to enlist in 1914. He returned, wounded, in 1916 and joined the Society while stationed at Rockcliffe Park, Ottawa. After completing his BA in 1920 and MA in 1922, he worked at the Lick Observatory on a fellowship for a couple of years before becoming an astronomer, and he eventually became the director, at the DAO in Victoria. Bert Topham (see Figure 3) served in the artillery during the entire war and was rendered deaf by a shell explosion. He recalled noting the movements of a bright star from the trenches. After the war, he learned from the *Observer's Handbook* that he had been watching Jupiter. His curiosity led him to become an outstanding observer and the first winner of the Society's Chant medal.

It has been said that virtually every Canadian during World War I had a relative or friend directly affected by the war. The two contemporary "fathers" of Canadian astronomy J.S. Plaskett and C.A. Chant, each had sons who volunteered in different ways. Harry Plaskett, 24, served overseas at Passchendaele and survived to work with his father and eventually to hold the prestigious position of Savilian Professor of Astronomy at Oxford University; James Chant, just turned 16, volunteered to do vital farm work during the war when there was great shortage of labour. There, he suffered an attack of appendicitis that took his life. His father never spoke publicly about his only son's death—presumably it was too painful.

We should not forget others who served in a civilian capacity. Before Canada had much research capacity of its own, some Canadians aided in British war research. Allie Vibert Douglas was one outstanding example (see Figure 4). She interrupted her undergraduate studies in mathematics and physics at McGill to serve as a statistician at the London War Office. At the age of 23 she was awarded an MBE (Member of the British Empire) for her valuable work. Later, she studied with Sir Arthur Eddington, wrote his biography, received the first Ph.D. in astrophysics in Canada, and became the RASC's first woman President. What an amazing person!

I have enumerated some other effects that the war had on the RASC in Figure 5. In comparison to the relentless worries and sacrifices made in various ways at home and abroad, these seem pretty trivial, but they were serious concerns at the time.

To end on a positive note, Canada did get a world-class telescope during the war due to very lucky timing (see Figure 6). In 1913, the government had agreed to finance the 1.83-metre reflector that would eventually be known as the Plaskett telescope at the DAO. Contracts were signed with Brashear and Company, in Pittsburgh, to do the optical work and with Warner & Swasey in Cleveland for the mounting, mechanical work, and the dome structure. The glass blank for the primary mirror was made at the Saint-Gobain factory in Belgium and was shipped to Brashear just days before war broke out. Not long after, the glassworks were bombed to smithereens. The United States was a neutral power, not entering the war until 1917, so not many American factories had been converted to produce munitions and other war-related equipment.

Consequently, work progressed on the Canadian telescope. After 1917, however, all the U.S. effort was directed to winning the war. George Ritchey, the optician at the Mount Wilson Observatory, was diverted from work on the 2.54-metre reflector, which in peacetime would likely have been completed

Figure 4 — Allie Vibert Douglas. Photograph by William Notman & Son Ltd. (Courtesy of Queen's University Archives, Allie Vibert Douglas fonds)

Other effects of the war on the RASC

- Members serving overseas were excused from paying annual dues to the Society.
- Annual grant from federal government temporarily cut from $2000 to $1000, resulting in a smaller *Observer's Handbook* for 1918 and 1919.
- RASC lent some small telescopes which were found to be "very useful in distinguishing and locating snipers, surveying the ground held by the Germans and directing operations. The telescopes were of especial value in preparing for the attack on Vimy Ridge." (Col. H.D.L. Gordon)
- Membership in Guelph Centre steadily declined during the war years. No meetings were held in 1918; even the annual meeting was cancelled due to the outbreak of influenza in December 1918 and the Centre ceased to function after that.
- Regina Centre suffered a similar fate.
- WWI nearly finished the Winnipeg Centre, but the National Council helped them weather the storm with a grant of $50.
- In Victoria Centre, membership and attendance at meetings dropped by about 59 percent during the war, and the influenza epidemic that followed forced the cancellation of meetings for nearly a year.

Figure 5 — Some other effects of the war on the RASC.

and ready for service before the Plaskett telescope. Thus, it happened that for a time, Canada had the distinction of operating the world's largest fully functioning telescope.

On a broader scale, Canadian science got a boost from a general recognition that pure research can be coupled with industry leading sometimes to practical benefits in unanticipated ways. This understanding gave the impetus for the government to the form an Honorary Advisory Council for Scientific and Industrial Research in December 1916—a first step in the formation of the National Research Council of Canada, the organization, which, in 1970, became responsible for our major observatories. In science as in the arts and in social and political spheres, the Great War had a lasting impact on Canada at home and in world affairs. ✶

Perter Broughton FRASC, B.Sc., M.Sc., longtime RASC member, is the author of the Society's history Looking Up!, *now out of print but available online at www.rasc.ca/sites/default/files/LookingUp-300-text.pdf.*

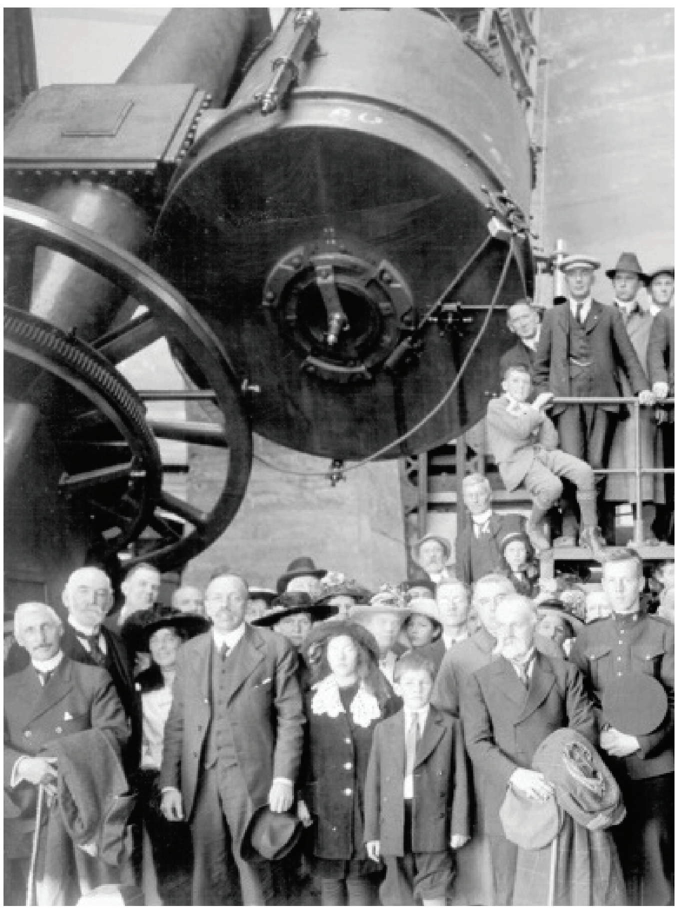


Figure 6 — RASC members and others gathered beneath the unfinished telescope at the Dominion Astrophysical Observatory on 1916 October 21. (Photo courtesy NRC.) Though the people are unidentified in the original photo, the young man in uniform is very likely J.A. Douglas McCurdy, pioneer aviator. (For comparison, see a contemporary image at https://novascotia.ca/archives/McCurdy/archives.asp?ID=16). The man on his right, with a coat over his arm, is J.A.D.'s father, Arthur McCurdy, an influential figure in the formation of the Victoria Centre and in the establishment of the DAO.

In Photos: Celebrating the early years of the RASC

by R.A. Rosenfeld (RASC Archivist)
(rosenfel@chass.utoronto.ca)

1. Early "star party"(?), ca. 1900. This image features the Society's then newly commissioned 4-inch O.G. refractor with optics by Thomas Cooke and Sons, York. The instrument survives to this day and is on display in our Archives. Sadly, the standard of dress for such occasions has declined over the intervening 120 years! Image RASC Archives.

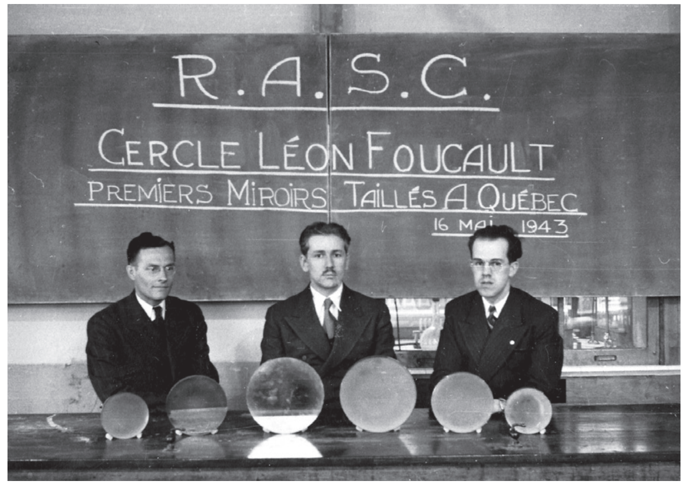
2. Early star party at Lambton Mills, ca. 1900. Shown are Society members and guests: unidentified figure, Zoro M. Collins (with hat on), unidentified figure, A. Horton, Andrew Elvins (the gnome-like presence in front), W.B. Musson, unidentified figure, Miss M.A. Howell, Mrs. Musson, Mrs. Webber, J. Webber, Miss McEachren (in a whiter white than anyone else), J.E. Maybee, John A. Paterson, D.J. Howell (side view), Miss Eva C. Howell, G.G. Pursey (blurred). To judge by the double image and partially ectoplasmic appearance of Pursey, Elvins, and one of the unidentified figures, it seems that some people just couldn't maintain a suitable late-Victorian immobility before the lens. Image RASC Archives.

3. Great Labrador Eclipse Expedition, from Chief Astronomer of Canada's Eclipse Album. RASC members Dr. W.F. King and Fr. Kavanagh, flanking an unidentified figure in the middle. The eclipse was on 1905 August 30th, but the government-supported expedition was clouded out. Like all eclipse expeditions, nevertheless, it was reportedly memorable for those who took part. Image RASC Archives.

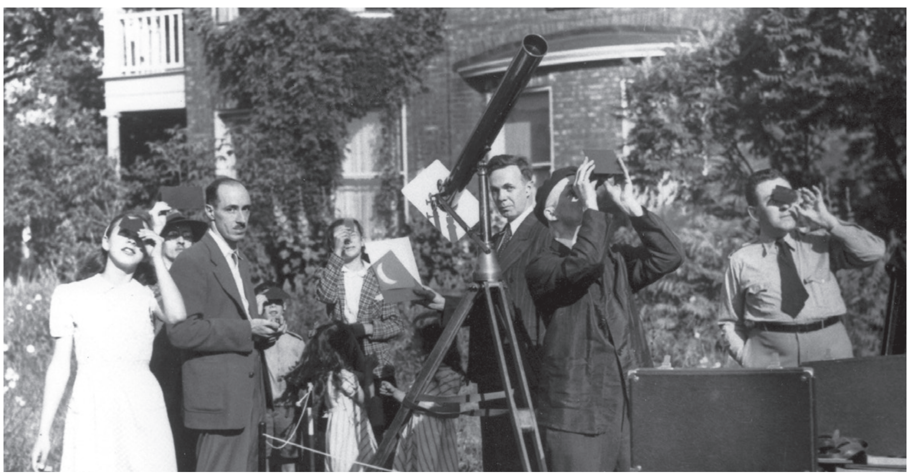
4. Members of the 1905 solar eclipse expedition. C.A. Chant and J.S. Plaskett seated in the foreground. Behind Plaskett is Walter Maunder of the Royal Observatory, Greenwich, and on his left the eclipse expert Annie J. Maunder, Fr. Kavanagh and Prof. Alfred T. De Lury. Behind Maunder is the Chief Astronomer of the Dominion of Canada, and leader of the expedition, W.F. King. Image RASC Archives.

5. Eclipse goers on August 7 of 1932 visiting Victoria Centre. Among the RASC members shown are Dr. Carlyle Beals, Dr. Harper, Dr. Helen Hogg, Dr. Frank Hogg, Dr. Joseph Pearce, Dr. J.S. Plaskett, and Boyd Brydon. They're with Sir Frank Dyson, the Astronomer Royal, Prof. Guido Horn d'Arturo of the Specola di Bologna, inventor of segmented primary mirrors, and leading selenographer, Walter Goodacre, leading selenographer of the British Astronomical Association and A. David Thackeray (not yet doctored, or become Radcliff Observer at Pretoria—he would in time become mentor to our current Honorary President, Prof. Doug Hube). A key to the image is at: http://adsbit.harvard.edu//full/1932JRASC..26..360B/0000361.000.html. We kept good company in those days. Image RASC Archives.

6. 1937 Dominion Astronomer Meldrum Stewart and geophysicist Professor Lachlan Gilchrist at a 1937 meeting of the Royal Society of Canada. It should be noted for the benefit of our younger readers that the activity of these RASCals at a sister Society's event was considered perfectly respectable at the time (note: the present RASC in no way condones the increase in atmospheric aerosol particles by such means). Image RASC Archives.



7. Telescope makers of the Cercle Léon Foucault of the Québec Centre on 1943 May 16. Shown are Paul H. Nadeau (Director of the Astronomical Service of the Province of Québec, and French translator of C.A. Chant's Our Wonderful Universe*), Prof. Marie-Louis Carrier, and Albéric Boivi. Contrary to the inscription, these weren't the first mirrors figured in Québec—the Jesuits were there first. Image RASC Archives.*



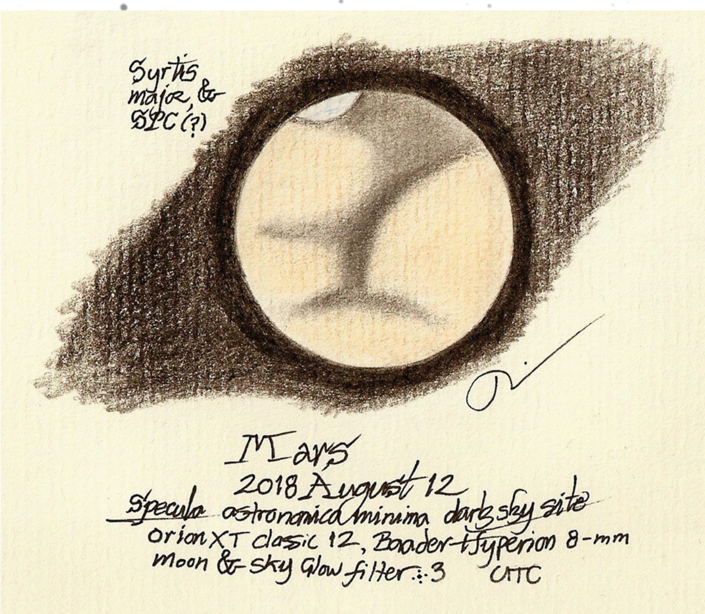
8. Solar eclipse party of 1945 July 9, hosted by Montréal Centre member DeLisle Garneau. Image RASC Archives.

9. London Centre presentation in April 1952. This image features the ingenious astronomical teaching apparatus of the Rev'd William G. Colgrove. Some of these survive to this day at the Hume Cronyn Memorial Observatory at Western and in the RASC Archives. Image RASC Archives.

10. Education and public outreach (although it may be "inreach") in the lecture room beneath the dome of the Montréal Centre's observatory, about 1960. Isabel K. Williamson in a dark blazer is standing toward the front, on the right. And the notorious "Levy" barograph is on the far left (www.rasc.ca/letter-levy). Image RASC Archives.

11. Image from the Calgary General Assembly of 1968. Malcolm M. Thomson, Chief of the Astronomy Division of the Dominion Observatory (and author of The Beginning of the Long Dash*, Toronto, University of Toronto Press, 1978) is in the centre foreground, on his right is Prof. J.E. Kennedy, and on his left is Prof. Ruth J. Northcott (partly obscured). Thomson was the outgoing and Kennedy the incoming National President at the GA. It need hardly be said that this image is tailor-made for a caption contest. Image RASC Archives.*

12. RASC and other dignitaries on the platform of the photographic zenith tube (PZT) at Priddis, Alberta, during the opening ceremonies on 1968 May 18, as part of that year's Calgary GA. J.E. Kennedy and Malcolm Thomson bookend guests from the United States Naval Observatory (including the superintendent, Capt. J.M. McDowell), the Royal Greenwich Observatory, and J.H. Hodgson, Director of the Dominion Observatories Branch at Energy, Mines, and Resources. The PZT was a precision astrometric telescope, with applications in chronometry and geodesy. It never caught on in amateur circles for some reason. Image RASC Archives. ✶



Here, we find a collection of sketches from members over our 150 year history.

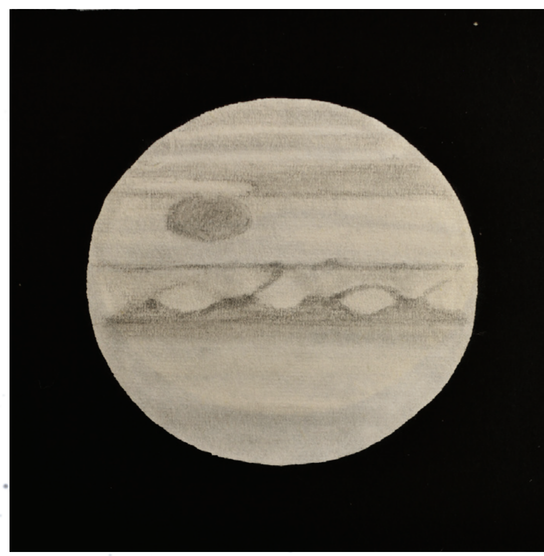
Figure 1 — R.A. Rosenfeld: Mars, 2018

Figure 2 — Allan Miller: Occultation of Saturn, 1883

Figure 3 — (top) Andrew Elvins: Jupiter, 1868

Figure 4 — (left) Andrew Elvins: Venus, 1868

Figure 5 — (bottom) Klaus Brasch Jupiter, 1961



Observing Tips

Lucky Observing (a Small-Scope Observer Conquers the RASC Deep-Sky Challenge)

by Chris Beckett, Unattached
(cabeckett@gmail.com)

[Note from Dave Chapman, RASC Observing Committee Chair: This is the eighth in a series of articles contributed by RASC members on observing, edited by me. For this instalment, I invited veteran observer Chris Beckett to write an account of Ted Wang's achievement of completing the RASC Deep-Sky Challenge 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.]

On 2018 July 3, Ted Wang, an unattached RASC member from Taiwan, completed the RASC Deep-Sky Challenge observing program and applied for his certificate. It is always a significant event when the Observing Committee receives an application for what many consider to be the RASC's most difficult observing program. Like many observers, Ted sketched all of his objects, but unlike others he submitted multiple sketches over several nights using some pretty interesting small-to-mid-sized apertures, a contrast to the large telescopes employed by most observers who choose to tackle the list these days. Ted's exemplary work caused the committee to step back and take a fresh look at the program, and I had some email conversations with Ted about his observing and equipment, which I share below.

The Deep-Sky Challenge (DSC) observing program of 45 objects (www.rasc.ca/deep-sky-challenge) has been awarded since 2008 but the list has existed for about 35 years. Alan Dyer and Alister Ling set out to create a set of all classes of objects they knew had reliably been seen in amateur telescopes but not necessarily the largest instruments, and, even though many would recognize objects from photographs, the list would prove a challenge for experienced observers. As Alan puts it: "all that is needed are good skies and skilled observation," and Alister adds: "the list was designed to introduce the unusual, fathom the depths, push yourself, evoke wonder."

As a follower of Ted's blog (s00639.blogspot.com), I was familiar with his work prior to his DSC application, as we share a mutual interest in small-to-medium sized equipment, particularly refractors and binoculars. He also pushes the limits of these instruments, and his observations often exceed what most observers have viewed through instruments several times larger. For the DSC he used: a TEC 140, Takahashi FC100-DL and CFF 92 refractors; 180-mm and 210-mm Takahashi Mewlons; 71-mm Borg "Homebrew EMS"; and Swarovski 15x60 binoculars, plus two reflectors—an Obsession 12.5″ and a Teeter Journey 12.5″.

Figure 1 — Ted Wang uses a variety of telescopes and binoculars to observe the deep sky.

Interesting equipment is one thing, but what really captured the Observing Committee's attention was Ted's approach, sketching and writing a detailed narrative of his observational process and methods. When I read Ted's blog, look at his sketches, or e-mail with him, I long for the dark, cold, clear nights at my remote observing sites, and he has one heck of a remote site. As Ted says: "For most of the DSC targets I have to go to Hehuan Mountain in one of our National Parks, that's three–four hours drive from my home, and the elevation is more than 3000 m (10,000 ft), the Sky Quality Meter reading is regularly 21.5–22.2—it's a perfect observing site where astronomy friends here like to go." A quick online search reveals Hehuan Mountain National Park is the first location where the Taiwan Government has applied for "Dark Sky" status with the International Dark-Sky Association.

When asked about his favourite DSC object, Ted replied, "It's difficult to tell which object is my favourite, since the DSC list includes various types of objects, and all are very interesting. However, I prefer the targets that contain multiple types of objects, like the IC 1318 complex and the IC 1396 complex—they are very rich inside, and there will always be something new to find in each observation. I like dark nebulae too, but they require a dark site. For example, only at the dark site can you see the dark nebula around IC 5146 (Cocoon Nebula), that is definitely my favourite."

When we spoke about the most challenging Challenge Object he experienced, Ted replied with a story about an online mix-up as follows:

"Galaxy clusters are the most challenging for me because of my telescope size for sure, but I learned how to observe with it

Figure 2 — Ted found the IC 1318 complex around Gamma Cygni to be his favourite object in the Deep-Sky Challenge.

quickly. After practice and more practice (I think Abell 426 is the best target for learning galaxy cluster observing techniques, even the tougher Abell 265), I could see PGC 54876 by direct vision and PGC 54883/54888 by averted vision at my first observation. So I would say the most difficult target for me was HH1/HH2 near NGC 1999. That's because there is limited information (physical or chemical properties, images, observing records) for an amateur observer to find."

"Generally, I study before observing every new object, to get a good understanding and to make an observing strategy/plan, but for this target I can almost do nothing, it is a kind of "lucky observing." One of the funny things is that I have tried

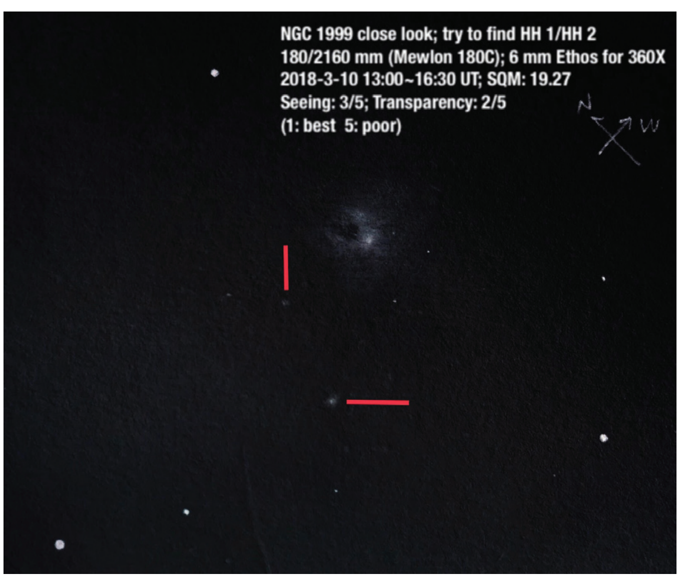


Figure 3 — Ted found the HH1/HH2 emission nebulae in Orion to be the most difficult objects in the Deep-Sky Challenge.

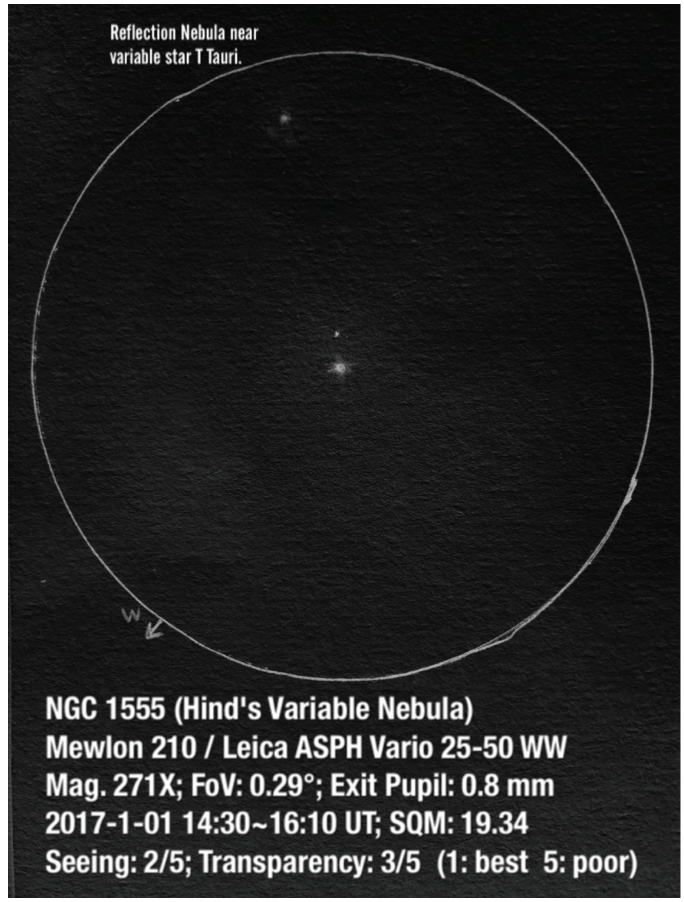


Figure 4 — Ted spent 2 years searching for NGC 1554, which turned out not to exist, although he did find NGC 1555.

so many times to observe a "wrong" target for 2 years, NGC 1554 (Struve's Lost Nebula) which is #11 in the SEDS.org version of the RASC DSC list, NGC 1554/1555. I saw NGC 1555 (Hind's Variable Nebula), but I never found NGC 1554. I thought I would eventually fail at finding this target. Fortunately, I finally checked the RASC *Observer's Handbook* and found that neither NGC 1554 nor NGC 1555 is included." [Editor's note: the existence of NGC 1554 is questionable and the RASC DSC list was updated in 2004]

The Observing Committee congratulates Ted on his exemplary work both for the completion of the Deep-Sky Challenge observing program as well as his excellent observations and sketches of all objects in the night sky . ✶

Chris Beckett is a long-time aficionado of binocular and wide-field telescopic observing of the deep sky, and author of WIDE FIELD WONDERS in the RASC Observer's Handbook—*that list would make a great observing project for those looking for a new challenge. He enjoys observing under the dark skies of Grasslands National Park, which, with his help, became an RASC Dark-Sky Preserve in 2009.*

Imager's Corner

More on Masks

by Blair MacDonald, Halifax Centre
(b.macdonald@ns.sympatico.ca)

This edition I'll continue on with the wonders of masks. Last time, we looked at some techniques to use masks to tailor noise reduction to the areas of an image that need it the most. In this column, we will a look at how to use a mask to tailor sharpening.

For this sharpening exercise, let's use the same M51 image we used for the noise-reduction example in the last edition. Figure 1 shows a tight central crop of the image after an arcsinh stretch and masked noise reduction.

Next step in processing this image is to sharpen it to clear up some of the detail. For this example, I've used a simple highpass filter applied with a soft light blend mode producing the image in Figure 2.

Careful inspection of the sharpened image shows that, although the bright central area has been sharpened, the noise in the background and the faint outer arms of the main galaxy has increased. In addition, in the streams of material surrounding the small companion galaxy, the noise has increased noticeably. Even a few satellite trails have been emphasized, detracting from the resulting image.

What we need is a way to limit the sharpening effect in these problem areas. For those paying careful attention, you will notice that these problem areas are the dim parts of the image while the brighter areas sharpen well with little increase in the noise level. All this means that, if we make a mask that is bright in the bright areas of the image and very dark in the dim areas, we can limit the sharpening to the brighter areas of the image. Here the mask has had a levels adjustment applied to darken the dim areas and brighten the core and then a slight blur was applied to prevent any noise in the mask from adding to the image noise during sharpening.

The result of applying the mask to the sharpening process is shown in Figure 4.

Compare this to the image from Figure 2. The core is well sharpened, and the brighter parts of the spiral arms show reasonable detail, while the problem areas are tamed with little increase in the noise level.

A variation on this theme is an edge mask. Here the mask is bright where there are edges in the image as shown in Figure 5.

This limits the sharpening effect a little more that the simpler mask shown in Figure 3. Sometimes it is useful to paint out the stars if the effect makes them look unnatural.

Figure 1 — Original image

Figure 2 — Simple highpass sharpen

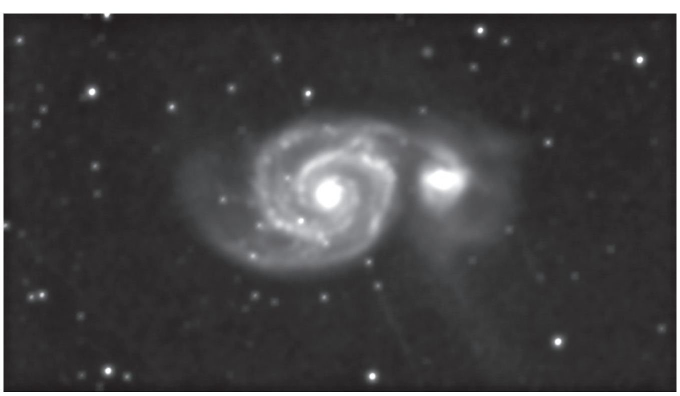


Figure 3 — Simple sharpening mask

Figure 4 — Masked sharpened image

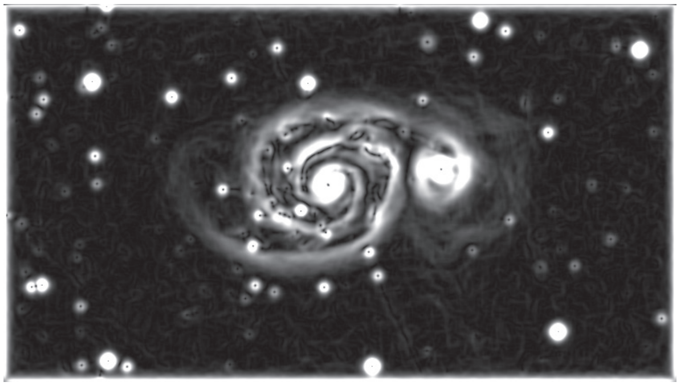


Figure 5 — Edge mask

Figure 6 — Combined sharpened image

One last trick that can produce great results is to sharpen differently sized details by varying amounts. Here the highpass filter (or whatever your favourite sharpening technique is) is set to sharpening the medium-sized detail using the simple sharpening mask. Next the frequency of the filter is changed to sharpen the fine detail, and an edge mask is used to limit the effect to the image edges, producing the image in Figure 6.

Compare the result with the original image.

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

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

Create a Logo for CASTOR and Win!

Canadian astronomers have established themselves in space-based astronomy by using space telescopes such as *Hubble* and *Chandra*. In 2003 Canada's MOST (*Microvariability and Oscillations of Stars*) space telescope was launched, and now Canada is a full partner in the *James Webb Space Telescope* (JWST).

Hubble and *Chandra* are nearing the end of their lifetimes, and JWST won't have the long lifetime of Hubble, so Canadian astronomers are already looking at what comes after JWST. The National Aeronautics and Space Administration is developing WFIRST (*Wide Field Infrared Survey Telescope*) and the European Space Agency is building *Euclid*.

Since both WFIRST and *Euclid* will operate in the infrared like JWST, ultraviolet and visible light capabilities in space will be lost when *Hubble* ceases operations. Because of this problem, many Canadian astronomers are supporting a proposal for a new Canadian space telescope, CASTOR, the *Cosmological Advanced Survey Telescope* for Optical and ultraviolet Research.

CASTOR is planned to have a primary mirror of a metre in diameter inside a spacecraft weighing about 500 kg. Its camera is planned to have a similar resolution to *Hubble*, but it would be able to cover a much larger part of the sky than Hubble.

CASTOR would provide unique data in the ultraviolet part of the spectrum to complement data from JWST, WFIRST and Euclid, assisting in the search for dark energy. It would also challenge and stimulate Canadian industry and Canadian science.

The Canadian Space Agency is conducting a study of CASTOR that Canadian astronomers hope will lead to approval of the mission. While CSA would lead CASTOR, other space agencies would be involved, including NASA and the Indian Space Agency, which would provide the launch vehicle.

Now Canadian astronomers are seeking a logo for CASTOR, whose name pays tribute in French to Canada's national animal, the beaver.

Members of the Royal Astronomical Society of Canada and the Fédération des astronomes amateurs du Québec are invited to submit their designs for a CASTOR logo.

Entries can be sent before 2019 February 1 to: RASC National Office at 203-4920 Dundas St West, Toronto ON M9A 1B7 or at nationaloffice@rasc.ca

They will be judged by a panel of astronomers selected by mission scientists, RASC and FAAQ.

The winner will receive a prize of merchandise from Canada's Museums of Science and Innovation.

Deadline: 2019 January 31

John Percy's Universe

Further Reflections on RASC150

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

We columnists have been asked to consider following the theme for this issue of the *Journal*—the RASC 150th anniversary. Having joined the RASC in 1961, I have lived through a significant fraction of its history and, in past columns, I have often looked further back into the history and heritage of our Society, and of Canadian astronomy in general. My column in February 2018 was specifically in celebration of RASC150. Here, I will just reflect on some of the highlights (for me). For a definitive history of the RASC, see Broughton (1994).

Our Origins

We should never overlook our founders. It takes passion and persistence to give an organization any permanence. In the first decade or two, the RASC's existence was tenuous, but it "stuck," thanks in large part to Andrew Elvins.

The RASC emerged in exciting times. Canada was born the year before. The Canadian Institute had been founded in 1849 to provide a venue for interdisciplinary discussion of science and technology. Mechanics Institutes, and similar organizations enabled the public to hear about and read about science. In Toronto, University College was established in 1853 and opened in 1859, and universities and colleges were beginning to appear in other cities—some offering astronomy courses or content.

Consolidation

By 1890, the RASC was on firm footing. Perhaps it was inevitable that such an organization would appear, but it helped that astronomy was a growing enterprise in Canada in the late 19th century. Canada's growth created a need for precision practical astronomy, in the form of timekeeping, surveying, meteorology, and Earth magnetism studies. The Dominion Observatory was founded in Ottawa in 1905, and there were smaller observatories for similar purposes elsewhere in Canada. There were professional astronomers, and most of them supported our young Society, in part because it provided a voice for Canadian astronomy.

Clarence Chant's birth in 1865 was close in time to the RASC's origin, and he became a guiding light for the RASC in so many ways, including by creating and editing the RASC *Journal* and *Observer's Handbook*. His numerous and varied outreach activities had multiple impacts, including the establishment of the David Dunlap Observatory.

Observatories

It's remarkable to think that, at the end of the Great Depression in the late 1930s, Canada had two of the three largest astronomical telescopes in the world, at the Dunlap Observatory in Richmond Hill, and the Dominion Astrophysical Observatory in Victoria. These were the legacies of Chant and of John S. Plaskett, respectively, but the public support of the local RASC members and Centres was significant. In both cases, the local Centre has assisted the observatory in its outreach activities.

Other universities and colleges had small observatories for teaching purposes, and some of the RASC Centres gradually built or acquired their own—partly for the use of members, but partly for public outreach.

Planetaria

The proliferation of planetaria was spurred on by the Space Age—increasing public interest in space. As my late colleague Don MacRae said, we had more planetaria "per square Canadian" than any other country. They were staffed with remarkable individuals who became expert at using this new technology to educate and inspire. In almost every case, the RASC had a part—small or large—in their founding. There

Figure 1 — On 2018 September 15, more than 3000 people gathered on the back campus of the University of Toronto for a star party, presented by the RASC Toronto Centre and the Dunlap Institute, University of Toronto, part of a national celebration of the RASC's 150th birthday. Source: Chris Sasaki, Dunlap Institute.

was a symbiotic relation: the planetarium often provided a home for the local RASC Centre, and the RASC assisted with outreach, such as by organizing solar or night-sky observing.

National Council

I joined National Council in 1965, as National Librarian. Most of the other officers were eminent Canadian astronomers, including my own graduate teachers and supervisors, so I felt rather "junior." But Executive Secretary Marie Fidler kept things from getting too formal, with her effervescent and generous personality. Henri Simard became National President in 1970, the first francophone, and the first amateur in the present sense of the term (some earlier presidents had been generalists or professionals in cognate fields).

Publications

For decades, *JRASC* was the printed voice of Canadian astronomy. By the mid-20th century, publication practices changed, and most professionals published their research work in international journals. Some research papers continued to be published in *JRASC*, but these were problematic for amateur members of the Society. In 1971, the Canadian Astronomical Society was established, and its website has now become the voice of Canadian professional astronomy. *JRASC,* in my opinion, is now much more aligned with the needs of our members.

The *National Newsletter* began in 1970, in part to better meet the needs of members. I was the first editor. It still continues, and I have been pleased to be a contributor during my term as Honorary President. Centre newsletters and websites are now a rich source of information about what's happening across the Society.

The annual *Observer's Handbook* is different in the sense that it not only serves our members, but it is in demand internationally. During my time on National Council, it was our "cash cow." I edited it for a decade and was a contributor for many years after. It slowly expanded and has continued to do so. Now, it is almost twice as big as in my day. And even more useful.

And let's not forget the *Beginner's Observing Guide*, established by Leo Enright, which filled an important niche for members in general.

Amateur Astronomers

Growing up. I was not an amateur astronomer, nor did I know any. My first encounter with them was in 1961 when I joined the RASC and attended meetings of the Toronto Centre. I got to know them even better when I joined National Council.

Amateur astronomers bring interests and skills to astronomy that professionals like me do not have. They reflect the diversity of astronomy's aspects and interdisciplinary connections. I was already aware that skilled amateur astronomers made important contributions to variable-star research, through the American Association of Variable Star Observers, which I shall discuss in my next column. Through the RASC, I encountered comet hunters, meteor and aurora and solar observers, and occultation chasers—I even chased one myself. There were telescope makers and astrophotographers, and amateurs who were on the forefront of computer applications to astronomy.

RASC Education, Outreach, and Communication

Initially, the RASC was formed as a discussion forum for its members, which we now call "inreach." Very soon, this was supplemented by events that would introduce astronomy to the public. Some members wrote newspaper columns or books, or produced radio or TV programs. This has continued and expanded, often in partnership with other organizations. I was delighted when the RASC was awarded the prestigious national *Michael Smith Award* in 2003 for excellence in the promotion of science in Canada, and I was proud to be at the award presentation in Ottawa. It was well-deserved.

Star Parties

On 2018 September 15, a few days before I wrote this column, I volunteered at a star party for more than 3000 people, held at the University of Toronto, and jointly organized by the Dunlap Institute and the RASC Toronto Centre (Figure 1). It was part of a National Star Party, honouring the RASC's 150th birthday.

But star parties are not a new thing. According to Peter Broughton's (1994) centennial history of the RASC, "in 1908 several hundred visitors came to the University of

Toronto campus to view the heavens through 'several large telescopes'…." Star parties are a unique experience and have been a staple of the RASC since its birth. When I joined in 1961, the Toronto Centre set up telescopes each year at the two-week Canadian National Exhibition, reaching thousands of people, young and old, who might not otherwise attend an astronomical event. More than one professional scientist has been "turned on" to science in their childhood by looking at the Moon, Jupiter, or Saturn through a telescope.

RASC Centres

The title of my column in the November 2018 *National Newsletter* was "In Praise of RASC Centres," which more or less expresses my high regard for them. As National President, I was the first in modern times to visit all the Centres. I was impressed by their different personalities, and by the quantity, quality, variety, and creativity of their activities and their outreach, all done voluntarily. I continue to be impressed. It's a real challenge, catering to people with such a wide range of interests and expectations. As I have said many times: the RASC has an exemplary balance between national and local activities!

International Year of Astronomy 2009

In 2009, astronomers around the world celebrated the 400th anniversary of Galileo's development and first use of the astronomical telescope. In more than the 148 participating countries, it was amateur astronomers and educators who drove the celebration, not professionals. In Canada, the organization was outstanding. A national organizing committee, chaired by Jim Hesser, represented the Canadian Astronomical Society (CASCA), the Fédération des astronomes amateurs du Québec (FAAQ), the RASC, and other groups. It catalyzed the organization of more than 3700 events, reaching almost two million people face-to-face, and millions more through the media. The variety and creativity of events and activities was even more remarkable than the quantity. They took advantage of astronomy's many connections, such as to literature and the arts, history and heritage, nature and the environment. We are still benefiting from this partnership, a decade later.

Diversity

When I joined the National Council, Canada was still visibly white, and so was the Council. We were fortunate to have some notable female professional astronomers, such as Helen Sawyer Hogg and Ruth Northcott in Toronto, and a few others across the country. But they were considered atypical, and they faced challenges that I was only partly aware of at the time.

There were few if any female amateur astronomers. In subsequent years, I encountered some in the Toronto Centre, and was delighted when Mary Lou Whitehorne became the first female amateur astronomer National President in 2010. But we have not had another since.

As for visible minorities who make up an increasing fraction of Canadians, especially in the cities, they are under-represented in the RASC. Our outreach events tend to reach the converted (and therefore the white), so we really need to consider how we can partner with and reach a more diverse audience. Our First Nations peoples have a long tradition of using the sky and incorporating it into their spirituality, but their connections with the RASC have been tenuous at best, though there have been some significant partnerships in the years since IYA.

So, there is still work to be done—as there always is—but we have momentum, a rich history to learn from, and a dedicated set of volunteer leaders at both the national and local level. I urge our thousands of members to reap the benefits of our Society, to engage with astronomy as deeply, and in as many ways as possible. *Quo ducit Urania!* ✶

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Broughton, R.P. (1994), *Looking Up: A History of the Royal Astronomical Society of Canada*, Dundurn Press.

John Percy FRASC is Professor Emeritus, Astronomy & Astrophysics and Science Education, University of Toronto. He served as National President 1978–1980, and Honorary President 2013–2018.

CFHT Chronicles

Large Surveys at CFHT

by Mary Beth Laychak, Outreach Program Manager, Canada-France-Hawaii Telescope.

Before we get to the meat of this column, I wanted to take the opportunity to wish the RASC a happy 150th anniversary from the entire staff at CFHT! While we do not often get the opportunity to work directly with the RASC, we greatly appreciate the contribution of the Society to astronomy. Congratulations on 150 years and we hope 150 more! On a personal note, I feel privileged to have the opportunity to share the work we are doing at CFHT with the RASC community and hopefully bring a bit of Hawaii Astronomy to Canada.

In September 2018, Dennis Crabtree from Herzberg Astronomy and Astrophysics at NRC compiled his annual list of total science impact per telescope. The total science impact gauges both the number of papers and their citation rate. For those unfamiliar with Dennis's analysis, he does not include the Hubble Space Telescope or the Sloan Digital Sky Survey (SDSS). SDSS is excluded because Dennis only includes telescopes that are not dedicated to surveys, but have astronomers still apply to for telescope time. This criterion will exclude the Large Synoptic Survey Telescope in the future according to Dennis.

For the previous several years, CFHT found itself as the third most scientifically productive telescope on Earth. We were happy with that, but this year… In 2017, CFHT moved up a spot to the number two position—behind our neighbors in Waimea, the Keck Observatory.

In an email send to the CFHT staff, our director Doug Simons attributed our ranking to four main factors: 1) the dedication and hard work of the CFHT staff, 2) the creativity of our user community who strategically use CFHT in large programs: 3) CFHT's impressive instrumentation, and: 4) our queue service observing strategy. Let's take a look deeper look at Doug's #2 reason, the creativity of our user community.

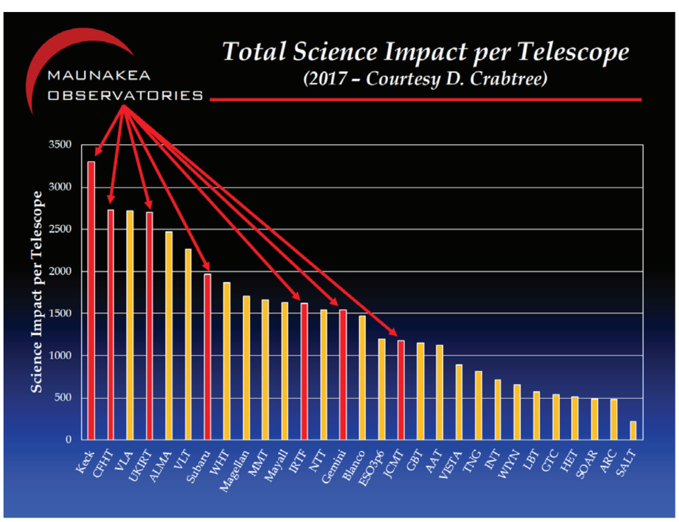


Figure 1 — Dennis Crabtree's annual "total science impact per telescope." CFHT's director Doug Simons modified the slide to highlight the rankings of the Maunakea Observatories.

We will start off by looking at a recent news release from the Pristine team. The Pristine Survey started in 2015, not as a large program, but a PI program spread across multiple agencies. The goals of the survey are to "gather a large sample of the most metal-poor stars in the galaxy, further characterize the faintest Milky Way satellites and to map the metal-poor substructure in the Galactic halo ranging from b ~30° to ~78°" according to the paper Pristine Survey I published in 2017.

The survey utilizes the CaHK filter on Megacam in tandem with existing broadband photometry from SDSS. Pristine focuses on the high-galactic-latitude regions (b> 30°). The filter has a width of about 100 Angstroms and covers the wavelength of the Ca, H, and K doublet lines (3968.5 and 3933.7 Å). "When combined with the SDSS broad-band g and i photometry, the team can use the CaHK photometry to infer metallicities down to the extremely metal-poor range." I took the previous sentence directly from the first Pristine paper in 2017 authored by Else Starkenburg and the Pristine team because it nicely foreshadows their current discovery.

On October 8, the Pristine team announced the discovery of a star that is among the least polluted by heavy elements. Such stars are extremely rare survivors of the early ages of the Universe, when the gas that stars are formed from hadn't yet been contaminated by the remnants of successive generations of dead stars. This new discovery opens a window onto star formation at the beginning of our Universe.

For the study of the early Universe, astronomers have different methods at their disposal. One is to look far into the Universe and back in time, to see the first stars and galaxies growing.

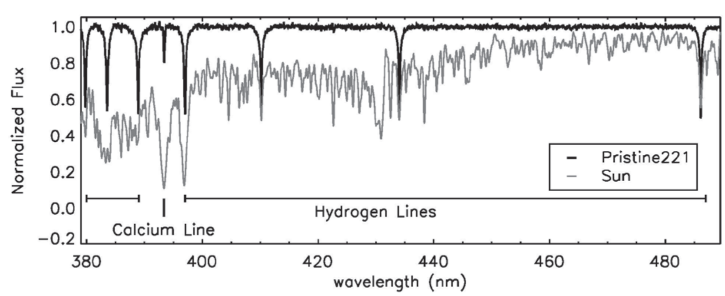


Figure 2 — The spectrum observed with the William Herschel Telescope on La Palma for Pristine_221.8781+9.7844, compared to the spectrum of the Sun. As can be seen, the spectrum of Pristine_221.8781+9.7844 contains far fewer features. Only hydrogen (the large dips) and a small amount of calcium (the small dip) can be seen in the spectrum of Pristine_221.8781+9.7844. This tells us that the star is ultra-metal-poor, it has an unusual lack of heavy elements in its atmosphere, which means that it belongs to an early generation of stars formed in the galaxy. Credits: E. Starkenburg and the Pristine collaboration.

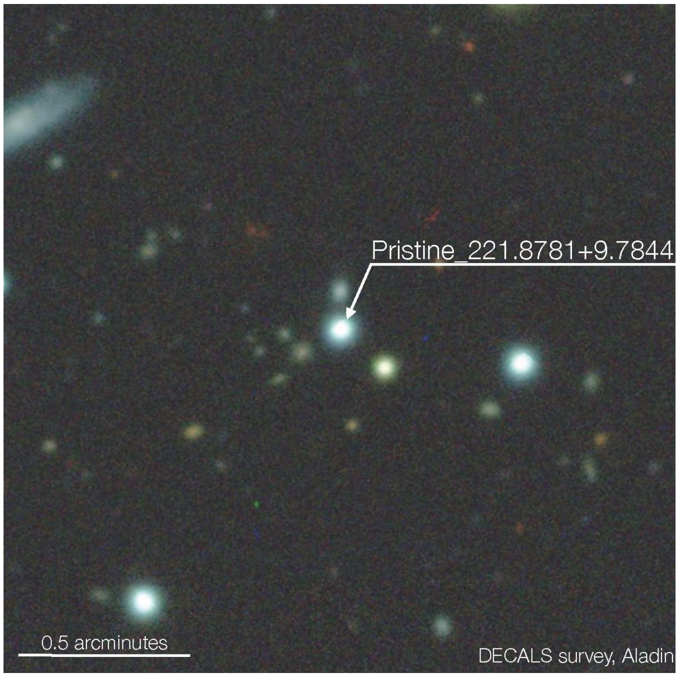


Figure 3 — Pristine_221.8781+9.7844 and its surroundings. Credits: N. Martin and the Pristine collaboration, DECam Legacy Survey, Aladin Sky Atlas.

Figre 4 — The CFHTLS Deep Field 1 image with Megacam. (Image is at www.cfht.hawaii.edu/images/CFHTLS-D1-Zoom)

Another option is to examine the oldest surviving stars of our home galaxy, the Milky Way, for information from the early Universe. The Pristine survey, led by Nicolas Martin (CNRS/INSU, University of Strasbourg) and Else Starkenburg (Leibniz Institute for Astrophysics, Potsdam) is looking for exactly these pristine stars.

The early Universe contained almost exclusively hydrogen and helium. Throughout the life of any star, the thermonuclear reactions take place at their core, creating elements heavier than helium (carbon, oxygen, calcium, iron, etc.) from the hydrogen and helium making up the vast portion of their gas. When these stars explode at the end of their lifetime, they enrich the surrounding gas with these "heavy" elements. This newly enriched gas serves as the birthplace for the next generation of stars. Each subsequent generation becomes more and more enriched with heavy elements created by their ancestors. Astronomers generally refer to any element other than hydrogen and helium as a "metal" and the overall percentage of those "heavy elements" as the metallicity of the star. Our Sun, for example, is made up of about two percent of these heavy elements. On the contrary, very old stars contain very small quantities of heavy elements. These very old, metal-poor stars are however extremely rare and extremely difficult to find in our cosmic neighbourhood.

The discovery of the star unveiled by the Pristine team was made possible thanks to a new mapping of the night sky conducted at the Canada-France-Hawaii Telescope, located in Hawaii. The Pristine team uses Megacam at CFHT to observe a small part of the ultraviolet light that is very sensitive to the abundance in heavy elements, and enables a discrimination of the rare, pristine stars from the much more common stars polluted in heavy elements. The team estimates that less than one star in a million is as pristine as the newly discovered star. Follow-up observations with spectrographs of the Isaac Newton Group, located in Spain, and the European Southern Observatory, located in Chile, confirmed that star Pristine_221.8781+9.7844 is almost void of heavy elements, with the concentration of heavy elements being 10,000 to 100,000 times lower than those found in the atmosphere of our Sun. Pristine_221.8781+9.7844 is one of the most metal-poor stars known and very similar to the most metal-poor star known (SDSS J102915+172927)

This star, whose discovery is presented in a publication of the *Monthly Notices of the Royal Astronomical Society*, brings strongly needed constraints on star formation models of the very first stars and opens a window onto an epoch that is still poorly understood. The discovery of Pristine_221.8781+9.7844 at the start of the Pristine project bodes well for the discovery of many such stars in the years to come.

Congrats to the Pristine team and we look forward to seeing future very metal-poor stars!

While Pristine is an example of a creative PI-led survey across multiple agencies, CFHT has hosted large programs at CFHT since 2003. The first large program was the CFHT Legacy Survey or CFHTLS, which started in mid–2003 and finished in 2009. More than 2300 Megacam hours over five years (about 450 nights per year) were devoted to CFHTLS.

CFHTLS had three components: 1) the supernova survey and deep survey; 2) the wide synoptic survey and; 3) the very wide survey. With the creativity typical to astronomers, these surveys were known as the SNLS (supernova legacy survey), the deep, the wide and the very wide surveys. The CFHTLS is a seminal survey for CFHT and I will devote an upcoming column next year, our 40th anniversary year, to the survey and its impacts.

In 2008, CFHT moved to smaller and more numerous large programs. The observing time can use several instruments and can be spread evenly over all semesters or concentrated on fewer, specified semesters. Multi-agency proposals are greatly encouraged, with the PIs spread across the CFH partners.

The list of large surveys from 2008–2012:

- The Pan-Andromeda Archaeological Survey (PandAS)
  PI Alan McConnachie
  Megacam, 226 hrs, spread over the B semesters
- The Next Generation Virgo Cluster Survey (NGVS)
  PI Laura Ferrarese
  Megacam, 771 hrs, spread over mainly A semesters
- Magnetic Protostars and Planets (MaPP)
  PI Jean-Francois Donati
  Espadons, 690 hrs, spread over A and B semesters
- Magnetism in Massive Stars (MiMeS)
  PI Greg Wade
  Espadons, 640 hrs, spread over 9 semesters.
- CFHQSIR: Searching z-7 quasars with WIRCam in the CFHT-LS Wide fields
  PIs Jean-Gabriel Cuby and Chris Willott
  WIRCam, 160 hrs, over 2010B–2012B
- Thermal Emission of Transiting Exoplanets (TETrES)
  PI Ray Jayawardhana
  WIRCam, 168 hrs, over 2010B–2012B

Large surveys 2013–2016

- The Outer Solar System Origin Survey (OSSOS)
  PI Brett Gladman
  Megacam, 560 hrs, over 8 semesters
- CFHT-Luau: The CFHT Legacy survey for the u-bank all-sky universe
  PIs Alan McConnachie and Rodrigo Ibata
  Megacam, 350 hrs, over 2015A to 2016B
- Mass Assembly of early-type GaLAxies with their fine Structures (MATLAS)
  PI Pierre-Alain Duc
  Megacam, 300 hrs, over five semesters
- Binarity and Magnetic Interactions in various classes of Stars (BinaMIcS)
  PIs Evelyne Alecian and Greg Wade
  Espadons, 604 hrs, spread over eight semesters
- Magnetic Topologies of Young Stars & the Survival of close-in massive Exoplanets (MaTYSSE)
  PI Jean-Francios Donati
  Espadons, 478 hrs, spread over eight semesters
- History of the Magnetic Sun
  PI Pascal Petit
  Espadons, 215.8hrs, spread over 2015A to 2016B semesters

Large Surveys 2017-2019

- The Canada-France Imaging Survey (CFIS)
  PIs Jean-Charles Culliandre and Alan McConnachie
  Megacam, 271 nights
- VESTIGE : A Virgo Environmental Survey Tracing Ionized Gas Emission
  PI Alessandro Boselli
  Megacam, 50 nights
- The CFHT Infrared Parallax Program: Mapping the Brown Dwarf-Exoplanet Connection
  PI Michael Liu
  Wircam 60 nights

With the addition of SPIRou in 2018, the CFHT Science Advisory Committee (SAC) and Board of Directors put an additional call for large program proposals in 2018. Two additional large programs will overlap with the 2017–2019 large programs listed above.

- The SPIRou Legacy Survey (SLS)
  PI Jean-Francois Donati
  PIRou, 300 nights
- The Star Formation, Ionized Gas and Nebular Abundances Legacy Survey (SIGNALS)
  PI Laurie Rousseau-Nepton
  SITELLE, 54.7 nights.

I will dive deeper into the large programs in upcoming articles, but I wanted to list them all to show the variety of the large programs that astronomers have utilized CFHT for over the past 15 years. The CFHT Legacy Survey gave more than just data; it provided a legacy of large programs. The programs range from our Solar System to z-7 quasars, from exoplanets to Andromeda, single stars to superclusters. The scientific merit of these programs is also enormous, just look at CFHT's current rankings in the world.

On the topic of impressive instruments, Doug's #3 point about CFHT, a brief SPIRou update. SPIRou commissioning runs are continuing and looking good. Much like the August run, the team focused on refining the integration of SPIRou into the CFHT queue observing tools. They also continue work on characterizing the instrument. All important things for that SPIRou Legacy Survey we will be starting…

Happy Holidays and see you all in 2019! ✶

Skyward

When Meteors Graze the Sky

By David Levy, Kingston and Montréal Centres

If I were just getting started in astronomy, who knows what field would have attracted me? In the 1960s, it was comets, and I have no regrets. And notwithstanding the truism that there are no "ifs" in history, it is possible that I would have chosen meteors instead. Besides, meteors and comets are closely related.

Each time a comet rounds the Sun, tiny specks of dust come off its surface. These specks of dust orbit the Sun in the same orbit as the parent comet, but when the Earth crosses that orbit, those specks of dust may enter the atmosphere and burn up. Thus, while we may spot a comet but once in its orbit, its meteors we can see every year.

Because of that, throughout the year we are treated to very good shows of meteors. But each year, the same meteor shower is different. On August 12 this year, for example, I saw 22 Perseid meteors on the night of maximum, a lot fewer than the 112 I counted on 1962 August 12 from my grandfather's country home at Jarnac, Québec. On that fateful night, the meteors appeared to fall into Jarnac pond, then float down through streams to the Ottawa River and hence to the St. Lawrence. Years later this thought reminded me of Jean Cabot enjoying a rich Perseid meteor shower from the Gulf of St. Lawrence. No wonder the Perseids are nicknamed the "Tears of St. Lawrence".

For those readers who like to save these articles, here is a listing of the year's 10 best meteor showers.

Quadrantids

These meteors peak just a day or two after New Year's, starting the year off with a bang, as it were. Their maximum is on the morning hours of January 3, but even though it is one of the best showers of the year, it lasts only a few hours. The shower is associated with the now deceased comet 2003 EH1, and its meteors radiate from the archaic constellation Quadrans Muralis, now a part of Boötes.

Lyrids

This magnificent shower, whose meteors emanate from Lyra, started badly for me. In 1963, on April 22 and 24, I was out seeing one bright meteor the first night and none the second night.

"This was the most disappointing failure I have ever had," I wrote in my diary at the time. I have had finer failures since then, but actually these observing sessions from my youth were quite a success! Over the years I have enjoyed some lovely Lyrid sessions. The best one was 1976 April 23. That was the night I asked myself if any of the authors whose writings I enjoy have enjoyed these meteors. That was the night I began my interest in the night sky and English literature. These meteors derived from Comet Thatcher from 1861.

Eta Aquariids

Just two weeks after the Lyrids, the Eta Aquariids, radiating from Aquarius, appear on the morning of May 4.

They come from Halley's Comet, the most famous comet of all. The also provided the brightest meteor I have ever photographed.

Figure 1 — The picture is of a brighter Geminid meteor the author saw and photographed in December 2017. Photo by David Levy.

Delta Aquariids

The first of two major summer showers, The Delta Aquariids, also radiating from Aquarius, peak on July 27 when the Earth crosses the orbit of Periodic Comet Machholz. Astronomers are not certain that this is the parent comet, but it is the leading candidate. This is my favourite "teaching meteor shower." For several years, during the 1960s, I led many children as they counted these meteors.

Perseids

This is the second-best meteor shower of the year. Peaking on August 11 or 12, this shower can produce more than 100 meteors, radiating from Perseus, on a good night. The shower is derived from Comet Swift-Tuttle, which was discovered in 1862 and returned in 1992.

Orionids

Like the Eta Aquariids, these meteors are derived from Halley's Comet. They peak on October 21, but there is a second maximum on October 24. It is a very interesting meteor shower; its meteors radiate from Orion. I photographed one of these meteors passing directly in front of the Andromeda Galaxy!

Taurids

Peaking on the morning of November 4, the Taurids come from Encke's Comet, one with the fastest orbital period (3.3 years) of any comet. It features some 15 meteors per hour, radiating from Taurus, but since they tend to be bright, the shower appears better than it really is.

Leonids

On November 17, it is possible to see the maximum of this meteor shower. Usually the shower is weak, with just a handful of meteors each hour. However, when the shower's parent comet, Tempel-Tuttle, is nearby, the rates can climb dramatically. In 1833, the sky over England was literally blazing with meteors, and in 1966 over the western United States, observers counted some 40 meteors per *second*. Although the rates were not as high when the comet returned in 1999, Wendee and I counted 2106 meteors on the night of 2001 November 19—by far the most we had seen in a single night.

Geminids

The image above had the strongest meteor shower of the year. Peaking on December 13, the meteors, radiating from Gemini, can come very frequently on a good night. I have seen more than 900 on one particularly dark night. The Geminids come from a comet that died long ago, and which is now known as asteroid 3200 Phaethon. I saw that particular asteroid as it moved through the sky last fall.

Ursids

Peaking on December 21, this pre-Christmas meteor shower comes from Comet 8P/Tuttle, one of the 19th-century comets Horace Tuttle discovered. The meteors emanate from Ursa Minor, the Little Dipper.

If you build it…

"If you build it," said the voice, "he will come." In eastern Iowa near the town of Dyersville, near a well-kept farmhouse, lies a regulation baseball diamond in the midst of a cornfield. This is the "field of dreams" from the 1989 movie, *Field of Dreams*. On the beautiful Sunday afternoon of September 9, Jeff Struve and I drove down to visit the site as part of the Eastern Iowa Star

Figure 2 — On Sunday, September 9, 2018, I photographed a portion of the baseball field.

Figure 3 — The house, complete with the picket fence. If you look carefully, on the left you can see the “if you build it’ sign.

Party he had so well organized. With impact-crater specialist Jennifer Anderson and her husband David, we saw where one of my favourite movies was filmed. Dr. Anderson had just delivered a stunning and lively lecture about her impact-crater research at Winona State University’s geosciences department.

The theme of *Field of Dreams* revolves around baseball. Even though I am a baseball fan, the movie’s influence on me was not about the sport but about the dreams. It is about a dream I began to have in the fall of 1965 just as my interest in the night sky was advancing by leaps and bounds. That fall, two Japanese comet hunters, Kaoru Ikeya and Tsutomu Seki, discovered what would become the brightest comet of the 20th century. I first saw Comet Ikeya-Seki’s lovely tail rising out of the St. Lawrence River late that October, and I have never forgotten it.

Two months later, I began my own program of searching for comets. It had three goals, to search for comets and exploding stars (officially referred to as novae); to discover a comet or a nova; and to conduct a research project on comets and novae.

Over the course of my life I have now discovered 23 comets, and when I co-discovered the comet that collided with Jupiter, I really felt as if I dipped myself in magic waters. And the research part, which connects to poetry and the sky, became my 1979 Master’s thesis from Queen’s and my 2010 doctorate from the Hebrew University. Along the way, I have also made two independent discoveries of novae.

When I visited in September, the house and field looked exactly as they were in the movie. The picket fence in front now has a sign that says, “If you build it.” The second part is left off. I interpret its absence as indicating that not all dreams come true. Maybe yours will, maybe it won’t. But it is about the dream, whether it is baseball, the night sky, or anything else. At the close of the film Ray Kinsella asks, “Is there a heaven?”

“Oh yeah,” his dad replies. “It’s the place dreams come true.”

And if somehow your dream does come true, you could add the words of Ray’s skeptical brother-in-law: “When did these ball players get here?” ✶

David H. Levy is arguably one of the most enthusiastic and famous amateur astronomers of our time. Although he has never taken a class in astronomy, he has written more than three dozen books, has written for three astronomy magazines, and has appeared on television programs featured on the Discovery and 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.*

Dish on the Cosmos

Novae Then and Now

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

As the RASC celebrates its 150th anniversary, it is worth reflecting on the nature of astronomy in 1868 and how much has changed over those years. In 1868, the very basis for this column—long-wavelength astronomy—did not even exist. William Herschel had discovered infrared radiation decades before and James Clerk Maxwell had just begun to lay the groundwork for understanding electromagnetic waves. It would be a further 20 years before Heinrich Hertz even demonstrated that radio waves existed. In the mid-19th century, astronomy meant using optical light, as it had for the millennia before.

The optical part of the full electromagnetic spectrum is dominion of starlight. With typical surface temperatures of 3000 K to 30,000 K, stars emit most of the light in the Universe that our eyes can see. The logic of the situation is probably reversed: our eyes see the wavelengths of light that they do because that is where our Sun gives off copious amounts of radiation that can be seen underneath the Earth's atmosphere. Water vapour and other molecules block light in the infrared and ultraviolet from ever reaching the surface of the planet. Thus, as a species, we were destined to be optical astronomers first and fathom the depths of the sky through understanding the stars.

With the founding of the Society, the stars in the sky were well catalogued, it was the changing nature of the skies that caught the attention of astronomers. In reviewing the early transactions and activities of the RASC, I noted great interest in the evolving sky. Because of their relative proximity, the objects in the Solar System were favourite targets with long discussions of their evolving appearance. Variable stars were also a favourite topic for discussion, focusing in particular on sudden changes of brightness or colour for different stars.

While several events captivated the early astronomers in the RASC, the phenomenon of novae is frequently discussed in the transactions. Novae are common enough to be the subject of discussion but also rare enough that they are novel and discussion worthy. I was particularly tickled by a quote from the 1893 Transactions of the Astronomical and Physical Society of Toronto discussion of Nova Aurigae (1893): "As a result of changes in the appearance and in the spectra of the Nova, certain very ingenious theories with regard to it would have to be materially modified, if not abandoned altogether." Novae were a mystery in the early days of the RASC.

Thanks in part to the efforts of the RASC, pooled with scientists the world over, a picture for understanding novae emerged over the next several decades. What is now referred to as a "classical nova" is part of the lifetime of a binary star system where the two stars are in close orbit around each other. In the later stages of stellar evolution, an evolving

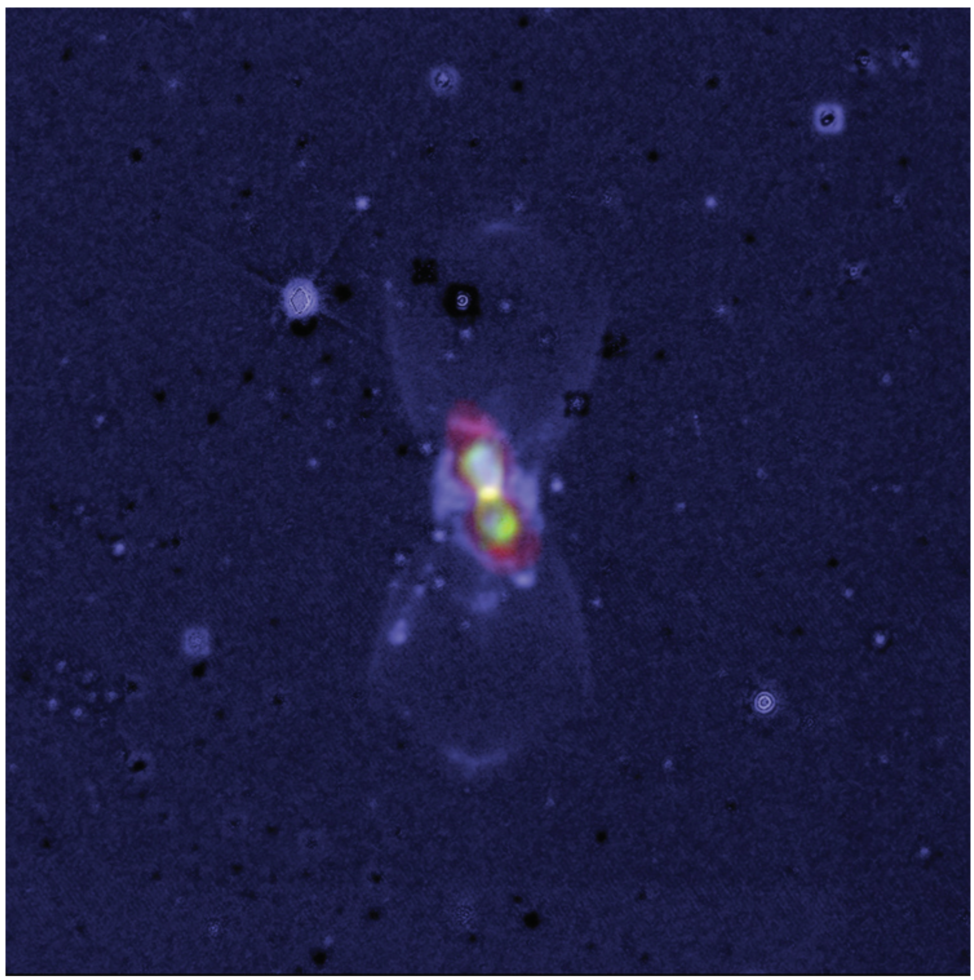


Figure 1 — Imaging of the CK Vul system. The blue image shows hydrogen gas emission from the system displaying the shape of the material ejected from the system. The yellow image in the centre shows the light from the A1F molecule, indicating where the radioactive material has been produced, illustrating that it is clearly connected to the explosive event. Credit: ALMA (ESO/NAOJ/NRAO), T. Kaminski & M. Hajduk; Gemini, NOAO/AURA/NSF; NRAO/AUI/NSF, B. Saxton

star will grow in size to become a red giant. For some close binaries, the size of those giants is comparable to the separation between the two stars. In this case, the stars can transfer material from one star to another.

A key fact in this story is that stars evolve at different rates, with a massive star evolving faster than a low-mass star. A classical nova occurs when the more massive star in a binary system becomes a red giant, shedding some mass onto its companion, and then completing its evolution to a white dwarf star. A white dwarf star is the carbon/oxygen "ash" left over after nuclear fusion powers the star's light through its lifetime. The carbon and oxygen are difficult to burn, so a white dwarf is just a cooling remnant left behind. Later, the originally lower-mass star also undergoes evolution, swelling into a red giant and sharing material across the orbital gap and onto the white dwarf. The outer layers of the donor star are raw stellar fuel and can actually ignite in a thermonuclear explosion. Such ignition usually happens deep within stars, providing the engines for their light. This release of energy does not destroy the star because the star's gravity holds it together. In contrast, the material raining down on the surface of the white dwarf star is not trapped in place by the heavy weight of the outer layers of the star. Instead, the material builds up and ignites in an explosion, fusing all the hydrogen-rich material into helium, which releases a huge burst of light that is visible across the gulf between stars. Novae can repeat the process as new material falls down to the surface of the white dwarf to start the process over.

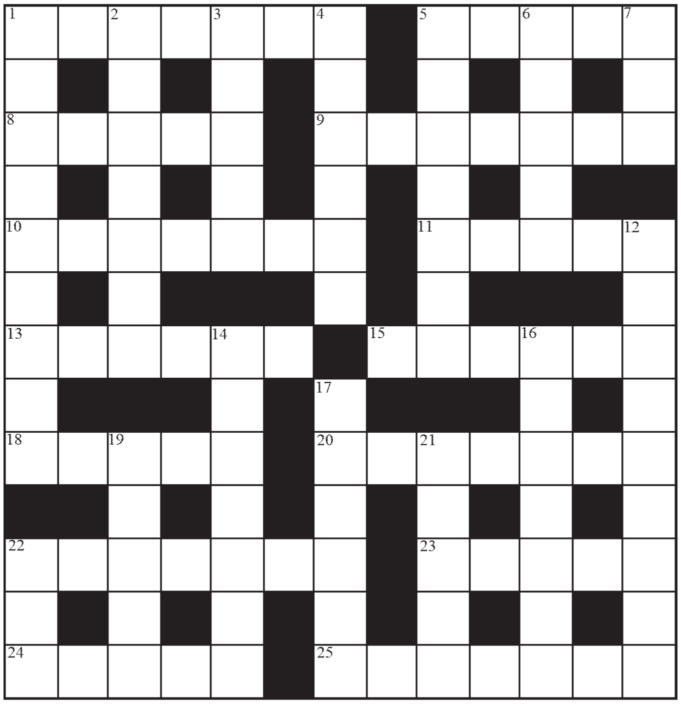
This explanation would puzzle the scientists in the early days of the RASC, but it is backed up by clear lines of evidence and fits naturally into our picture of stars. But while we can feel confident about this understanding now, binary and variable stars still present a wealth of mysteries that puzzle our own deliberations. One such nova is associated with CK Vulpeculae, which reached 2.6 magnitudes back in 1670. The event followed the usual pattern of novae, fading from view over several weeks. The nova never repeated, but it was the target of study as our eyes on the sky grew in capability. Different astronomers began to note strange things about CK Vul: it was cool and dusty for a nova remnant, not the typical result of an exploding layer of hydrogen. More vexingly, satellites detecting high-energy radiation later revealed that the remnant was giving off the characteristic radiation from the radioactive decay of ^{26}Al. The presence of this decay is noteworthy because ^{26}Al has a half-life of about one million years, meaning it had to be made recently in the CK Vul system. But was the material actually made in the nova explosion?

To answer this question, we required another answer from elsewhere in the electromagnetic spectrum. Here, using the Atacama Large Millimeter/submillimeter Array (ALMA), astronomers were able to identify the molecule aluminum flouride (AlF) and show that the molecule was actually in the material from the explosion remnant. Something in the CK Vul event produced a richer nuclear brew than the typical helium gas from the nova. Making the radioactive aluminum requires dredging material up from deep within individual stars in catastrophic events. Several ideas have been put forward that could explain this phenomenon. The most standard is that this system is the result of a common-envelope merger where the red giant grows to engulf the white dwarf, causing the two stars to spiral together and merge, ejecting the inner layers of the stars. However, other ideas propose that a brown dwarf (a low-mass object below the mass cutoff required to be a star) spiraled, into a white dwarf prompting the explosion instead. Other theories abound, all of which are unsatisfying. Perhaps new data will emerge soon that will require these "certain very ingenious theories" to be "to be materially modified, if not abandoned altogether." In this fashion, our comprehension of the skies grows. ✶

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.

Astrocryptic

by Curt Nason



ACROSS

1. Tag it as a pointer in the sky (7)
5. Means to turn the table (5)
8. Drain out of the sky below your feet (5)
9. Express displeasure to the elevation of his Celestial Navigator (7)
10. Elementary tribute to our Muse (7)
11. Sonde dispatched to orbital intersections (5)
13. Birds reside unusually in M11 (6)
15 Ninety-nine step back from a Martian feature (3,3)
18. Modified Erfle was a knockout back in Germany's capital (5)
20. Outstanding evolution of a star (7)
22. An unusual lunar eclipse (7)
23. Astronomy writer returns little energy on the go (5)
24. Eris turned after a first point in the sky (5)
25. Prismatic records of electron capture in rotation traps (7)

DOWN

1. Ask Aulden about a supernova progenitor (9)
2. Rocket scientist in drag, circling. Odd? (7)
3. I follow rotating star about my ankles (5)
4. Hesitant sound a nut makes around equinox (6)
5. Comet in orbit for the lunar cycle (7)
6. Aid an irregular chunk near Neptune (5)
7. Type of star appearing in midseason game (3)
12. Bright light sought to prove a sun explodes (9)
14. Little King Reg brings Kirk's helmsman back (7)
16. One hundred born first, like Neptune among the planets (7)
17. Stars of the diamond (6)
19. Sister scrapes potassium iodide from the teapot (5)
21. Mars lander lost its lead and landed on the Moon (5)
22. Sacrificial spot below Scorpius (3)

Answers to October's puzzle

ACROSS

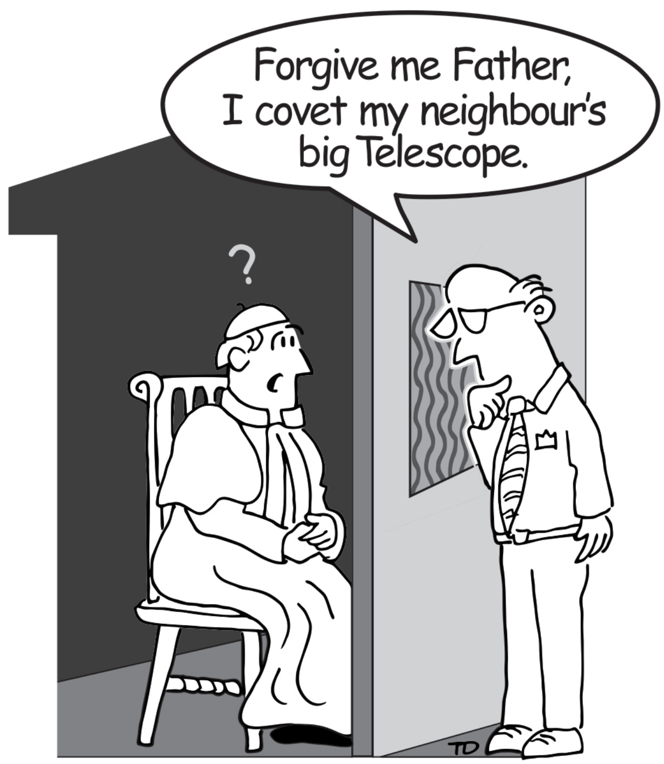
1 ERRAI (hid); **4** ECUADOR (ECU+anag); **8** GENERAL (anag); **9** EPSOM (anag); **10** IONIA (Io+in(rev)+ a); **11** RESCUER (re+anag); **12** HIND'S VARIABLE (anag); **16** ALGENIB (anag); **18** PLAGE (2 def); **20** CLEAR (CL+anag); **21** MACULAE (f=m); **22** RASCALS (RA+anag); **23** SAROS (anag)

DOWN

1 ENGLISH (anag); **2** RONAN (R+Onan); **3** INROADS (homonym); **4** ELLERMAN BOMBS (Kellerman-K+bombs); **5** USERS (2 def); **6** DISTURB (2 def); **7** ROMER (homo.); **13** NAGLERS (an(r)ag); **14** IMPACTS (imp+acts); **15** EYE LENS (an(Y)ag); **16** ALCOR (hid); **17** NORMA (2 def); **19** ALLER (2 def)

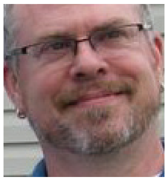
It's Not All Sirius

by Ted Dunphy



Binary Universe

To Follow the Stars



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

The Arrow of Time

I've been thinking about time a lot lately. I have found recently I need to know the current sidereal time for my location with some accuracy. I just discovered I am more than 20,000 days old. And that I wish I could roll back the clock. Of course, when we peer through an ocular of a telescope, we look into the distant past, perhaps to before there were dinosaurs. We recently observed the equinox, the period of "equal night." It always makes me a little sad, the end of summer; but the dark skies are getting longer. For some strange reason, my old netbook computer runs rather fast, so I have to regularly synchronize with NTP servers. While using the Burke-Gaffney Observatory, I need to consider the Atlantic time zone.

Did you know that about 150 years ago engineers and inventors tried to improve on timing issues from town to town and between countries? It was a little tricky knowing exactly when your train would arrive or depart. Some proposed standard times and time zones. It was Sandford Fleming who suggested this system be used worldwide at a meeting of the Royal Canadian Institute on 1879 February 8. He also promoted the prime meridian and use of a 24-hour clock, which influenced the creation of Coordinated Universal Time.

The local sidereal time (LST) for astronomical purposes has always been a curiosity for me but never something that I needed to worry about directly. Does that make me a young whipper snapper? I've grown up on the cusp of full manual and automatic self-aligning telescopes.

My first telescope package was based on the Super Polaris mount with polar axis scope and setting circles but no motors or hand controller. I recall reading the manual many times trying to understand the right ascension (moving) and declination (fixed) setting circles. I attempted a few times using them in the field but never found targets. Hence, I stumbled into star hopping.

Looking back, it is likely a mutiny of mistakes was made on my part. I'm curious to try again, knowing what I know now and very good at accurate polar alignment—I have a hunch I'd hit my targets with just setting circles. Still, when I'm visually observing and certainly when I'm imaging, I'm using a modern mount controlled by software. These tools insulate the user from spherical trigonometric calculations and the sidereal time of the sky.

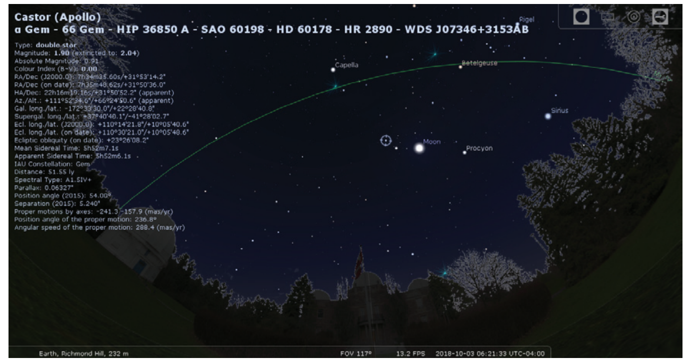


Figure 1 — Object selected in Stellarium. A litany of facts including sidereal time is listed at the left.

But when I want to fly a 74-inch diameter telescope in a large observatory north of Toronto with an excited horde of civilians anxious to look through the heritage instrument, suddenly I need to be very good with setting circles, and I need the sidereal time to the second.

I thought I'd share with you how you might determine the local sidereal time in case you find yourself with a pure manual telescope or you just want to earn your stripes. Perhaps you want to complete for the first time or repeat an observing certificate without relying on a go-to mount. This assumes you don't have an antique sidereal clock on your observatory wall.

Sidereal time is the time it takes the Earth to complete one rotation in relation to a distant object in space like a star but not the Sun. This is different than our regular neat-and-tidy 24-hour clock. To look up the sidereal time you might already have a solution in your pocket—on your smartphone, tablet, or portable computer—so no app download or software install may be required.

Stellarium

Click on an object in any new version of Stellarium on a Windows or Macintosh computer and you'll likely see the Mean and Apparent Sidereal Time shown along with all the object data (see Figure 1). This assumes the option is enabled.

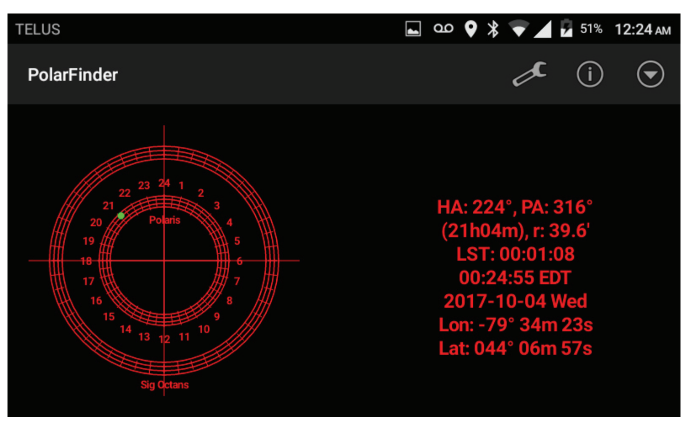
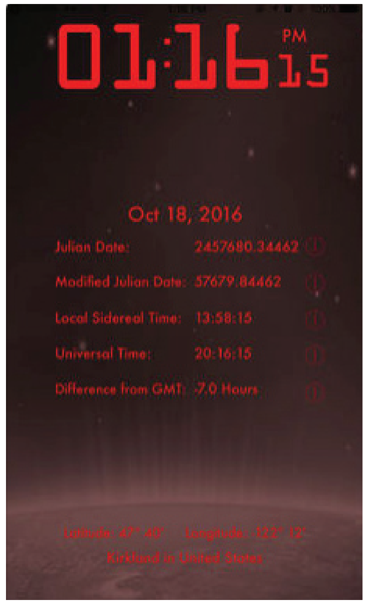


Figure 2 — The Local Sidereal Time is listed beside the polar-scope field of view.



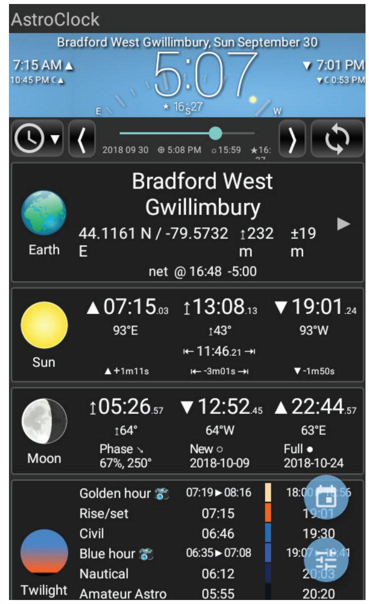


Figure 3 — MySiderealTime has one thing to do and it does so in an astronomer-friendly display.

Figure 4 — SkyTime keeps it simple with the Julian Date and Local Sidereal Time.

Figure 5 — The rich display of Astro Clock with sidereal time near the top.

You can toggle it on with the Configuration dialogue box via the Information tab. See the February 2015 issue of the Journal for my review of Stellarium. stellarium.org

SkySafari

I wrote about this popular planetarium app in the August 2015 issue of the *Journal*. I just now tested this is SkySafari 5 Plus on an Android phone. If necessary, tap the Time button and set to Now and advance at the normal time rate. Then tap the Settings button and choose the "Date and Time" option. Swipe to reveal the bottom of the page. You will find the sidereal time noted and ticking away.

Don't forget, some versions of SkySafari can be downloaded for free. skysafariastronomy.com

PolarFinder

My go-to app for the LST has been "PolarFinder," the handy Android tool I use when trying to precisely aim my equatorial mount to the North Celestial Pole. You may recall I showcased this little app in the December 2017 *Journal*. Upon launching PolarFinder, you'll see a set of data that includes the "Hour Angle" and LST (Figure 2) beside the field-of-view simulation.

One time when I used it, the sidereal numbers didn't match up with others. That's when I discovered my longitude had not automatically updated from the GPS signals, not getting through a large metal roof I presume. When I set the location manually, it was fine.

Also, I have sometimes spotted a negative sign on the time values. On these occasions PolarFinder forces me to do math in my head. I do not like to do that.

play.google.com/store/apps/details?id=com.techhead.polarfinder

If you don't have an astronomy app on your phone, you might really want to consider one. Maybe you don't think you want it or need it. Or maybe you have an older device and it can't handle a big app with demanding memory and video requirements. So here are a couple of very simple or single-minded apps that relay the needed info.

MySiderealTime

This app is a dead-simple tool that does one thing. From the Google Play store, I downloaded the free Android tool, which only took a moment as it is so small. After acknowledging the About screen, the main display appears with red text and digits (Figure 3). It takes a moment to poll the GPS satellites and then the local sidereal time shows.

I've yet to test MySiderealTime where GPS signals are weak...

www.watware.com

SkyTime

For your iOS device or your iWatch, try SkyTime. Like MySiderealTime, this is a free app that preserves your dark adaptation (Figure 4).

SkyTime requires iOS version 10.0 or higher.

itunes.apple.com/ca/app/sky-time/id473539346

Astro Clock Widget

For the time geeks, consider Astro Clock Widget from Erratic Labs. This Android tool shows a plethora of information (Figure 5) on a dark background. This includes the sunrise, transit, and set times, similar data for the Moon, twilight times with the "golden hour" and "blue hour," along with all the planet-rise, meridian-crossing, and set times. That's the tip of the iceberg...

Figure 6 — Perhaps the most beautiful display of sidereal time on a modern device.

By default, the LST doesn't show but in the advanced options it can be turned on. The sidereal data then appears in the top banner in small numerals below the local time.

My favourite part? It offers a home-screen widget so I can see the local sidereal time quickly by just turning on my phone. play.google.com/store/apps/details?id=it.lucarubino.astroclock-widget

Emerald

Now, I admit I have not tried Emerald. But the inexpensive software gets honourable mention for the prettiest app, particularly if you sport a wearable. You can "skin" your Android or iOS watch with a rich and detailed clock display.

Some of these, like the Emerald Observatory, Chronometer (Figure 6), or Chronometer HD show the sidereal time. emeraldsequoia.com

So now you have many options for determining the local sidereal time, which should prove very handy when you need to wrangle setting circles.

Bits and Bytes

"Astrospheric," the sky-condition app I featured in the August 2018 issue, was upgraded with a "smoke factor." In fact, back in August when the wildfires across North America were raging, the author updated the apps and website to activate the enhanced transparency model by default. The symbol beta (β) shows when the more complex modelling is applied. Probably not an issue now and hopefully we won't need the feature next summer. ✶

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.

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compiled by Nicole Mortillaro

Titles

Authors

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

See the published schedule at www.rasc.ca/sites/default/files/jrascschedule2019.pdf

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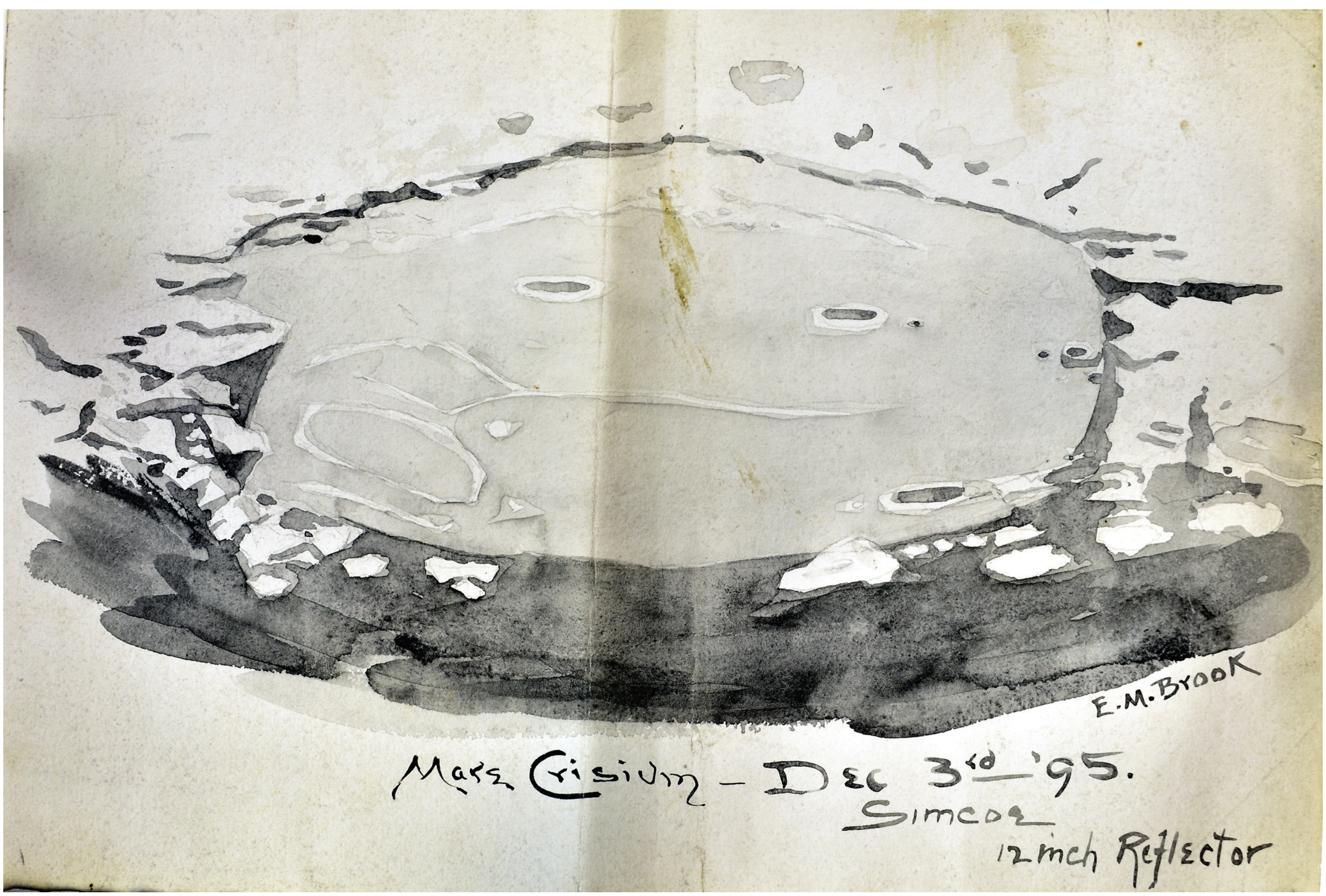
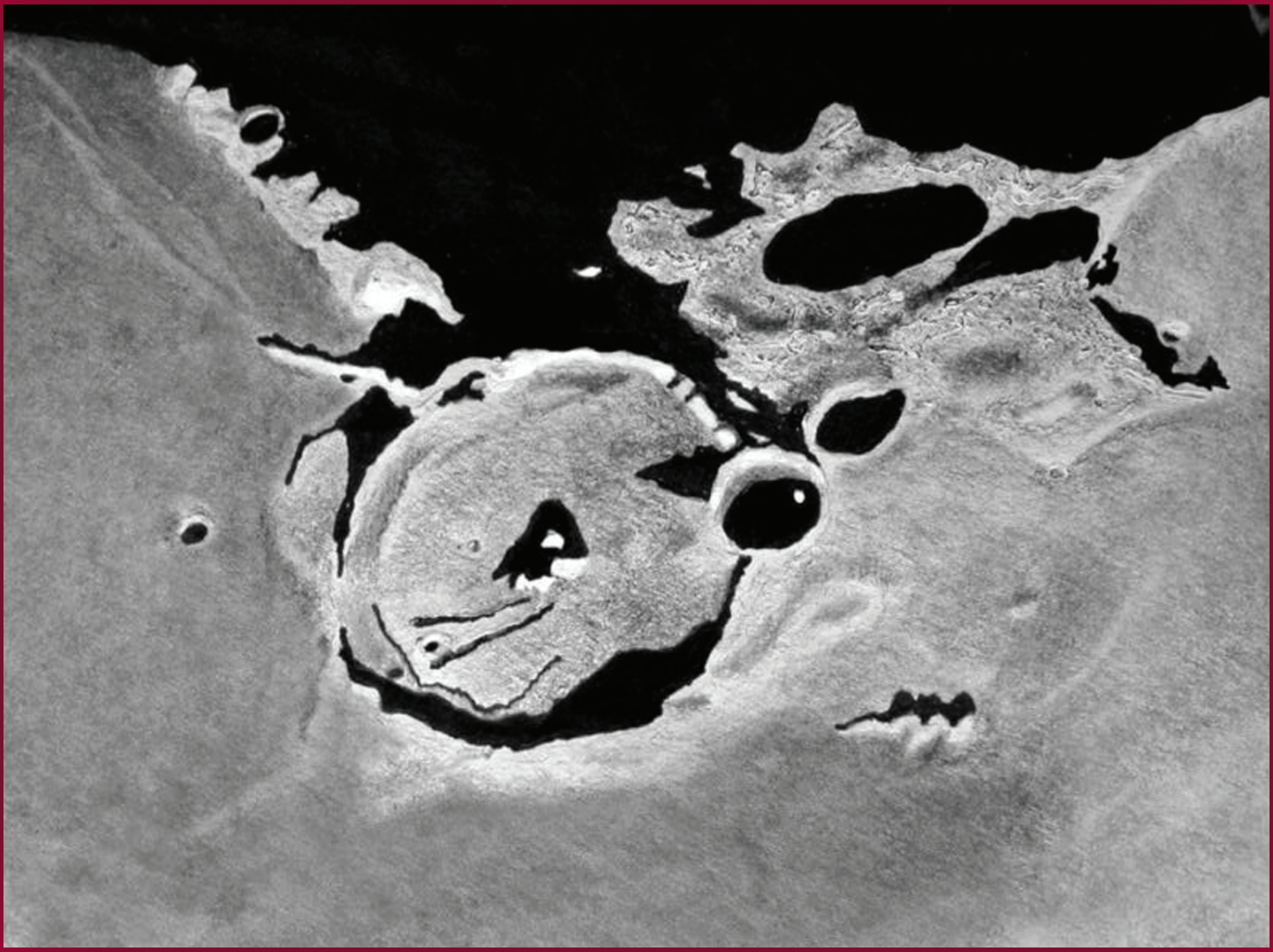
Great Images

by Eva Brook: Mare Crisium, 1895





Journal

Great Images

Gerry Smerchanski: Gassendi 2013