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Journal

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Comparison of the Black-Drop Effects
13th Mi'kmaw Moon
Records of ACOM and MIAC

The Witch's Broom in glorious colour

The Best of Monochrome.

Drawings, images in black and white, or narrow-band photography.

This mosaic of the Rosette Nebula was taken by Klaus Brasch. Originally taken in colour, Brasch converted it to black and white. He used a C-14 HD at ƒ/7 and a Canon 6D. It is composed of four overlapping images, each consisting of 4 x 300-second stacks all shot at ISO 6400 through an IDAS LPS-V4 filter. "This black-and-white rendition shows remarkably different nuances than typically evident in colour images." Brasch says.

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Brian McGaffney did a fantastic job capturing the Veil Nebula, (NGC 6960) with the star 52 Cygni. McGaffney used a Moravian G4 16000EC OAG and processed it with Maxim 6.03, CCDsoft, CCD stack, PI, and PS 6 CS. The telescope was on an ME mount, with a modified Ceravolo 300 setup at ƒ/4.9 for 1800 mm. He added both Hα and OIII to the RGB.

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.

His Excellency the Right Honourable **David Johnston**, C.C., C.M.M., C.O.M., C.D., Governor General of Canada, is the Viceregal Patron of the RASC.

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President's Corner

by Craig Levine, London Centre
(craigslevine@gmail.com)

Many of you are reading this on your Mac or Windows PC, or your tablet (Android or iOS), or even your smartphone. A few of you are even reading it in the time-tested and traditional hand-held paper model for word, paragraph, and article delivery. Is either one better than the other? I recall a decade ago when the RASC made the financial decision to move this venerable publication from a paper-based delivery method to primarily an electronic one. There was much consternation and debate about it at the time, but it survived, and allowances were made for those who prefer reading it in the same way as it had been since 1907.

I straddle the line in terms of preference. While my tablet is an amazingly convenient device and can hold thousands of books and many magazines, all in high-res colour that would be cost-prohibitive to match on paper, I do love the feel of a printed publication. Paper is tangible, traditional; it can last in a library for decades, and it can be shared and left for others to find and enjoy. Electrons stored in the memory of a device and displayed on a screen are ephemeral and have no real sense of permanence to them, however convenient in the moment.

I raise this point of paper vs. electronic as a metaphor for larger questions facing the national organization and our Centres. Whereas the driver for the aforementioned change of format for the *Journal* was mostly economic, changes are being required of us in all areas of the RASC from a plethora of directions. For example, we are living in a time of rapid changes in how we communicate, and with whom. I'm old enough to remember when most communications and interactions were very local, with more-infrequent interactions further afield via expensive long distance phone calls, and very asynchronous mail via the post office. Today, I have instant video calls with family across the continent, instant message exchanges with friends living all over the world, and I carry on multiple email conversations every day. I had to embrace the pace of change in order to keep up or be left behind. And so it goes with the RASC.

A key question for the RASC, then, as a national and local entity is: how to adapt to the changing landscape around us? Into which social-media platforms of the day do we invest precious staff and volunteer time in order to be relevant for current and prospective members? Which collaboration platforms do we settle on for easy interaction among members across the country? What are we doing now "because we've always done it that way"?; in all areas of communication and interaction, what do we need to look at with fresh eyes in order to be more effective in carrying out our mission to our membership and to society at large? What have we tried in the past, that wasn't successful at the time, that we need to revisit because the landscape has shifted underneath us?

I am excited and energized by the review and renewal process, and by the collaborations with the many bright and talented RASC members I've had the pleasure of interacting with since the spring. As we drive our strategic-planning process to the finish line and in our subsequent regular reviews of the plan, I'm looking forward to many more engaging conversations. The suggestions from our members have been remarkable, open, and very insightful. ✶

News Notes / En Manchettes

Compiled by Jay Anderson, FRASC

Little guy whizzes by

A team of University of Arizona astronomers have obtained observations of the smallest asteroid—with a diameter of only two metres—ever characterized in detail. Catalogued as 2015 TC25, the diminutive rock is also one of the brightest near-Earth asteroids, reflecting 60 percent of the sunlight that falls on it. Discovered last year, 2015 TC25 made a close flyby that saw the small object cruising past the Earth at a distance of 128,000 kilometres, a third of the distance to the Moon.

2015 TC25 was discovered by the University of Arizona's Catalina Sky Survey last October and studied extensively by a team led by Vishnu Reddy, an assistant professor at the University of Arizona's Lunar and Planetary Laboratory. The team used four Earth-based telescopes for the study. Reddy argues that new observations from the NASA Infrared Telescope Facility and Arecibo Planetary Radar show that 2015 TC25's surface is similar to a rare type of highly reflective meteorite called aubrites. Aubrites consist of very bright minerals, mostly silicates, that formed in an oxygen-free, basaltic environment at very high temperatures. Only 1 out of every 1000 meteorites that fall to Earth belongs to this class.

2015 TC25 also appears to be monolithic: a chunk of solid rock rather than a rubble pile like many bigger asteroids, which often consist of many types of rocks held together by gravity and friction. The tiny asteroid also lacks the layer of dirt-like regolith that blankets its larger brethren.

"This is the first time we have optical, infrared, and radar data on such a small asteroid, which is essentially a meteoroid," said Reddy. Thanks to coordinated observations with Lowell's 4.3-metre Discovery Channel Telescope, the NASA Infrared Telescope Facility, and the Magdalena Ridge Observatory 2.4-metre telescope, the team found that 2015 TC25 is a fast rotator with a period of only 2.23 minutes and an irregular shape. As far as the little asteroid's origin is concerned, Reddy believes it likely was chipped off from its parent, 44 Nysa, a main-belt asteroid large enough to cover most of Los Angeles.

Small near-Earth asteroids such as 2015 TC25 are in the same size range as meteorites that fall to Earth. "Being able to observe small asteroids like this one is like looking at samples in space before they hit the atmosphere and make it

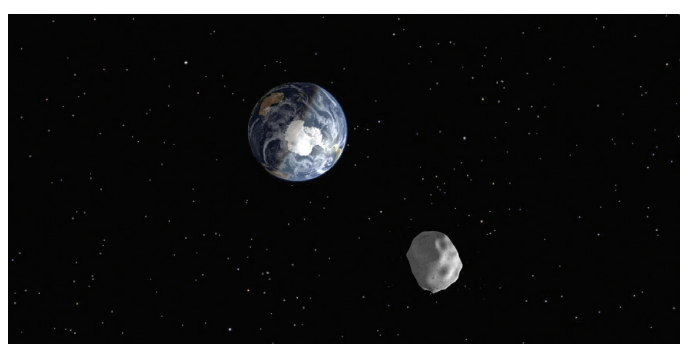

Figure 1 — An artist's impression of the passage of 2015 TC25. Image credit: NASA / JPL-Caltech.

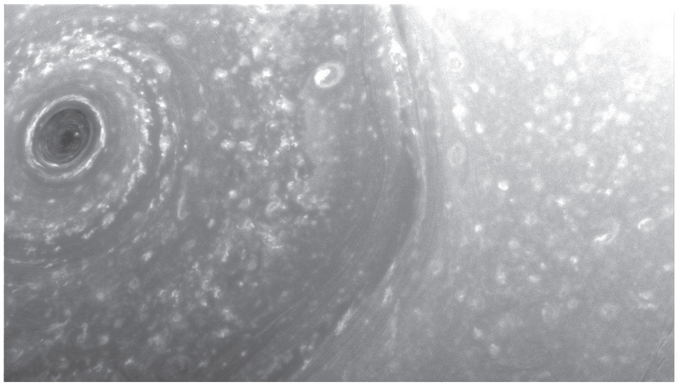

Figure 2 — This view shows part of the giant, hexagon-shaped jet stream around Saturn's north pole on Dec. 3, 2016, at a distance of about 390,000 kilometres from Saturn

to the ground," Reddy say. "It also gives us a first look at their surfaces in pristine condition before they fall through the atmosphere."

"It's especially important to study the physical properties of small near-Earth asteroids because of the threats these objects pose to us," says Stephen Tegler, co-author of the study and a professor in the Department of Physics and Astronomy at Northern Arizona University "The meteoroid that caused injuries and damage in Chelyabinsk, Russia, in 2013 was less than 20 metres in diameter."

Assembled in part with material provided by the University of Arizona.

Cassini begins ring-grazing orbits

On December 4, the *Cassini* spacecraft completed the first of a series of ring-grazing orbits that will mark its final year of studies at Saturn. On this dive, just beyond Saturn's F ring, the spacecraft's radio-science instrument transmitted a radio signal to Earth through Saturn's rings in a uniquely long sweep a few hours after the ring-plane crossing. *Cassini* will make a series of 20 ring-plane crossings at 7.2-day intervals, lasting until April 2017. "Even though we're flying closer to the F ring than we ever have, we'll still be more than 4850 miles (7800 kilometres) distant. There's very little concern over dust hazard at that range," said Earl Maize, *Cassini* project manager at JPL.

During the first highly elliptical orbit, *Cassini* studied Saturn's northern hemisphere and atmosphere; *Cassini*'s Visual and Infrared Mapping Spectrometer made a nine-hour movie of Saturn's North Pole; and several instruments measured the boundaries of Saturn's upper atmosphere, a critical observation, because future orbits will send *Cassini* skimming through the outermost reaches of the atmosphere for direct sampling. The first grazing orbit also featured observations of Enceladus's active south pole and scanned the moon Tethys to acquire new views of its mysterious red-striped regions.

We are all made of star stuff—again

A team led by UCLA astronomers has used new data to show that stars are most likely responsible for producing dust on galactic scales, a finding consistent with long-standing theory. Dust is important because it is a key component of rocky planets such as Earth.

Jean Turner, a UCLA professor in the Department of Astronomy and Physics, her graduate student S. Michelle Consiglio, and two other collaborators studied a galaxy, II Zw 40, roughly 33 million light-years away, because it is vigorously forming stars and therefore useful for testing theories of star formation. "This galaxy has one of the largest star-forming regions in the local Universe," Turner said. The researchers obtained images of II Zw 40 using the Atacama Large Millimetre/submillimetre Array telescope at wavelengths in the millimetre and submillimetre part of the electromagnetic spectrum, just slightly shorter than microwaves.

Consiglio and her team observed the central region of II Zw 40, a part of the galaxy with two young clusters of stars, each containing up to a million stars. Using images collected at different wavelengths, they constructed a map that separated the emission by the dust in the galaxy from that of the local gas clouds. The researchers then tested whether the location of the galaxy's dust was related to the location of the galaxy's star clusters. They found that it was: II Zw 40's dust was concentrated within roughly 320 light-years of the star clusters, supporting their hypothesis that the cluster stars are responsible for producing the dust. "The double cluster is a 'soot factory' polluting its local environment," Consiglio said.

Scientists have long theorized that stars produce dust by expelling elements fused deep within their interiors, enriching their host galaxies with elements heavier than hydrogen and helium. However, astronomical data have thus far not backed up that claim. "People have looked for this large-scale enrichment of galaxies, but they haven't seen it before," Turner said. "We're seeing galaxy-scale enrichment, and we see clearly where it is coming from."

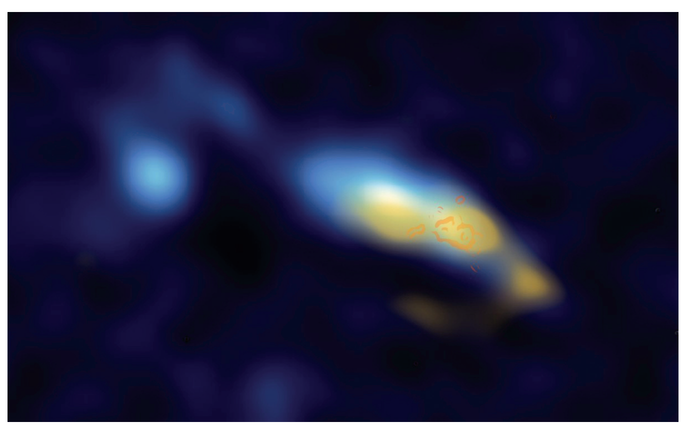

Figure 3 — In the galaxy II Zw 40, dust (shown in yellow) is strongly associated with clusters of stars (shown in orange). Credit: S. M. Consiglio et al., Astrophysical Journal Letters, 2016

The researchers propose that the dust enrichment is obvious in II Zw 40's star clusters because they contain large numbers of very young, massive stars, which are the producers of dust. "The evolutionary time scales of these stars are short enough that you see the dust before it has a chance to get dispersed very far from its source," Turner said. "We're looking at the best place to see dust enrichment, in large star clusters," Consiglio added. "Our goal now is to find other sources and look at them in different stages of evolution to better understand the evolution of these giant star clusters and how they enrich their environment in dust."

Prepared in part with material provided by UCLA.

Chandra views Cygnus X-3's Little Friend

Cygnus X-3 is a binary-star system in which a massive, evolved, Wolf-Rayet star is slowly losing mass to a compact companion, producing a flood of X-rays in the process. The compact companion is very close to the Wolf-Rayet star, orbiting with a period of 4.8 hours. The Cgy X-3 system is a bright radio source that producing jets of material that travel at speeds approaching that of light.

In 2000, observations of this system by the *Chandra* X-Ray Observatory revealed another X-ray source only 16 arcseconds from Cyg X-3. Further observations 6 years later showed that the new source was extended and that it varied in brightness with the same 4.8-hour period of the Cyg X-3 system. The "Little Friend," as it came to be known, was apparently reflecting the varying light from the nearby Wolf-Rayet system. From the delay in the light cycle between the two objects, the distance of the Little Friend could be determined, and researchers concluded, after further observations with *Chandra* in 2013, that the nearby object was a small, dense cloud, about 0.7 light-years in diameter called a Bok globule. The Little Friend has a mass between 2 and 24 times that of the Sun.

When the Smithsonian's Submillimeter Array (SMA), a series of eight radio dishes atop Mauna Kea in Hawaii, was turned toward the Cyg X-3 / Friend system, an unexpected discovery was made—the Bok globule itself had a jet, though much slower and weaker than that of Cyg X-3. Jets in a Bok globule are a sign of a developing protostar. Thus, in one image from *Chandra* and the SMA, we have a Wolf-Rayet system nearing the end of its stellar lifetime, while a new star is being born in the Little Friend.

The properties of Cygnus X-3 and its proximity to the Little Friend also give an opportunity to make a precise distance measurement using the slightly delayed arrival of the reflected light variations from Cyg X-3, because the path the reflected X-rays take is longer than a straight line from Cygnus X-3 to Earth. By measuring the delay time, astronomers could set the distance from Earth to Cygnus X-3 at about 24,000 light-years.

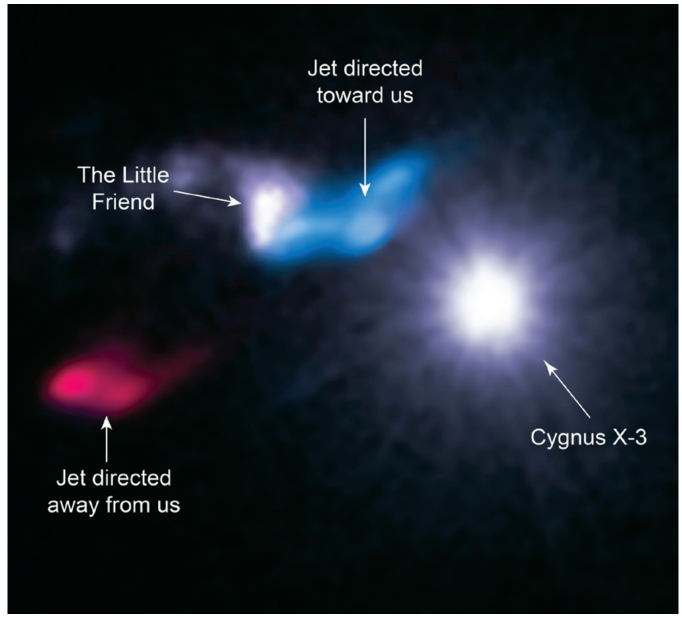

Figure 4 — This composite image shows X-rays from NASA's Chandra X-ray Observatory (white) and radio data from the Smithsonian's Submillimeter Array (red and blue). The X-ray data reveal a bright X-ray source to the right known as Cygnus X-3, a system containing either a black hole or neutron star left behind after the death of a massive star. Within that bright source, the compact object is pulling material away from a massive companion star. Astronomers call such systems "X-ray binaries." Image: Harvard-Smithsonian Center for Astrophysics.

Because Cygnus X-3 contains a massive, short-lived star, scientists think it must have originated in a region of the galaxy where stars are still likely to be forming. Nearby regions are only found in the Milky Way's Perseus spiral arm. However, Cygnus X-3 is located well away from this arm and any others. "In some ways, it's a surprise that we find Cygnus X-3 where we do," said co-author Michael Dunham of CfA and the State University of New York at Fredonia. "We realized something rather unusual needed to happen during its early years to send it on a wild ride."

The researchers suggest that the supernova explosion that formed either the black hole or neutron star in Cygnus X-3 kicked the binary system away from its original birthplace. Assuming that Cygnus X-3 and the Little Friend formed near each other, they estimate that Cygnus X-3 must have been thrown out at speeds between *640,000 and 3.2 million kilometres per hour*.

Assembled in part with material provided by the NASA and the Chandra X-ray Center.

ExoMars returns first high-resolution images

The Colour and Stereo Surface Imaging System (CaSSIS) aboard the European Space Agency's ExoMars *Trace Gas Explorer* (TGO) spacecraft returned the first of its

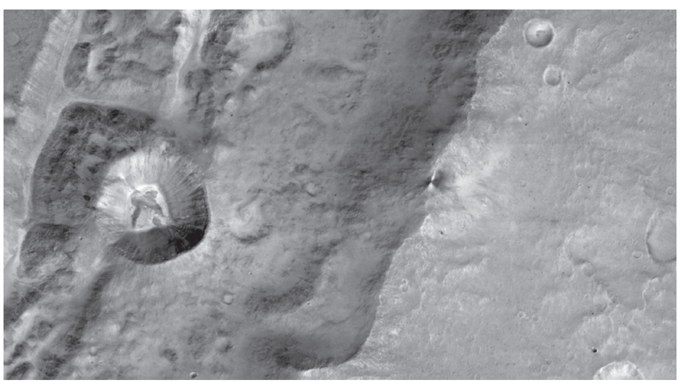

Figure 5 — Close-up of the rim of a large unnamed crater north of a crater named Da Vinci, situated near the Mars equator. A smaller, 1.4 km-diameter crater is seen in the rim along the left-hand side of the image. The image scale is 7.2 m/pixel. Image: ESA/Roscosmos/ExoMars/ CaSSIS/UniBE

high-resolution images of Mars's surface late in November. CaSSIS is capable of exceptional resolution when at the lowest point of its highly elliptical orbit around the planet. The camera was developed by a team from the University of Bern led by Prof. Nicolas Thomas from the Center for Space and Habitability (CSH).

"We saw Hebes Chasma at 2.8 metres per pixel," says Thomas. "That's a bit like flying over Bern at 15,000 kilometres per hour and simultaneously getting sharp pictures of cars in Zurich."

CaSSIS also has colour and stereo capabilities that were successfully tested, though the region over which the spacecraft was passing was rather bland in the colour sense. A 3-D reconstruction of a region in Noctis Labyrinthus was produced from a stereo pair of images. This first analysis shows one of the steep-sided slopes characteristic of the region.

The imaging technique used by CaSSIS is called "push-frame." It takes short exposures (framelets) at a very rapid rate and these images are put together on ground to produce the final product. For Hebes Chasma, the framelets were acquired with 700 microseconds exposure time at a rate of one framelet every 150 milliseconds. The high-resolution imaging system is designed to complement the data acquired by the other instruments on TGO and other Mars orbiters, while also enhancing our knowledge of the surface of Mars.

Mars is a dynamic planet and CaSSIS offers the ability to study changes that occur day-by-day and over the Martian seasons. Further studies of possible liquid water on the surface will be one of the main aims. CaSSIS will also support the other instruments on TGO by trying to identify sources of trace gases, including methane, which is a short-lived molecule seen in the Martian atmosphere first by ESA's *Mars Express* spacecraft.

Composed in part using material from the European Space Agency. ✶

Research Papers / Articles de recherche

A Comparison of the Black-Drop Effects during the Transits of Mercury in 2016 and Venus in 2004–2012

By Duval, M., Sauvé, R., and St-Onge, G.*, Dorval Astronomy Club (CDADFS)*

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Abstract

The black-drop effect during the 2016 transit of Mercury against the Sun has been observed and photographed by amateur astronomers in Dorval (Montréal, Canada), confirming that the black drops of Mercury and Venus are produced by the halos observed around the planets and the Sun, because of the imperfect optical resolution of the instruments used. The differences between the black drops of Mercury and Venus are due to the differences in size between the halo and the diameter of the planets.

Résumé

Le phénomène de la goutte noire a été observé et photographié pendant le transit de Mercure de 2016 devant le Soleil par des astronomes amateurs de Dorval (Montréal, Canada), confirmant que les gouttes noires de Mercure et Vénus sont dues aux halos observés autour des planètes et du soleil en raison de la résolution optique imparfaite des instruments utilisés. Les différences observées entre les gouttes noires de Mercure et Vénus sont attribuables à la différence de taille entre le halo et le diamètre des planètes.

1. Introduction

The transit of Mercury against the Sun of 2016 May 9 has been observed and photographed by members of the Dorval Astronomy Club (CDADFS). The characteristics of the black-drop effect have been compared to those observed during the transits of Venus in 2004 and 2012 and reported by the CDADFS in this Journal (Duval et al., 2005, 2012) and on its website (Dorval Astronomy Club), in good agreement with other published observations (Pasachoff, 2012;, Schneider et al., 2004).

2. Instrumentation, Methods and Observations

The instrument used by R. Sauvé was a 90-mm TopCon Telephoto with a focal length of 500 mm at *f*/5.6 and *f*/8, equipped with a Nikon camera. The size of pixels in this camera was ~2.5 arcseconds (206 x 6.1/500). Throughout this article, arcseconds will be indicated as ″.

The characteristics of the black drop of Mercury have been measured from photos of the contact point taken with this instrument, using the same methods as in the case of Venus (Duval et al., 2005, 2012).

Photos of the black drops of Mercury and Venus, taken at contact points with instruments of comparable resolution and producing similar widths of halos around the planets, are presented in Figure 1, where different magnifications have been used to facilitate visual comparisons (the actual diameters of Mercury and Venus during these transits were 12″ and 54″, respectively, according to the Observer's Handbook of The Royal Astronomical Society of Canada (RASC) of 2016 and 2004.

3. Results and Discussion

As observed and explained during the transits of Venus (Duval et al., 2005, 2012), the photos of Mercury and Venus in Figure 1 are composed of:

- the bright disk of the Sun in the upper background,
- the dark black sky in the lower background,
- an apparent inner black disk of the planets in the foreground,
- a continuous halo of greyish colour around the apparent inner black disk of the planets, located above and inside the real disk of the planets, and due to the bright light of the Sun blurring over and inside the planets,
- a similar halo between the bright disk of the Sun and the black sky, located above the sky,
- a black-drop effect in between the inner black disk of the planets and the black sky.

In the case of Mercury, around the continuous greyish halo, there is also an outer layer containing isolated pixels not continuously connected to one another. More generally, the boundaries between the various components of Mercury, the Sun, and the sky are not as sharp as in the case of Venus.

This is because of the small diameter of Mercury, requiring higher magnifications and resulting in images of pixels in the photos that are large (~2.5″) compared to the diameter of the planet (~12″). As a result, pixels are not always located entirely above one component (e.g. the inner black disk), but partially above it and partially above the continuous halo/real disk of the planet. The same occurs at the boundaries between the continuous halo and the outer layer, and between the bright disk of the Sun, the black sky, and the halo in between.

Furthermore, this crossover of pixels above these components changes from one photo to the other, since the planet is moving across the Sun and across the grid of pixels in the camera. Such photographic conditions can also produce variations of intensity between pixels, in regions where contrast is weak and near detection limits, e.g. in the outer layer.

Taking into account these effects, and also the well-documented value (RASC, 2016) of the real diameter of Mercury as a yardstick (12″), it has been determined that the diameter/size of the various components in the photos of Mercury are;

- for the outer layer: between ~8 pixels (~20″) away from contact point, and ~6 pixels (~15″) at contact point (G. St-Onge),
- for the continuous halo/real disk: ~5 pixels (~12″),
- for the apparent inner black disk: ~3 pixels (~8″),
- for the black drop: ~1 pixel (~2″).

These values, as well as the other characteristics of the black drop of Mercury, are indicated in Table 1, with the terms used in Table 1 indicated below the table. Also indicated in Table 1 are the characteristics of the black drop observed previously with Venus (Duval et al., 2005, 2012), using an instrument of similar resolution producing a similar width of the continuous halo, as deduced from Figure 3 of Duval et al. (2012) related to the transits of Venus of 2004 and 2012.

A schematic representation of the black-drop effects of Mercury and Venus is indicated in Figure 2, based on Table 1 and Figure 1. As in Figure 1, different scales are used in Figure 2 for Mercury and Venus to facilitate visual comparisons.

It thus appears that, as in the case of Venus (Duval et al., 2005, 2012):

1) the black-drop effect during the transit of Mercury is due to the formation of a continuous halo around the planet and the Sun, because of the imperfect optical resolution of the instrument used, as explained in detail in Figure 2 of ref. (Duval et al., 2012).

2) the apparent inner black disk of the planet Da appears visually smaller than its real disk D, because of the halo produced over and inside the planet by the Sun. Similarly, the apparent bright disk of the Sun, including the halo around it, appears visually slightly larger than its real disk.

The black drop of Mercury, however, appears bigger (S in Table 1), longer (L/Da) but narrower (W/Da), than the black drop of Venus.

Table 1: Characteristics of the black drops of Mercury and Venus

Years of Transit	Mercury	Venus	
	2016	2004 – 2012	Units
D	12	54	″ (arcseconds)
H	2	2	″
Da	8	50	″
L	2	2	″
W	2.2	24.5	″
S	9	2.5	″
L/Da	25	4	%
W/Da	27	49	%

(see below for definition of terms used)

D	Diameter of the real disk of the planets on the day of transit, from RASC *Observer's Handbooks*.
H	Width of the continuous halo around the apparent inner black disk of the planets (over and inside the real disk), and of the halo around the Sun above the sky, from photos.
Da	Diameter of the apparent inner black disk of the planets, from photos.
L	Length of the black drop, perpendicular to the disks of the planets and the Sun, from photos.
W	Width of the black drop, tangentially to the disks of the planets and the Sun, from photos.
S	Surface of the black drop at contact point, divided by surface of the apparent inner black disk of the planets, from photos.

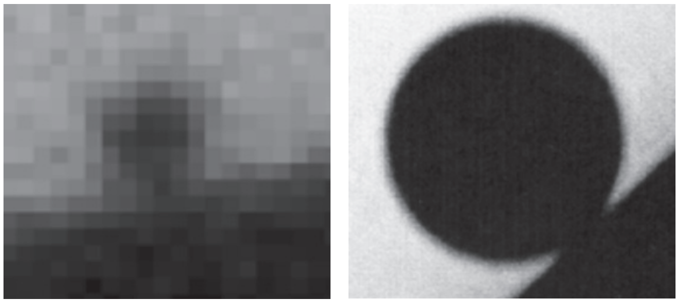

Figure 1 — Photos of the black drops of Mercury and Venus, using instruments of similar resolution (~2″). Different magnifications are used for Mercury and Venus in this Figure (actual diameters of the planets were 12″ and 54″, respectively)

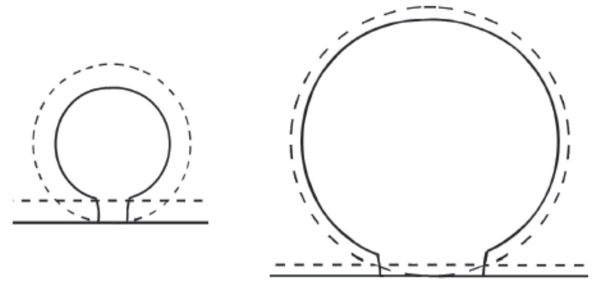

Figure 2 — Schematic representation of the black drops of Mercury and Venus. Different scales are used for Mercury and Venus in these graphs (actual diameters D were 12″ and 54″, respectively)

This is in apparent agreement with observations made during the transits of Mercury on 1999 November 15, and Venus on 2004 June 8, by the *Transition Region and Coronal Explorer* (TRACE) spacecraft (Schneider, Pasachoff, 2012; et al.). The differences between the black drops of Mercury and Venus, however, are more difficult to see with high-resolution telescopes such as the one used by TRACE (<1″) because they produce much smaller and fainter black-drop effects, as explained in Duval et al., (2005, 2012).

These differences between the black drops of Mercury and Venus are essentially due to the relative size of the continuous halos compared to the diameter of the planets (H/Da or L/Da), and are not affected in practice by the actual and exact position of the real disks D of the planets against the Sun (dotted lines).

4. Conclusions

The black-drop effect with both Mercury and Venus is due to the formation of halos around the planets and the Sun because of the imperfect optical resolution of the instruments used.

The black drop of Mercury, however, appears to be visually bigger, longer, and narrower, compared to the diameter of the planet, than the black drop of Venus.

This difference is due to the smaller diameter of Mercury for a similar size of halo and resolution of instrument used. ✶

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In Search of the 13th Mi'kmaw Moon[1]

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Introduction: Calendars, Ancient and Modern

Whether we hang it on the wall by the phone, or consult the "app" in our smart phones, each of us uses a calendar of some sort to organize our lives. Does the weekend start tomorrow? When is Aunt Betty's birthday? How many weeks until vacation? Nowadays, people all over the world use the *civil calendar*, which is the same as the *Gregorian calendar*, first authorized for use in Roman Catholic countries by Pope Gregory XIII in 1582, but later officially adopted by most other countries, and now considered an international standard. The establishment of the Gregorian calendar, with its unequal months, leap years, and rules for determining the date of Easter, makes a fascinating story, but here we share another calendar story: the timekeeping methods of North American indigenous peoples before the arrival of the Europeans—specifically the *Mi'kmaq* of Atlantic Canada (the noun "Mi'kmaq" is pronounced "meeg-ga-mak").

Figure 1 — A postage-stamp likeness of Mi'kmaw Grand Chief Membertou in traditional regalia, holding a fishing spear, with a wigwam and canoe in the background. Membertou was among the first indigenous leaders to convert to Christianity, along with his extended family. (Library and Archives Canada)

The Mi'kmaq inhabited what are now the eastern Canadian provinces of Nova Scotia and Prince Edward Island, plus parts of Québec, New Brunswick, and Newfoundland, in areas not far inland, as they were a semi-nomadic people, spending summers fishing along the seashore and winters hunting in the forests. Their lives were finely tuned to the ecological cycles that governed their food supply, and their calendar speaks of events such as the running of maple sap, the laying of bird eggs, the ripening of berries, and the mating of the moose (a staple); however, their "calendar" did not hang on a wall! The Mi'kmaq, like other native peoples of North America, naturally observed celestial and seasonal cycles to reckon the passage of time and to organize their activities: (1) the rising and setting of the Sun created day and night; (2) the annual variation of the Sun's heat drove the ecological events throughout the year; and (3) in between the daily and yearly cycles, the Moon waxed and waned through its phases, presenting most often 12 but sometimes 13 full Moons to divide a year. The *Mi'kmaw* (pronounced "meeg-ga-maw") way of reckoning time was relational: these cycles were observed, their embedding was recognized, and they were accepted as part of Life. The European way of reckoning time was based on mathematics and astronomy, and the calendar they brought to their New World had origins in the same celestial cycles, but had become disconnected with the celestial lunar cycle. Of course, the cycles of the Moon carry on, but they now unfold on the pages of the Gregorian calendar.

Eventually, the dominance of the Europeans resulted in the First Nations' acceptance of the Gregorian calendar, attendance at church, and adoption of the 7-day week. These European norms became the new order, and the traditional First Nations' ways, passed on by oral tradition, began a slow decline over hundreds of years until the present day, when the teachings of the moons (as distinct from months) are all but forgotten. Today, the traditional names for the moons have been mapped onto the 12 Gregorian months, as "translations" of those time intervals, and the 13th moon has lost its way in a game of calendrical musical chairs, with 12 chairs (months) and 13 players (moons). Through a method called "Two-Eyed Seeing," a term coined by Elder Albert Marshall of the Eskasoni First Nation on Cape Breton Island (Marshall, 2004), we are attempting to recover lost knowledge about the Mi'kmaw calendar and the role of the Moon in it, with one eye learning from the traditional teachings, and the other eye applying conventional science to interpret those teachings.

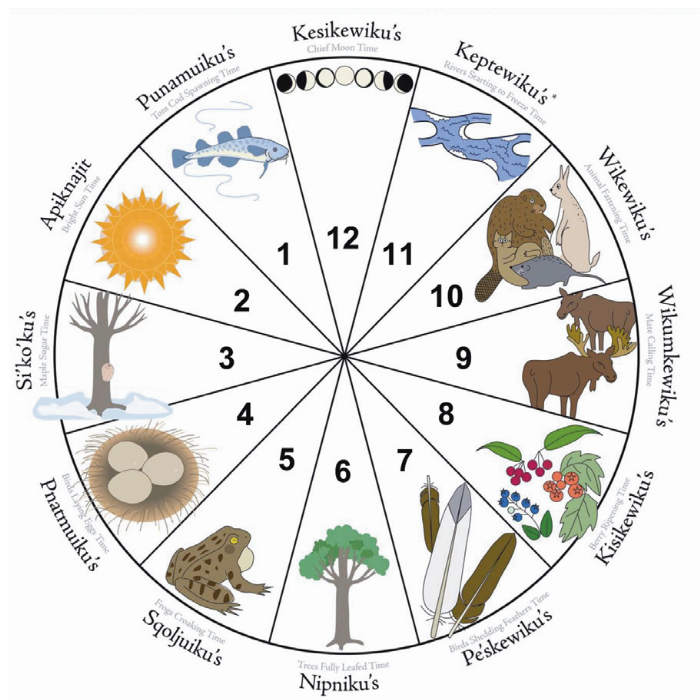

Figure 2 — The 12 principal moons of the Mi'kmaw calendar from Table 1. (after Prof. Cheryl Bartlett, Institute for Integrative Science and Health, Cape Breton University)

The short story of the Moon Chief, which we will share later, captures the essence of Two-Eyed Seeing.

In what follows, we will continue to use "Moon" to refer to the celestial body (or to a specific instance of full Moon); "moon" to mean a regular lunation (new Moon to new Moon), with the full Moon at the centre; and "month" to mean any one of the unequal periods of time that divide the year in the Gregorian calendar.

The Teachings

Before getting into the details, let's establish that the moon was a time period important to the Mi'kmaq and other indigenous peoples of North America. We need look no farther than Leona Cope's paper "Calendars of the Indians North of Mexico" (Cope, 1919). The author's comprehensive compilation of previous writings on the topic make a good case that indigenous peoples divided the year into moons, although the number of days making up a moon was not well-defined, and perhaps of little importance to their ways. Cope places the Mi'kmaw calendar within a broad spectrum of continent-wide indigenous calendars having a variety of moon names and meanings; however, all these calendars use moons to divide the year, and the moon names usually relate to seasonal events. One clear message that emerges is that—with no central authority dictating policy—the nature of indigenous life allowed for seemingly infinite variation in language and custom regarding the reckoning of time, even between neighbouring bands.

The often-consulted periodical *Old Farmer's Almanac* (published annually since 1792) uses 12 Algonquin-based names (with some variation) for the full Moons. From that list, we see the familiar Harvest Moon (usually in September, sometimes in early October) and Hunter's Moon (the next in the series). Other names in the list refer to obvious ecological events. A careful review of the *Old Farmer's Almanac* over successive years reveals that in some years the calendar makers insert an additional full Moon (Grain Moon, sometimes Corn Moon or Barley Moon) to ensure that the Harvest Moon is the full Moon closest to the autumnal equinox. A 13th moon showed up in 2009, 2012, and 2015—expect to see the next in 2017. It is interesting to note the reference to agricultural activities among the Algonquin moons and the importance of placing Harvest Moon near the equinox.

The first Europeans to faithfully record the customs of the Mi'kmaq were the Jesuit and Franciscan brothers, during the 17th and 18th centuries. Father Chrétien Le Clercq wrote "They count the years by winters, the months by the moons, the days by the nights" (cited in Mechling, 1959). (Camping enthusiasts will appreciate the day/night distinction, as it highlights the number of times one has to make and break camp on a journey.) Abbé Maillard wrote "This nation counts its years by the winters. When they ask a man how old he is, they say 'how many winters have gone over your head?' Their months are lunar, and they calculate their time by them. When we would say 'I shall be six weeks on my journey,' they express it by 'I shall be a moon and a half on it.'" (also cited in Mechling, 1959). On a more sombre note, consider the appeal by Grand Chief Paussamigh Pemmeenauweet to the young Queen Victoria in 1841 regarding the state of her native subjects in Nova Scotia (Petrone, 1991): "My people are in trouble. *I have seen upwards of a thousand moons* [our emphasis]. When I was young I had plenty: now I am old, poor and sickly too. My people are poor."

Now, let's look more closely at the twelve principal moons in the Mi'kmaw cycle (which rarely line up exactly with conventional months). The moons in Table 1 were published with associated artwork as a poster in 2008 by Cape Breton University's Institute for Integrative Science & Health (www.integrativescience.ca). The names are presented as approximate English versions for simplicity, along with their nominal months, and actual lunations and full Moon nights for the Gregorian year 2016.

Most of the moon names are self-explanatory, but some deserve a little more description. The tom cod (also called frost fish) is a species of fish that lives in the brackish waters where freshwater rivers empty into the salty ocean. They spawn in the cold months, swimming upstream, where the Mi'kmaq would fish them through the ice near their inland camps.

Cathy has a funny story about Snow Blinding Time:

> *"I was driving the highway home from work one sunny February day, when Dave called me to talk about our project (I was using a hands-free phone, of course). When I answered, I told him how hard it was for me to drive, because I had forgotten my sunglasses, and the glare from the snow was blinding me. Dave replied, 'do you know what moon it is right now?' and then it suddenly struck me: it was Snow Blinding Time. Even though I knew of this from the teachings, I suddenly got it, as I was experiencing it for myself. My view of time, the calendar, and our project changed at that instant."*

Later the same year, Cathy shared more stories involving her elementary-school-age niece, Holly:

> *"My niece called me up one day, all excited. 'Auntie, Auntie, last night I heard the peepers!' I answered her, 'that's wonderful, Holly, do you know what moon it is right now?' Holly replied, 'I don't know but I bet it has something to do with peepers!' I explained to Holly that it was Frogs Croaking Time and that hearing the peepers meant that spring had arrived. The very next moon, Holly told me of watching the leaves bud out on the trees, and she seemed to know that it was Trees Fully Leaved Time, even before I told her."*

Dave collected an interesting interpretation of the Animal Fattening Time, commonly known as Hunter's Moon elsewhere. An elder Mi'kmaq named Tom Christmas explained "by tradition, one never hunted the female moose

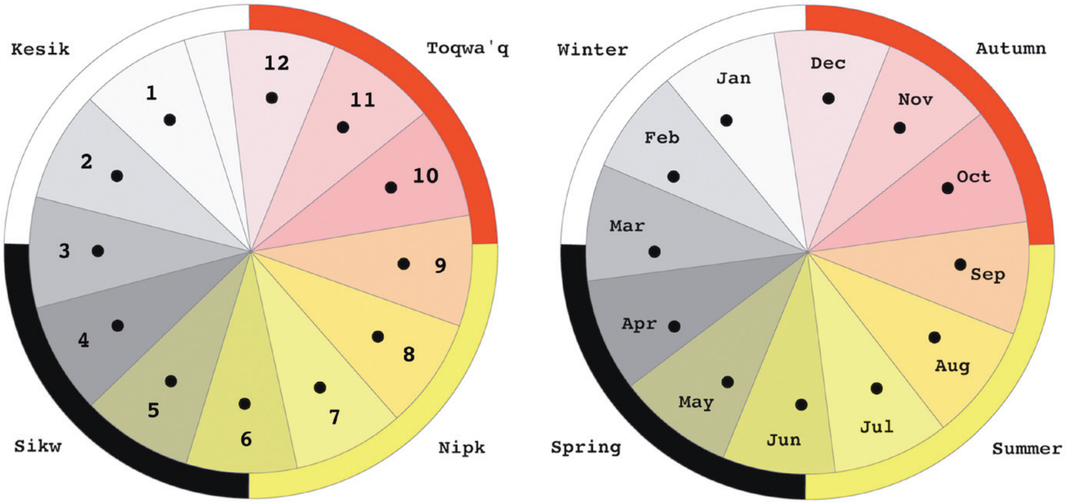

Figure 3 — Mi'kmaw moons (left) and Gregorian months (right) for the year 2016, relative to the seasons (winter solstice at top), showing the times of the 12 full Moons. Note that the full Moons occur in the middle of the moons, which do not add up to a full year. The first moon of the following cycle begins 11 days earlier. The months fill the year, but the full Moons have no special time within the months. By coincidence, the last 3 months of 2016 closely match the last 3 moons.

while she was nursing her calves, but by Animal Fattening Time, the calves were feeding independently, so the female was fair game. The male moose was fair game anytime, as moose was a staple food in the Mi'kmaw diet." (Sadly, the spread of the white-tailed deer into Nova Scotia also brought a parasite deadly to moose, and those animals are long-gone from our mainland forests, but have been re-stocked in Cape Breton.)

In almost all current Mi'kmaw language sources, the above moons are taught simply as the Mi'kmaw equivalents to the Gregorian months, but this is a simplification; the 2008 poster had a tantalizing footnote: "There are 12 moons in this Moon Calendar, to go with the 12 months in a year. In the past, the Mi'kmaq included 13 moons in a year." To understand this puzzling footnote, we must turn to astronomy.

The Astronomy

In grade school, we learn that a year has 365¼ days. That is the length of the annual solar cycle that drives the seasons at temperate latitudes: the tilt of the Earth's axis provides concentrated sunshine for long hours during summer, and weak sunshine for short hours in the winter. It's hard to count fractional days, so we count 365 days in most years and we add a "leap day" to the calendar every 4 years (or so) after February 28 to allow the Sun to match the fast-running calendar. In this way, the vernal (spring) equinox, summer solstice, autumnal equinox, and winter solstice stay in their "proper" positions around day 19–23 of the months March, June, September, and December. Prior to Julius Caesar, the Romans kept a 355-day lunar calendar. Caesar introduced a major calendar reform, a solar calendar 365 days long with a leap day added every 4 years. That was not enough, however, as the average length of the year is closer to 365.2422 days. Pope Gregory XIII approved a fine-tuning of the calendar by introducing exceptions to the 4-year leap-day rule. Most of us have forgotten why this is done, but we accept it without too much fuss (keep this in mind for when we look at moons and months!).

The lunar cycle complicates things, counting-wise. The average time between full Moons is 29½ days (there's another pesky fraction!). Even by counting alternate months of 29 days and 30 days, after 12 moons have passed, the year only adds up to 354 days, 11 days short of a regular year. The ancient Romans gave up following the Moon exactly, and sprinkled the 11 extra days around the calendar, adding days to months here and there (and taking one away from February) to get the 12 months we have now of length 30 or 31 days (28 or 29 days for February). In other words, to get 12 fixed divisions of a year, the Romans abandoned the moon cycle that the word "month" is based on! Now the full Moon (or any other phase) has no fixed place in a month, but could show up anywhere. In other words, moons can overlap months, and the two are rarely coincident.

With the stretched Gregorian months, one can even have two full Moons in a month (on average, about every 2 years, 8 months). It's easy to see how: if a full Moon takes place on the 1st or 2nd day of a month, there will be another full Moon 29.5 days later, at the end of the same month, on the 30th or 31st, depending on the length of the month (never February). For example, the year 2015 had full Moons on July 2 and July 31. The same logic holds for any lunar phase; for example, 2016 has new Moons on October 1 and October 30 (not that anyone will be able to see them). These Moon-month shenanigans get really crazy in 2018, when (in Universal Time) there are two full Moons in January, none at all in February, and again two full Moons in March—be prepared for a lot of social-media silliness in early 2018! Calendar systems that follow the true lunar cycle (such as that of the Mi'kmaq) do not have this artificial problem—the moon begins and ends at new Moon and the full Moon is smack dab in the middle, where it should be; however, since the lunar and solar cycles do not reconcile perfectly, there is a price to pay: the leap-month or 13th moon.

Cultures that did not abandon the lunar cycle, but made it work within the solar cycle, include the Babylonians, the

Jews, and the Chinese. They all devised complex lunar-solar calendars that added a 13th moon every 2 or 3 years (usually by simply repeating a moon name) so that the moons more-or-less kept in step with the Sun. In effect, they add leap-moons to their calendars, just as the Julian and Gregorian calendars add leap-days. This practice delays the start of the next 12-moon cycle relative to the moons from the previous year. It is for this reason that holidays such as Chinese New Year and Jewish New Year do not have fixed dates relative to the Gregorian calendar, but seem to jump around—it's all about the Moon!

The 13th Moon of the Mi'kmaq

The Mi'kmaq, like many North American indigenous nations, probably did not have a codified set of rules for adjusting their moon calendar. There is no evidence that they counted days or made precise celestial measurements; however, by necessity, they were naturally observant about their environment to ensure survival, and were keenly aware of the enmeshed ecological and celestial cycles (circles and cycles are an important part of Mi'kmaw spirituality even today). The Mi'kmaq would have noticed their ecologically themed moons getting ahead of the natural changes around them, and would agree among themselves to insert a 13th moon to get the cycle back on track (it is important to note that such a correction is unnecessary if the moons are not matched to natural events). The teachings are unclear on how the moon cycle was corrected, but there are definite clues that it was. Some teachings suggest that it was as simple as stating "let this moon go by." Other teachings point to a 13th moon called Kjiku's (Great Moon), but they vary on where it was placed. In common Mi'kmaw language dictionaries, one often sees Kjiku's listed as a synonym for Kesikewiku's (Chief Moon), both being assigned to the month of December. One wonders if the dictionary makers were recording a fact, or were simply unfamiliar with the astronomical basis of the system! It is not much of a stretch to imagine that the European recorders of Mi'kmaw culture were just a little bit biased toward their own cultural practices. The clarification of the two moon names Kjiku's and Kesikewiku's is a key to solving this puzzle.

Chief Moon—the Essence of Two-Eyed Seeing

The story of the Moon Chief (Robertson, 1973) provides an opportunity to apply the method Two-Eyed Seeing to investigate the importance of the Chief Moon Time in the Mi'kmaw calendar. Chief Moon Time is the exceptional moon, as it is the only moon that does not refer to an earthly ecological event such as the croaking of frogs or the running of maple sap—instead, it refers to a celestial event, as we will show. First, the story (our paraphrase):

There is an old man who could no longer hunt, and he and his wife are starving in the cold winter. He asks her if Moon Chief is out that night, and when she confirms it, the old man goes outside and appeals to Moon Chief, recounting the days when as a young man he would hunt the moose in winter (a good time to hunt because the deep snow slowed the prey) and provide for his family. The next day a moose is found in the snow by the wigwam, and the old man is able to kill it, thus providing food to keep them until spring. Clearly, the spirit of Moon Chief is powerful, and he rules in the dead of winter.

At first, the story seems to provide no clue about the calendar, until one thinks about the astronomy. Near the winter solstice, the Sun is low in the sky and spends little time above the horizon, which is why it is so cold. Full Moons always do the opposite of the Sun: they rise when the Sun sets, they set when the Sun rises, they are always opposite the Sun in the sky. Near the winter solstice, the full Moon is high in the sky and spends many hours above the horizon—the days are short and the nights are long. There is plenty of light to hunt moose in the deep snow. If one had to choose one moon to be the chief

Table 1: The Mi'kmaw moons of 2016

moon	month	lunation	full Moon night
1. Tom Cod Spawning Time	January	January 10 – February 8	January 23/24
2. Bright Sun Time*	February	February 9 – March 8	February 22/23
3. Maple Sugar Time	March	March 9 – April 7	March 22/23
4. Birds Laying Eggs Time	April	April 8 – May 6	April 21/22
5. Frogs Croaking Time	May	May 7 – June 4	May 21/22
6. Leaves Fully Leafed Time	June	June 5 – July 4	June 19/20
7. Birds Shedding Feathers Time	July	July 5 – August 2	July 19/20
8. Berry Ripening Time	August	August 3 – September 1	August 17/18
9. Mate Calling Time	September	September 2 – September 30	September 16/17
10. Animal Fattening Time	October	October 1 – October 30	October 15/16
11. Rivers Starting To Freeze Time	November	October 31 – November 29	November 13/14
12. Chief Moon Time	December	November 30 – December 29	December 13/14

* also known as Snow Blinding Time

of them all, what better choice than the one nearest the winter solstice? This moon is the Chief Moon! Other First Nations call the full Moon near the winter solstice the Long Nights Moon. Additionally, this insight provides a richer meaning to the question "how many winters have gone over your head?"

To illustrate, the Chief Moon of 2016 takes place on the night of December 13/14. In Halifax, Nova Scotia, the Moon rises at 4:46 p.m., reaches a maximum altitude of 63° above the horizon, and sets at 7:56 a.m., having spent 15 hours and 10 minutes in the sky; back on July 19/20 (the closest full Moon to the summer solstice), the Moon rises at 8:07 p.m., reaches a maximum altitude of only 26°, and sets at 5:52 a.m., for a total of only 9 hours and 45 minutes in the sky (see Figure 4).

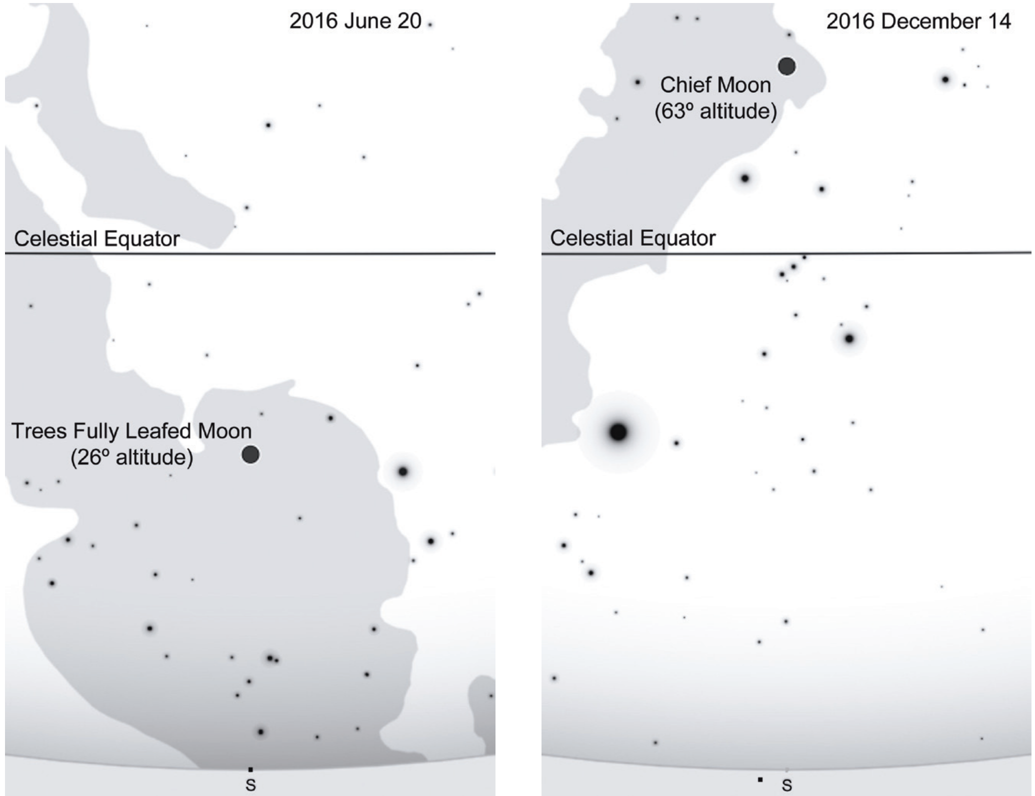

Figure 4 — The full Moons nearest the 2016 spring solstice (left, above Sagittarius and Scorpius) and winter solstice (right, in Taurus), at the time of meridian transit at position 44º 38′ N 63º34′ W. The difference in altitude of the near-solstice Moons is only 37º in 2016, just one year after a minor lunar standstill—this difference will increase yearly to 57º in 2025!

Two-Eyed Seeing can also be applied to interpret well-meaning accounts by those with Euro-centric calendar views. Nova Scotian historian Thomas H. Raddall (Raddall, 1977) wrote "the Mi'kmaq celebrated the Spring Feast seven days after the first New Moon in May." The Spring Feast was a long-established tradition that attracted Mi'kmaq from far and wide, many of whom had to travel long distances to what is now called Point Pleasant Park in Halifax. For a successful gathering, the timing would have to be well understood! However, Raddall's account is problematic for two reasons: Firstly, before European contact, the Mi'kmaq would have known nothing about the Gregorian month of May—to them, it would have been Frogs Croaking Time, the fifth moon after Chief Moon (no one who lives in Nova Scotia could miss the sounds of the Northern Spring Peeper, who mate between April and early June). Coming right after Birds Laying Eggs Time, the nighttime chorus of spring peepers would have heralded the approach of the Spring Feast. Secondly, observing the instant of new Moon is impossible—the Moon is too close to the Sun in the sky, and in practice is unobservable for several days around that time, so counting days from such a poorly defined instant makes little sense. However, 7 days after new Moon, it is the lunar phase of first quarter. In springtime, the first-quarter Moon would appear high in the southern sky at sunset, half-lit by the Sun, easy for anyone to see. Moreover, around that time of the moon, the night-to-night change of the Moon's phase is the most rapid and noticeable, making it as good as an alarm clock for meeting friends. If the time of new Moon was uncertain, the appearance of the crescent Moon in the western evening sky would have served as an "alert" to celebrants that the meeting time was approaching. A Mi'kmaq would surely have said "meet you at the half-Moon in Frogs Croaking Time."

Toward a 21st-Century Mi'kmaw Calendar

So far, we have established the important role of the Moon in the time reckoning of the Mi'kmaq, we have identified the 12 principal moons used in their calendar, and we have made a strong case that a 13th moon was used to keep the ecologically themed moons in step with the Sun. It may be too late to recover the name of the 13th moon and the exact manner in which it was used—there may not even have been common nation-wide customs. Recognizing that cultural practices evolve and change with the times, there is an opportunity now to take the 12 Mi'kmaw names that have been harnessed to the Gregorian months, and restore their function as names for the succession of moons; however, to do that, we need to identify a 13th moon, and we need to create a rule to specify when to insert it in the cycle. There are several ways this could be carried out.

For instance, the 13th moon could be *Kjiku's* (Great Moon Time) and it could precede *Kesikewiku's* (Chief Moon Time) when necessary, to ensure that Chief Moon is the full Moon closest to the winter solstice. A variation on this would invert the order, having Great Moon Time follow Chief Moon Time when the latter arrives too early, with Great Moon falling closest to the solstice. In either case, the cycle would resume with Tom Cod Spawning Time. The insertion of the 13th moon could be calculated with astronomical precision, by a simple comparison of the instants of the nearby full Moons and the instant of the winter solstice.

Let's see how this would work for the years following 2016, particularly around Chief Moon Time. During 2017, the moons progress in the usual way, one full Moon near the beginning of each Gregorian month, until we reach December (see Table 2). With the winter solstice taking place on December 21, the full Moon of December 2/3 is 18 days too soon—the next full Moon on January 1/2 is closer to the winter solstice, only 11 days after. If we assign the early December full Moon the role of Chief Moon, then the early January full Moon must be the 13th full Moon, *Kjiku's* (for want of a better name). Following Great Moon Time, the normal sequence resumes, although note how the moons straddle the Gregorian months—it is at the time of adding the 13th moon that the discord between moons and months is the greatest.

In this article, we have tried to consolidate what is known about the traditional time-reckoning methods of the Mi'kmaq that involve the Moon, but we cannot claim our account is comprehensive, as there may be unrevealed teachings, so we continue to search. Furthermore, we have shown one way the 13th moon could be reintroduced into a moon-based calendar—perhaps not the calendar of past times, but a 21st-century calendar that respects the spirit of Mi'kmaw tradition of keeping in step with natural cycles, while being calculated by astronomical methods, in the spirit of Two-Eyed Seeing. ✶

Endnotes

1 This article received second prize in the Joan and Arnold 2016 Science Writing Contest and was published (in modified form) in the *Griffith Observer*, Vol. 80 No. 11 (November 2016). It is reproduced here in *JRASC* by permission of the Editor of the *Griffith Observer*, Dr. E.C. Krupp. Also, the authors jointly presented the banquet presentation "One Moon—Two Eyes" at the 2015 RASC General Assembly in Halifax, Nova Scotia.

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Cathy Jean LeBlanc is a graduate of St. Thomas University (B.A., 2002). She is a Physical Activities Leader for Acadia First Nation, a Mi'kmaw cultural interpreter, an artist, and a member of the Big Drum group, Women of the Shore.

Dave and Cathy are project partners in Mi'kmaw Moons (www.facebook.com/www.MikmawMoons)

Table 2: Some Mi'kmaw moons for 2017–2018

Moon	Month	Lunation	Full Moon night
11. Rivers Starting To Freeze Time	November	October 20 – November 18	November 3/4
12. Chief Moon Time?	December	November 19 – December 18	December 2/3
13. Great Moon Time?	January	December 19 – January 16	January 1/2
1. Tom Cod Spawning Time	Jan/Feb	January 17 – February 15	January 30/31
2. Bright Sun Time	Feb/Mar	February 16 – March 17	March 1/2
3. Maple Sugar Time	Mar/Apr	March 18 – April 15	March 30/31
4. Birds Laying Eggs Time	Apr/May	April 16 – May 15	April 29/30

CFHT Chronicles

2016 Science Discoveries

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

Welcome to the second annual CFHT Science Discoveries year in review! Astronomers from Canada, France, the University of Hawaii, China, and Taiwan all have access to CFHT. At the time of writing (2016 December 1) around 130 papers had been published using CFHT data, a number we expect to increase as the November and December papers are released. Much like last year, astronomers using CFHT archival data are publishing an increasing number of papers. I see those archival papers as a testament to the quality data collected by CFHT. The discoveries selected for this article all had accompanying press releases and were featured on the CFHT website's News page.

I wrote columns about three of CFHT's splashier discoveries already in this column—the Manx comet in "Nice Work CFHT," and then an entire column "Planets, Big and Dwarf, Abound," dedicated to the planetary related discoveries over the summer. I will give a short recap of each of those discoveries at the end of this column for completeness sake.

A Galaxy in Distress

In February, an international team of astronomers led by researchers at Laboratorie d'Astrophysique de Marseille (LAM) announced their observations of the galaxy NGC 4569, which showed spectacular tails of ionized gas extending over 300,000 light-years, or five times larger than the galaxy itself. Galaxies are not distributed evenly throughout the Universe. Some are found in dense clusters containing hundreds to thousands of galaxies. NGC 4569 is the most massive spiral galaxy in the Virgo Cluster—a cluster that encompasses between 1300–2000 galaxies. The Virgo cluster is found at the centre of the Virgo Supercluster of galaxies, the outskirts at which resides our own Local Group.

Figure 1 — The colour image of the galaxy NGC 4569 in the Virgo cluster, obtained with MegaCam at the CFHT. The red filaments at the right of the galaxy show the ionized gas removed by ram pressure. This is about 95 percent of the gas reservoir of the galaxy needed to feed the formation of new stars (©2015 CFHT/Coelum)..

Astronomers believe life in a large cluster, like Virgo, affects the way galaxies evolve. Clusters tend to contain more elliptical galaxies and fewer spiral galaxies compared to less-dense regions of space. Spiral galaxies within clusters include less gas and dust along with an older population of stars than similarly aged, isolated spiral galaxies. Astronomers propose several explanations for the difference between cluster and non-cluster galaxies. When two galaxies interact, the gravitational forces, called tidal forces, disrupt the most distant parts of the galaxy, even going as far as ripping the galaxy apart. The centre of the galaxy is left relatively intact, while the stars, gas, and dust in the outer regions have less gravitational influence from the centre of the galaxy acting on them, leaving them more susceptible to being tidally stripped.

Additionally, a process known as "ram pressure stripping" acts on the cluster galaxies. In ram stripping, a dynamical pressure is exerted on the interstellar medium of a galaxy as it moves through the hot, diffuse intergalactic medium found between the galaxies in a cluster. The ram pressure experienced by the gas in the galaxy is akin to the force a biker feels from the ambient air while travelling at a high speed.

Between the ram pressure and the tidal forces, cluster spiral galaxies lose much of the gas and dust located in their disks. Gas and dust play essential roles in star formation, and their removal by ram pressure and tidal stripping inhibits the formation of stars. Astronomers also suspect a third culprit in the removal of a galaxy's gas—a massive black hole at the galactic centre. These supermassive black holes inject energy through their accretion process into the surrounding interstellar medium. The influx of energy into the gas causes it to unbind from the galaxy.

Astronomers want to identify which of the above processes most impact cluster spiral galaxies. However, until recently, observing low-density gas under ram pressure was challenging. CFHT now has a high-efficiency, narrow-band H-alpha filter for Megacam. The new filter isolates the H-alpha emission line from the ionized gas, enabling its detection.

The LAM team turned Megacam and its new filter loose on NGC 4569, which moves through the Virgo Cluster at 1200 km/s. With the H-alpha filter, the team observed the spectacular tails of ionized gas extending over 300,000 light-years, five times the size of NGC 4569. The team identified ram pressure as the culprit in the stripping of the gas—an estimated 95 percent loss of the interstellar medium of the galaxy.

The results of the team's observations shine a light on the role of ram stripping. Previously, astronomers hypothesized that the supermassive black hole was responsible for the gas loss. With the new data, astronomers will need to take ram stripping into greater account in their galactic evolution models for cluster galaxies.

Small Scale Structure of the Diffuse ISM

Our next discovery moves from the interstellar medium of distant galaxies to the interstellar medium of our own Milky Way. Using Megacam, *Planck*, and WISE data, a team of astronomers observed the structure of the diffuse interstellar medium over several square degrees in astonishing detail. The study reveals the statistical properties of the interstellar turbulence over a wide range of scales from 0.01 to 10 parsecs.

The mapping of interstellar cirrus clouds is essential for astronomers. First, mapping the ISM assists astronomers studying faint, diffuse emission around distant galaxies. The light scattered by Milky Way cirrus clouds causes light pollution for astronomers studying distant galaxies. A characterization of the cirrus benefits their analysis of the distant light.

Secondly, the light scattered from the cirrus potentially contains information about the nature of the physical process involved in the evolution of matter in our own galaxy. The combination of Megcam's large field of view and high angular resolution will likely allow astronomers to reach the angular scale at which turbulent energy dissipates. Understanding the dissipation process leads to understanding how the dissipated energy heats gas and how that gas forms dense structures, which ultimately lead to star formation.

Interestingly, the Mass Assembly of early-Type GaLAxies with their fine Structures (MATLAS) team made this ISM discovery. MATLAS is a large program at CFHT investigating early type galaxies and the buildup of their scaling relations in great depth. Their program searches for the stellar populations in the outermost regions of early type galaxies—the tidal tails, stellar streams, and shells surrounding the galaxies and the Globular Cluster populations of the early type galaxies. Combined, these observations detail the merger history, evolution, and transformation of the galaxies. Because of the faint nature of their targets, the characterization of Milky Way cirrus becomes crucial to the MATLAS team's work.

Figure 2 — Optical images in true colours of the cirrus field obtained with MegaCam on the CFHT. Image credits: MATLAS collaboration, Pierre-Alain Duc.

A New Look at the Largest Known Disk Galaxy

In a publication accepted in *Astronomy and Astrophysics* in October, an international team involving French and Canadian researchers using CFHT have studied Malin 1, a nearby galaxy that has been known only since the 1980s and that shows an extremely large disk of gas and stars. The new observations of Malin 1, a prototype of the class of "giant low surface brightness galaxies" allowed the team to obtain new results in contradiction with one of the hypotheses concerning the formation of this type of galaxy.

Low-surface-brightness galaxies are galaxies fainter than the brightness of the ambient night sky. Their mass-to-light ratios are very low, meaning very little of the mass of the galaxy comes from objects we can see, like stars or bright regions of gas. Up to 95 percent of the mass of these galaxies appears to come from dark matter, making them the perfect petri dishes for the study of dark matter.

Because they are very diffuse and faint, giant low-surface-brightness galaxies, while massive, are difficult to observe and are still poorly understood. They may represent a significant percentage of the galaxies in the Universe. Because they are so faint, it is possible astronomers missed such objects in galaxy surveys. It is important to study them and understand their formation and evolution. This is now possible owing to the new generation of telescopes and modern detectors, with higher sensitivity to low surface brightness than in the past.

The team's research presents for the first time deep images obtained at six different wavelengths, from the ultraviolet of the GUViCS project to the optical and near-infrared obtained in the context of the Next Generation Virgo Survey with MegaCam on CFHT. Originally, these large observational campaigns were planned to study the Virgo cluster, but they also allow us to study objects in the background like Malin 1. The images offer us a new view of this spectacular galaxy, the largest galactic disk known, with a diameter above 250 kilo-parsec (in comparison, our Milky Way is only about 30 kpc wide and a kilo-parsec is equal to 3262 light-years).

The team of researchers extracted from the data the variation of the luminosity with the distance to the centre of the galaxy, as well as the how the galaxy looks in different wavelengths. The colours of galaxies strongly depend on the star-formation history. The comparison of the observations with predictions of various models allowed the team to estimate for the first time what must have been the history of star formation in the giant disk of Malin 1. It suggests that the giant disk has been in place for several gigayears, and that star formation proceeds at a regular long-term rhythm despite the very low density.

Figure 3 — Malin 1 imaged by the Next Generation Virgo Survey using Megacam on CFHT

This result is important as it contradicts a scenario proposed a few years ago predicting that these giant galaxies are formed during violent interactions. Moreover, in the context of the cosmological formation of galaxies, numerous interactions should have perturbed the disk of Malin 1. The formation of such a structure and its survival for a very long time offers then a challenge for the simulations of galaxy formation run by astronomers.

What is the future of Malin 1? The giant disk contains a large quantity of gas in which star formation will keep proceeding at a low rate for billions of years, increasing progressively the stellar mass of the galaxy. Unless another galaxy comes in the picture to interact with Malin 1 and totally change its destiny. Few galaxies, however, may play this role as Malin 1 is a relatively isolate galaxy.

Quick recaps:

In a paper published in the journal *Science Advances*, Karen Meech from the University of Hawaii and her team conclude that the object known as C/2014 S3 was formed in the inner Solar System at the time that the Earth was forming, but was ejected into the Oort Cloud at a very early stage. Their observations indicate that it is an ancient rocky body, rather than a contemporary asteroid that strayed out. As such, it is one of the potential building blocks of the rocky planets, such as the Earth, that was expelled and preserved in the deep freeze of the Oort Cloud. The authors conclude that this object is probably made of fresh inner Solar System material that has been stored in the Oort Cloud and is now making its way back into the inner Solar System—as a comet without a tail.

For the last 20 years, the giant planets known as hot Jupiters have presented astronomers with a puzzle. How did they settle into orbits 100 times closer to their host stars than our own Jupiter is to the Sun? In June, an international team of astronomers using Espadons announced the discovery of a newborn hot Jupiter, orbiting an infant sun V830 Tau—only 2 million years old, the stellar equivalent of a week-old human baby. The discovery that hot Jupiters can already be present at such an early stage of star-planet formation represents a major step forward in our understanding of how planetary systems form and evolve.

In July, the Outer Solar System Origins Survey (OSSOS) team announced the discovery of new dwarf planet orbiting the Kuiper Belt. The new object is roughly 700 km in size and has one of the largest orbits for a dwarf planet. It was discovered using CFHT and given the name 2015 RR245 by the International Astronomical Union's Minor Planet Center.

After hundreds of years further than 12 billion km (80 astronomical units, AU) from the Sun, RR245 is travelling toward its closest approach at 5 billion km (34 AU), which it will reach around 2096. RR245 has been on its highly elliptical orbit for at least the last 100 million years.

As RR245 has only been observed for one of the 700 years it takes to orbit the Sun, where it came from and how its orbit will slowly evolve in the far future is still unknown; its precise orbit will be refined over the coming years, after which RR245 will be given a name. As discoverers, the OSSOS team can submit their preferred name for RR245 to the International Astronomical Union for consideration. ✶

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

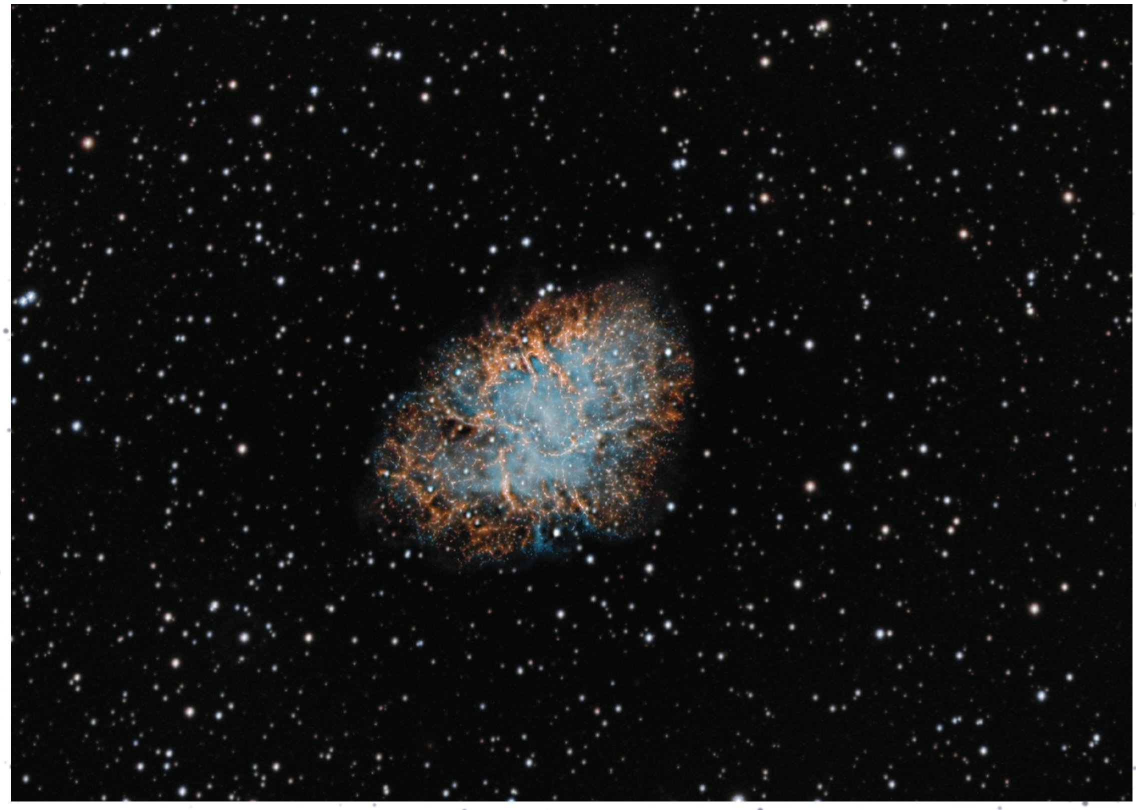

Figure 1 — The Crab Nebula is a favourite photographic target for many people. Dan Meek imaged the supernova remnant from his home in Calgary using an 11" Celestron Edge SCT using a QSI583wsg camera. It is an 8-hour LRGB image.

Figure 2 — This image of the 2016 September 1 annular eclipse was taken by Stephen Bedingfield from Reunion Island.

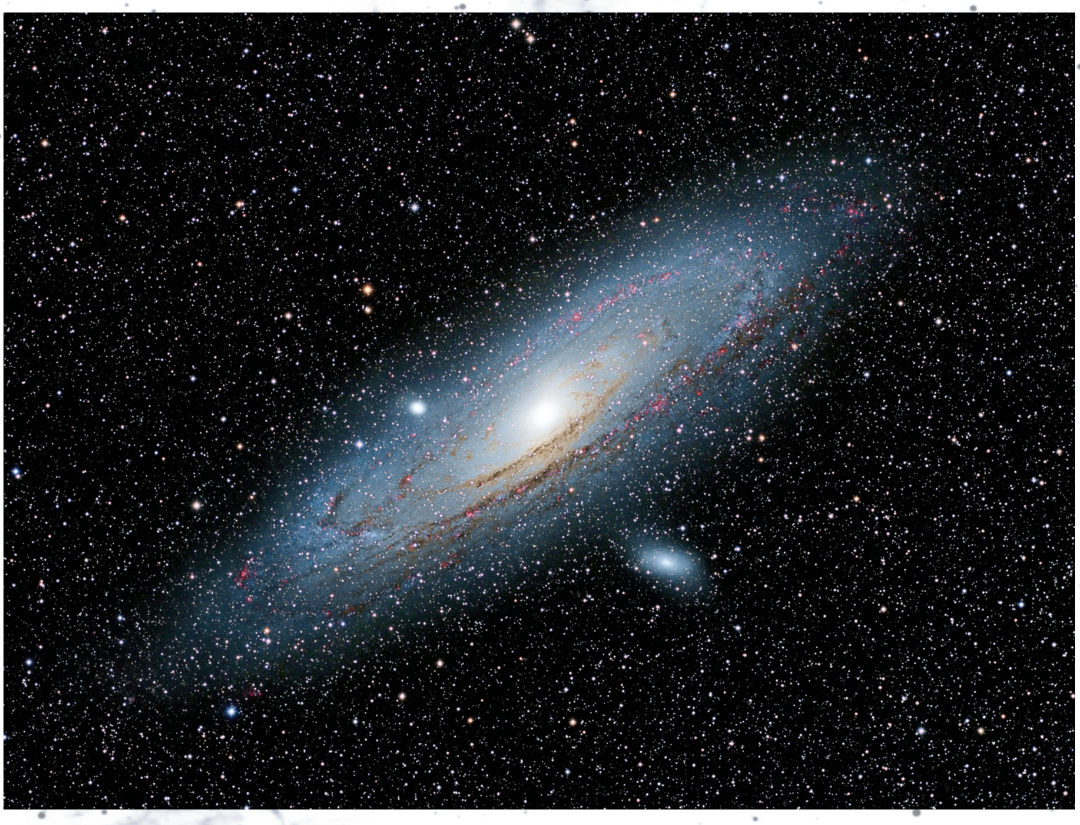

Figure 3 — It's another beautiful image from Ron Brecher. This time of an old favourite, M31, the Andromeda Galaxy. This was Brecher's "first light" image taken with his new Takahashi FSQ-106 refractor. He used a Moravian G3-16200 EC camera, Optolong Hα, R, G and B filters, at *f*/3.6, Paramount MX, QHY5 guide camera, 50-mm *f*/l guide scope. Acquisition was done with the TheSkyX.

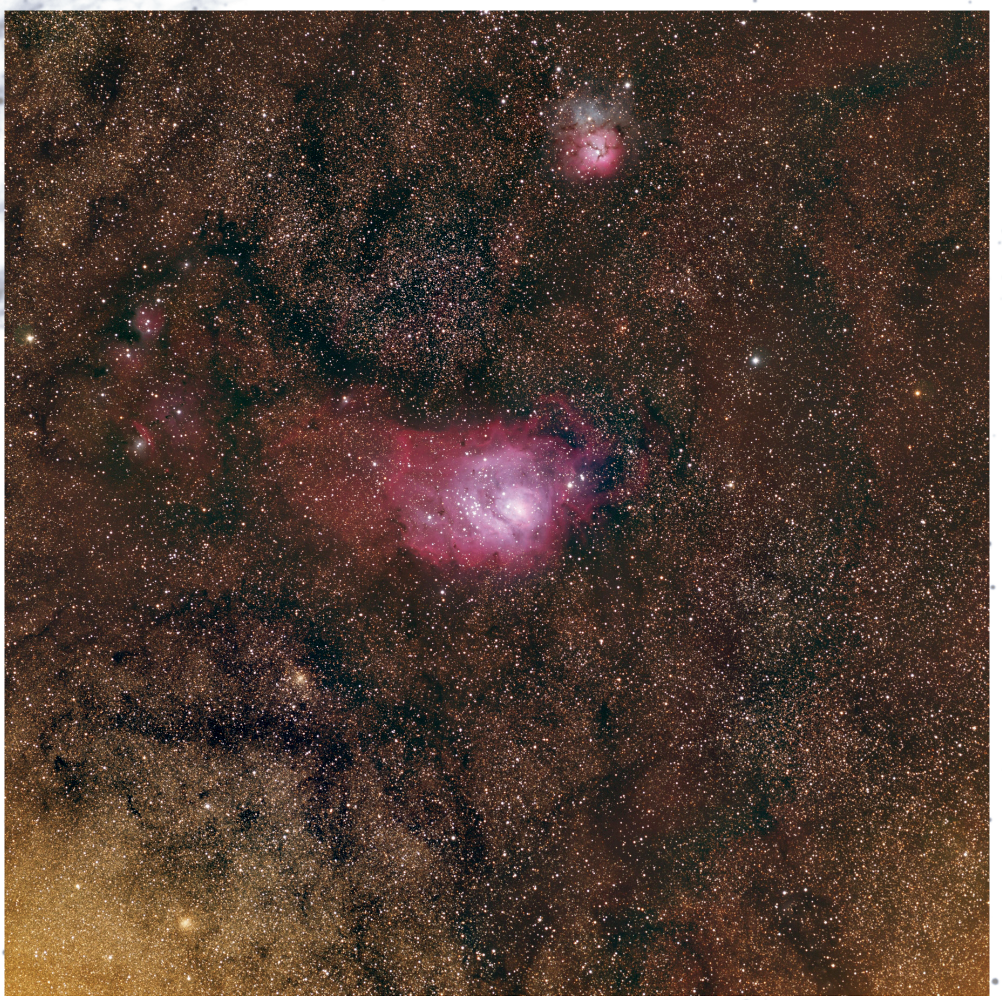

Figure 4 — Tim Lahey imaged the dense region around the Trifid and Lagoon Nebulae. The image is a total of about 75 minutes each of RGB, acquired with an Apogee U16M and filter wheel (Baader filters) through a Tak FSQ-106N riding on a Paramount MX at Arizona Sky Village. Mount control, guiding, and image acquisition was done using TheSkyX with Camera Add On. Lahey also used a KWIQ-Guider guide scope and camera. All image processing was done using PixInsight.

Skyward

Ancient Astronomy and a Canal

by David Levy, Montréal and Kingston Centres

Wendee and I have just returned from a fabulous vacation. We spent much of October cruising from Los Angeles to Mexico, Guatemala, Costa Rica, Panama, and Colombia. By far the highlight was our transit through the Panama Canal. During this excursion, we also had the chance to consider the history of this unique part of the world.

Do we take for granted that Central America is a poor cousin of the greatness of North America? If we pause to consider what the great Mayan civilization did for us thousands of years ago, we might not be so cavalier. The Mayans developed a powerful philosophy, and most pertinent to this column, they looked at the stars from great pre-Columbian cities like Chichen Itza on the Yucatan Peninsula.

The Mayans lived in what is now the central and southern portion of Mexico, as well as Guatemala and Costa Rica. Their civilization began as long ago as 2000 BC and stretched to the late Shakespearean period in the early 16th century, a period of more than 3500 years—far longer than our modern period. During this long period, the Mayan astronomers developed two calendars. An early calendar consisted of 260 days, and their later one created a "Mesoamerican year" consisting of 18 months of 20 days each, plus an extra five-day period tacked on. There is evidence that this calendar relates to three eclipse seasons, periods during which eclipses of the Sun and Moon can occur.

The Mayan calendar demonstrates the interest that civilization had in eclipses of the Sun and the Moon. Like the ancient Greeks, the Mayans understood that eclipses occur in cycles, and that any eclipse will repeat itself 18 years, 11 days, 8 hours later. Eclipses then, as now, prove that our sky is a moving, changing place, and that its brightest objects—the Sun and Moon—often get in each other's way. The Mayans were curious also about the other wandering things in the night sky, particularly bright Venus, which shines either as an evening star after dusk, or a morning star before dawn. Some Mayans possibly followed the motion of Venus through the open windows and doorways of *El Caracol*, a proto-observatory structure. And no doubt, comets and strange "temporary stars" (now understood as exploding stars or novae) would have greatly interested them, too.

Wendee and I did not get to visit these places during our tour, which highlighted the far more modern Panama Canal. But as our ship navigated that beautiful and fascinating waterway, our thoughts recalled the peoples who so bravely constructed it, and those who came long before, like the Mayans who ruled part of a continent, looked up, measured the stars, and wondered.

A canal, a telescope, and a star

What does a canal have to do with the night sky? For me, plenty. I remember visiting the Lachine Canal many times as a child growing up in Montréal. I even have a dim memory of watching the water raise our boat once. But actually standing aboard the *Norwegian Dream*, a gigantic cruise ship, to experience the Panama Canal had to wait until the fall of 2016. As the water surged quietly into and out of the locks on the Pacific and Caribbean sides of the canal, the ship rose and lowered as gently and as quietly as a toy boat in a bathtub. Being part of it was an amazing experience.

Figure 1 — Miraflores locks, Panama Canal

Being in Panama, on both the Pacific and Caribbean sides, led me to recall another childhood memory. When I was in high school, I would occasionally bring a tiny telescope I called Alouette. During recess or lunch I'd bring the telescope out of the school and get a reading on how many sunspots there were on the Sun. The telescope was so small it didn't capture many sunspots.

Figure 2 — Panama Canal Bridge of the Americas

I no longer have the original Alouette, but in 1970 I bought a new finderscope. I have now used that telescope, also named Alouette, for 46 years. Made mostly of war surplus materials, the revised Alouette served as a finderscope, but recently has evolved into a travel telescope. When I first got it, Acadia University physics professor Roy Bishop helped me get it installed and aligned, so I thought it proper that it be given a long-overdue first-light ceremony. At his Nova Scotia home on the morning of November 7, we used Alouette to enjoy a traditional view of Jupiter, the object I like to use to begin the careers of most of my telescopes.

What does all this have to do with the Panama Canal? I brought Alouette down there and used it to observe stars not normally visible from my Arizona home. In particular, the "star" of the Panama Canal was Achernar. I've seen it from Arizona but only as it lay sleeping at the horizon, opening its eyes and winking at me briefly before setting again. But in Panama, Achernar shone high and prominently in the southern sky.

Because of an effect of the Earth's wobble called precession, Archernar appears to be moving northward. In a few thousand years it will become more easily visible from most of the United States and even southern Canada.

Figure 3 — Miraflores lock

Figure 4 — Alouette and Jarnac

Achernar is a big star, 6.7 times more massive and 3150 times more luminous than our Sun. Even though it is about 139 light-years away, it shines as one of the brightest stars in the sky. It rotates about its axis so quickly that it isn't even spherical, but instead it is flattened into an oblate spheroid so dramatically that its equator is half again as fat as its poles. Moreover, Achernar is surrounded by a very large gaseous envelope that grows outward from the star, collapses inward and then regrows.

It is this final fact of Achernar's envelope that brings me back to the Panama Canal. As I looked through Alouette at Achernar, I could imagine that envelope quietly growing and shrinking, just as the waters in the locks we passed through a few hours earlier rise and fall, lifting and lowering the ships that pass through. The canal helps define two continents. Achernar, even as seen through Alouette, helps define a Universe. ✶

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

Binary Universe

Tour the Solar System

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

Where's my flying car? I guess I shouldn't complain.

My first IBM PC had more power and memory than the *Apollo* Guidance Computer. In our pocket, we can carry a 256 GB USB drive with 64,000 JPG photos. I have a tiny, thin device that can tell me exactly where I am on the planet using data from orbiting satellites. For decades, in real-time, with a telephone, we spoke with friends and family in different parts of our huge country or on the other side of the planet; now, with our computers, tablets, and smartphones, we participate in video calls. I can look at live or near real-time images from space probes and telescopes. Dick Tracy's watch is pretty limited by today's standards. Our smartphones might blow the doors off Kirk's communicator. Humans have been working in low-Earth orbit for more than 16 years. We're building instruments capable of accurately detecting the content of atmospheres of exoplanets. I can fabricate a replacement plastic part for just a few dollars. I verbally ask questions of Google and it answers.

Still, I want my flying car! And space elevator. Better batteries, while we're at it. A cloud filter. And travel agencies offering last-minute seat sales to the Moon and Mars. Wouldn't that be amazing? Alas, not in my remaining years. In the meantime, I downloaded NASA's *Eyes on the Solar System* from the Eyes web page (http://eyes.nasa.gov/), and I enjoy its many virtual tours.

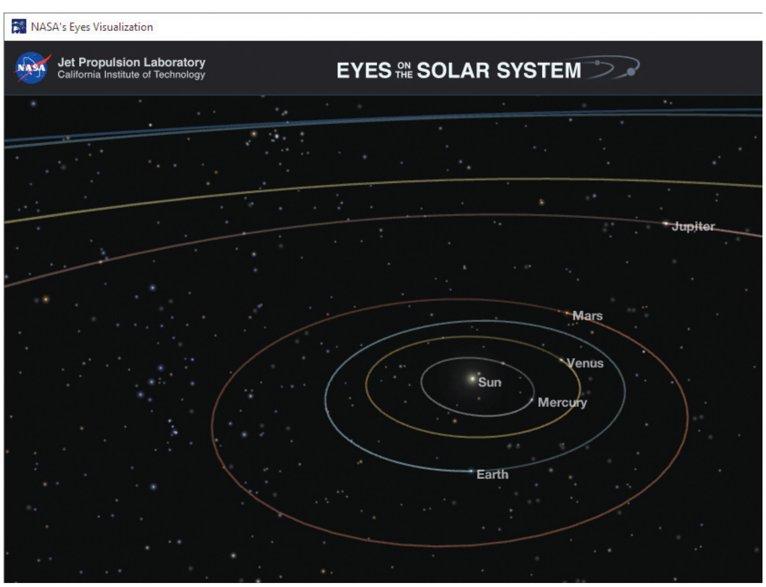

Figure 1 — Eyes on the Solar System running in Simple Mode with easy-to-use buttons

Eyes on the Solar System (EotSS) was released in 2010 about a year after *Eyes on the Earth*. The product originally ran within a browser and required a special gaming plug-in for rendering. Now it is a stand-alone product and works on Windows (7 or higher) and the Macintosh (OS 10.8 or higher). The most recent member to this family is *Eyes on Exoplanets*, which I recall Dr. Sara Seager showing (the beta version then) during her talk at the Ontario Science Centre on 2014 September 24. The focus of this article is on EotSS, but all the apps are similar in features, look and feel, and controls.

EotSS is dynamic computer visualization software made by the Jet Propulsion Laboratory (JPL). It depicts the major and minor planets, many of their moons, as well as a number of asteroids and comets. In addition, the app can show various spacecraft launched (or to be launched) by NASA. I find it fascinating that it displays the past, present, and future position and orientation of spacecraft and planets based on current real-time data from JPL.

The app can be operated in a simple or advanced configuration and you can easily go back and forth.

Simple mode offers an uncluttered interface (see Figure 1) with a handful of buttons and an initial view of the inner Solar System. I like the subtle colours applied to the orbital paths. A short audio-visual tour helps you get oriented and then encourages you to explore the software interface.

All aboard the space-tour bus! Please keep your arms inside the windows. If you don't touch anything, an automated script begins and you visit each major planet and some of its moons rendered with the latest imagery. Immediately, your breath may be taken away with the stunning graphics. There is a strong sense of three-dimensional space. We quickly drop in to NASA's *Voyager 1* deep-space probe, launched in September 1977. From *Voyager*, we turn back to the Solar System—it's far, far away. The last leg of our whirlwind tour is to get up close and personal with Mars, its tiny lumpy moons, and the orbiting spacecraft. Briefly, we touch down, and then it's back on the bus, because we're late for a very important date: the moons of Saturn await. Sadly back home, to our water world, blue toward the Sun, of course; aglow with city lights on the dark side.

The Destinations button allows a self-guided tour. You can visit and linger at many Solar System bodies including the Sun, hang out in the asteroid or Kuiper belts, and wander over to a few comets. A window provides general information with a Stats panel, if you want the numbers, and Extras, with hyperlinks out to the web. The Missions button focuses on NASA probes and landers.

As a child of the Space Race, I grew up watching rocket launches and staring at the grainy images of distant worlds. In EotSS, I checked out the first satellite launched

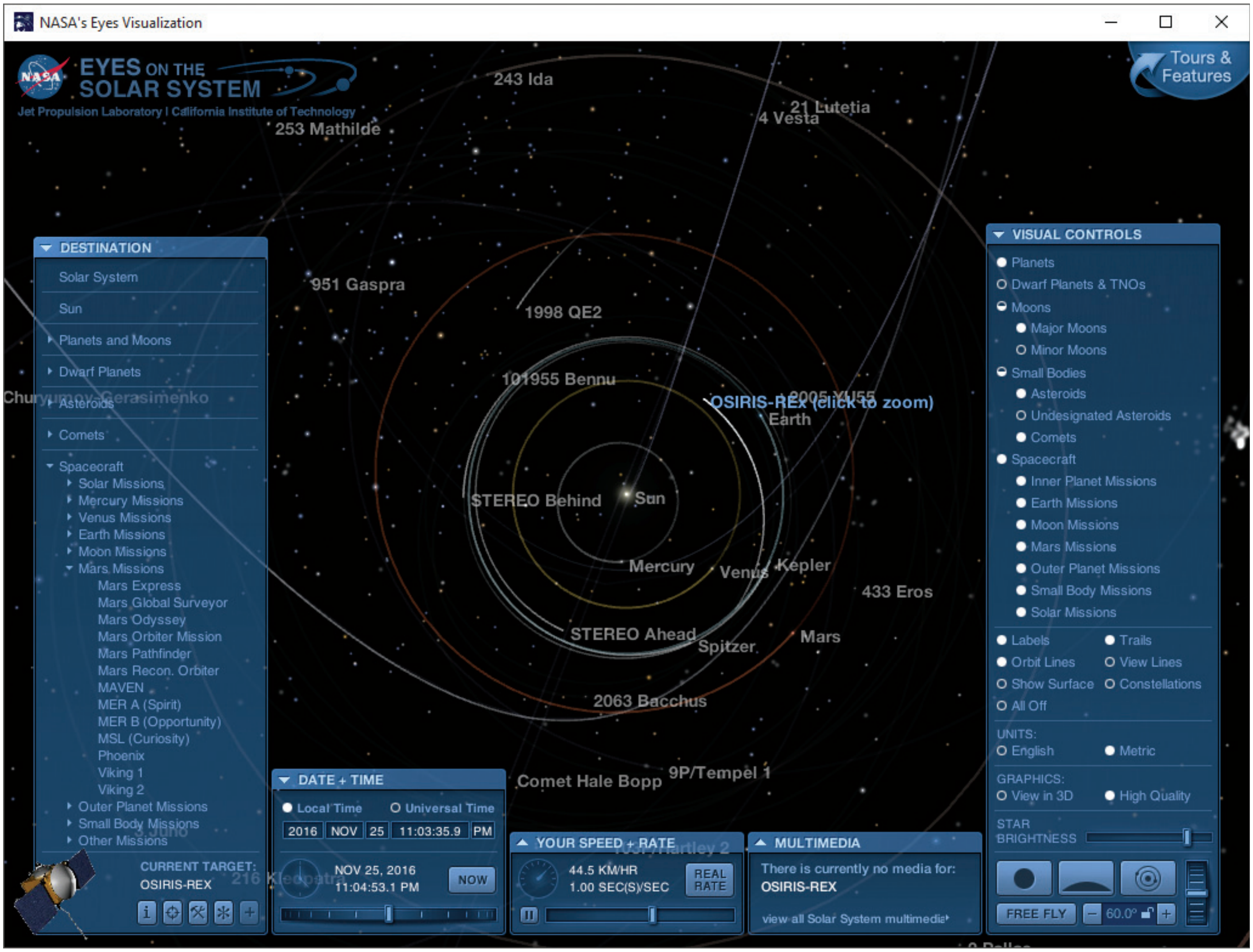

Figure 2 — Advanced mode offers many tabs and controls, plus scripted

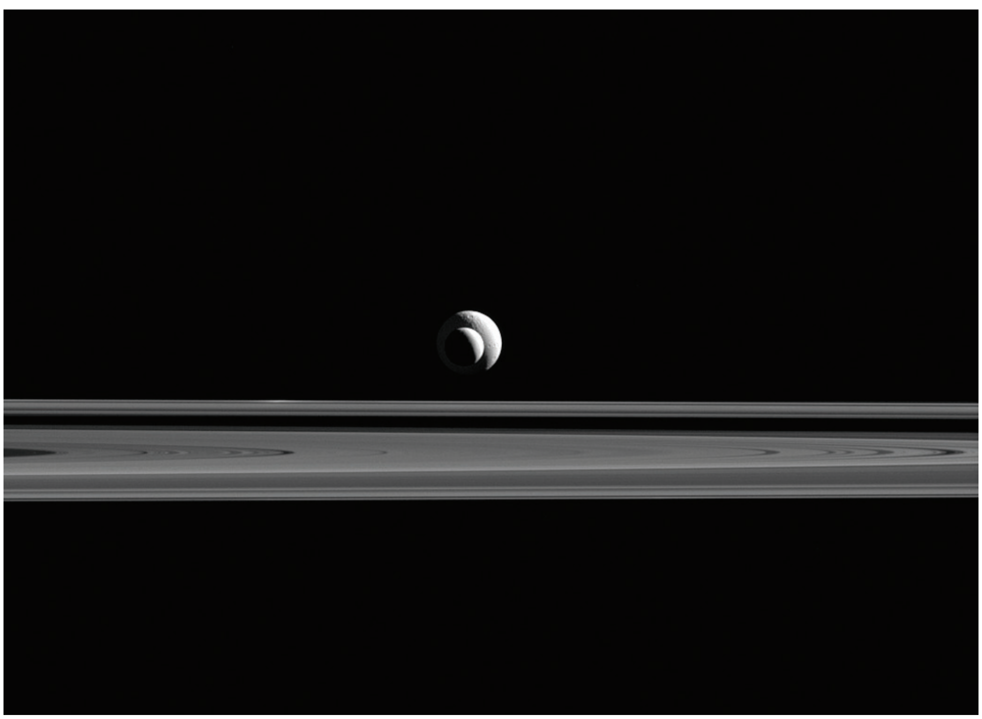

Figure 3 — A long-focal-length image from Cassini *space probe of Enceladus in front of Tethys.*

in 1958 by the United States, *Explorer 1*, deployed before my parents met. I had fun reviewing the first successful interplanetary mission in December 1962 as backup unit *Mariner 2* was directed to Venus. I remember cutting out the articles from my local newspaper in the 1970s during the *Pioneer* I and II missions. Then I shifted to December 2018 when *OSIRIS-Rex* will begin its rendez-vous operations with asteroid Bennu. That's going to be very exciting.

The News button lists fairly recent events. And finally, the fascinating People button helps us learn about the women and men behind the scenes. I recognized Steve Squyres from his book *Roving Mars* and John Grunsfeld from all the NASA TV I watched during the *Hubble* servicing missions.

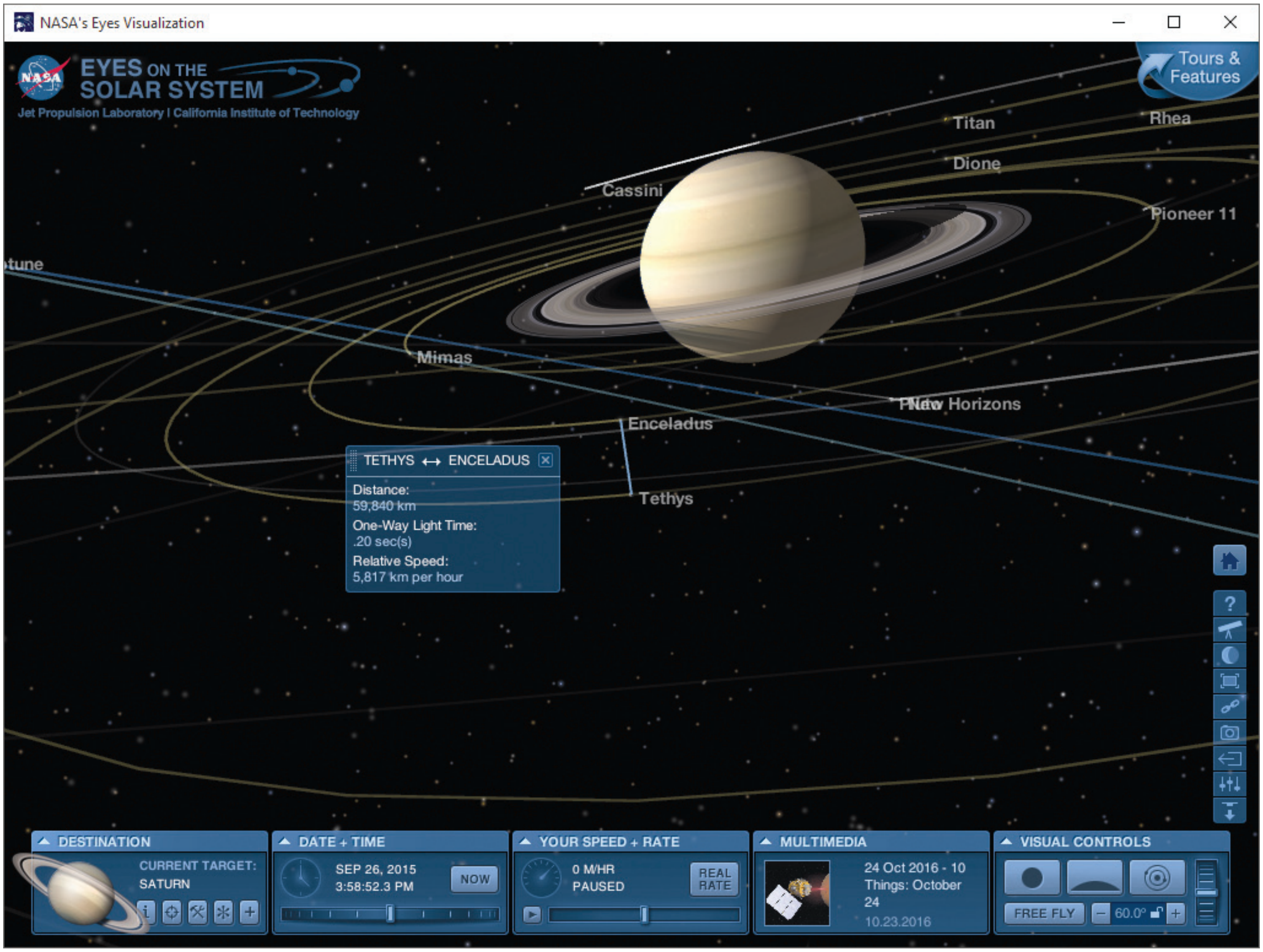

Figure 4 — Looking the other way. Tethys selfie with Cassini *two million kilometres away.*

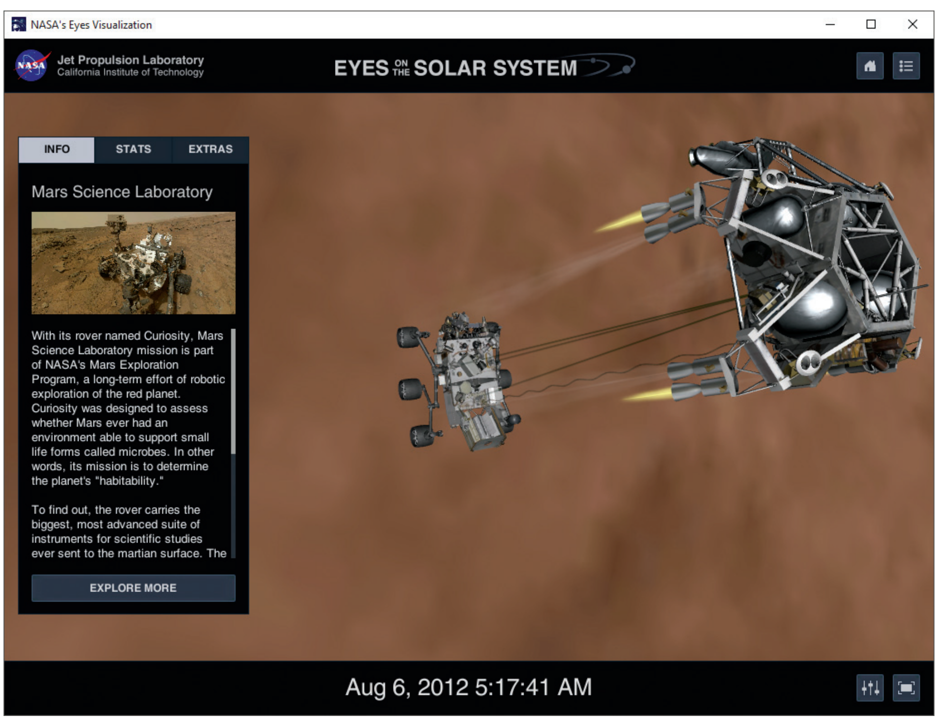

Figure 5 — You can relive the "seven minutes of terror."

At any point, you can interact in the application. Dragging the mouse button or using designated keys allows you to pan and move about the targeted object. It's easy to zoom in and out with the mouse roller wheel. You can click on an object, say a moon, to display the Info window. If you spot something in the background that you want to go to, double-click on it to zoom in and focus.

Advanced mode places you above the Sun and zooms to show Jupiter's orbit. An array of controls (Figure 2) appears at the bottom of the screen in an area called the Dock.

The Destination tab lets you select a Solar System object or spacecraft. It was here I happily discovered duck-shaped 67P/Churyumov-Gerasimenko was listed. There are more than two dozen asteroids to explore.

The Date + Time panel lets you shuttle backward and forward or go to a specific date and time. It also includes a handy Now button. You can change the time rate, positive or negative, and quickly set to the real-time rate. The Multimedia tab contains article links. Lastly, the Visual Controls lets you adjust and toggle many options, such as the constellations, orbit lines, and the measurement units. Here you can also change the lighting: EotSS can display the objects in natural, shadow, and flood lighting. Also, there is a button to let you float free. Don't forget to attach your tether.

The Destination tab also includes a button for the Cool Tools, which provides a distance-measurement option and a size comparator.

With direct control, I was able to journey over to Tethys and look back past Enceladus (Figure 4) as orbiting *Cassini* snapped a shot of a most impressive alignment (Figure 3) of the small moons near the Saturnian ring plane.

One other very interesting tab is at the top-right of the display, the Tours and Features. Here you can experience the upcoming 2017 solar eclipse, from above the Earth, while looking safely at the Sun. You can select one of the designated locations for the time-specific details and simulated view. The Juno probe tour shows the orbital insertion slingshot around Jupiter through the frightening radiation zones. You, too, can revel as Juno becomes the fastest-moving object made by humans. Ride on the New Horizon craft as it rips past Pluto. I really enjoyed the Instrument View graphics. Relive the "seven minutes of terror" as Curiosity plummets through the thin Martian atmosphere. Will the sky-crane correctly deploy (Figure 5) and carefully lower the rover to the hostile red world? These special tours are scripted and offer unique controls. They are a lot of fun and bear repeat viewing with all the various options and speed controls.

This is all pretty amazing stuff, right? Well, you ain't seen nothin' yet. Dive into the Visual Controls panel and switch on the View in 3D option. Then grab your stereographic anaglyph (red/green) glasses and prepare to be astounded. Wow. Wow! I thought it looked very good before before, but not surprisingly, the 3-D mode takes it up a notch. In full-screen mode with HD graphics, you get a strong sense that you are piloting your own spacecraft.

It is very easy to get up and running in EotSS, particularly in Simple mode, I think (but then I have a lot of experience with 3-D gaming immersive environments). Advanced mode is a little intimidating with all the features. Thankfully, there is on-board help. Also, astronomer Amy Mainzer delivers a very helpful video on YouTube (www.youtube.com/watch?v=GLN-T3-nsiU) to let you get settled. Back at the website, there is a Frequently Asked Questions page for troubleshooting tips.

Starting the application is a somewhat lengthy process, particularly on an older computer, due to both updates and graphical-rendering requirements. It is checked and updated every time you start. This may feel a bit like the current crop of software, updates all the time, when you least expect it, often when you're in a hurry, but this, again, is so we may see planets and spacecraft accurately positioned. This also means you must have active internet connection. Needless to say, the program is graphically intensive. It wants a lot of memory. I would recommend you close all other apps so EotSS will run smoothly at a high frame rate.

I experienced occasional glitches on my home computer and sometimes would need to back up a step or reset. On one of the relatively new Windows 10 entry-level laptop owned by my Centre's Outreach Committee, I saw the application freeze, but a software restart got it working fine. A friend installed it on his Alienware i7 with 16 GB RAM and 8 GB video memory running Windows 64-bit and he reported it operated "very quickly, seamlessly, with no lag, and looked sharp." I thank Ian Wheelband and Phil Chow for testing on newer computers.

Some people use the open-source *Celestia* software for similar virtual 3-D experiences, but I understand it lacks the detailed information and late-breaking data of NASA spacecraft.

The free NASA's Eyes products, in general, only work on desktops and laptops at this time. They say they are working on versions for mobile devices and tablets.

There is much to explore in *Eyes on the Solar System*. That's good news with the grey months ahead of us. So, dim the lights. Go full screen. Hide the Dock. Better still, toggle on Photo mode, which hides all the chrome. And have a nice trip!

Update Bits

SkySafari version 5 for Android is available from the Play Store. The basic version is free; Plus is USD $15; and Pro is USD $40. Visit http://skysafariastronomy.com/ for more info. ✶

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, co-manages the Carr Astronomical Observatory, and is a councillor for the Toronto Centre. In daylight, Blake works in the IT industry.

Dish on the Cosmos

Are We Alone?

by Erik Rosolowsky, University of Alberta
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One of my favourite aphorisms is from the science fiction author Arthur C. Clarke on the possibility of extraterrestrial intelligence: "Two possibilities exist: either we are alone in the Universe or we are not. Both are equally terrifying." In the past 20 years, astronomy has been transformed by the discovery of planets around other star systems (exoplanets). Reasoning from our own existence, we think that planets are the logical place to find other life. In finding that planets are common throughout our galaxy, one of the major reasons to think that life is rare in our Universe has been removed.

Given the abundance of planets, another question seems to be developing, posed this time by Enrico Fermi who asked simply "where is everybody?" Fermi was known for using quick physical reasoning to estimate quantities. It became apparent to him that if beings like us were common in the Universe, we should see evidence for other civilizations visiting Earth. The lack of clear evidence that this has ever occurred raises the so-called Fermi Paradox, asking if intelligent life is common, why haven't we seen a sign of it?

There is a suite of resolutions to the Fermi Paradox ranging from the trivial (we really are alone), to the idea of physical censorship (the Universe is a physically hostile place with supernovae and gamma-ray bursts), or even active censorship (there are aliens but they destroy any civilization that could compete and the ships are on their way). Other ideas speculate on the nature of aliens, arguing that technological civilizations are self-limiting and we'll use up our planet soon, or that intelligence is rare even if life is common. Another idea is that we simply do not understand enough about physics to look for the real signatures of advanced civilizations. After all, most of the Universe is dark matter and dark energy, and the applications of this poorly understood physics may be where all the signs of civilization exist. While these are all engaging ideas to turn over in our heads, there simply is no scientific resolution to this idea without more data. By definition, aliens are not like us, so we cannot pick the best ways to carry out our search. If we want to resolve Fermi's Paradox, we have to sift all our views of the Universe and look for things we cannot explain without a physical explanation. However, we are on the verge of reaching scientific answers to these questions.

In reasoning from our own view of ourselves, we consider how could other civilizations detect us across the gulf of interstellar space. We have long considered our transmission of radio signals to be one of the signatures of our technology. Radio telescopes are fantastically sensitive. A mobile phone transmitting from the Moon would be the brightest source in the radio sky at the radio-wave frequencies of its transmissions. With current telescopes, we could detect these "leakage" signals from nearby stellar systems. Detecting an extraterrestrial radio signal requires several factors to line up: we must be looking in the right direction at the right time at the right signal frequency. Then, we have to recognize the signal for what it is among the noise of the radio Universe. Some of our most powerful transmitters are terrestrial radio stations, where the number of the (FM) radio station, for example, 94.9, indicates to the frequency of the (carrier) wave in megahertz (MHz). At these frequencies, the Universe is radio-loud with strong emission from electrons travelling near the speed of light and bending in the galactic magnetic field. This "synchrotron" radiation pervades the galaxy and is sufficiently strong that it would quickly drown out our own civilization's radio broadcasts. The older AM band is at even lower frequencies and transmissions do not travel through the Earth's ionosphere.

At higher frequencies, our radio transmissions can stand out from the galactic background. The range from 1000 MHz (= 1 GHz) to 10,000 MHz is a relatively quiet zone in terms of physical phenomena, but this bandwidth is filled by our own radio transmissions. The wealth of wireless communication led by the boom of WiFi transceivers and mobile phones fills this frequency band with billions of individual small transmitters. Indeed, radio observatories must spend a great deal of effort to filter out our own terrestrial transmissions that completely drown out the astronomical signals. If we think about detecting our civilization, the leakage from our communications is a clear signal that intelligent life is on our planet.

By analogy, searching for these signals from other civilizations is a sensible route forward. Our telescopes are incredibly sensitive and radio waves are an efficient and rapid way of communicating across interstellar distances. The basic search must scan a huge combination of time, space, and frequencies. Previous searches for extraterrestrial radio signals have only scanned a thin slice of all the possible combinations. Our lack of evidence does not place an interesting limit about the frequency of intelligent life except to say that it isn't plentiful and obvious. The problem is further complicated by physics: the galaxy is filled with warm plasma that smears out clear radio signals, like from technological broadcasters. This smearing is well understood and can be corrected for, but the farther a signal moves through space, the more this "dispersion" smears it out. Checking all the possible dispersions in a certain direction, time, and frequency adds yet another dimension to the search. Targeting specific stellar systems along the search direction will keep the problem manageable. Another complication is the nature of our communications is changing. Digital communications do not appear as steady, well-defined signals, but they jump around in time and broadcast frequency to make the most of the limited range of the electromagnetic spectrum. All this speaks to the difficulty in searching for similar signals: why should such signals be simple and steady?

Finding an elusive signal from another civilization seems almost impossible when the vastness of the galaxy combines with the reality of dispersion and that these signals may be quite difficult to identify as meaningful. These challenges can be met through a combination of next-generation radio telescopes combined with our exponentially growing computing power. Some of the facilities that I've discussed in this space (the Square Kilometre Array in Figure 1 or the Canadian HI Mapping Experiment) have minimal moving parts and are able to tune into a region of the sky purely through their computing power. This allows them to look in hundreds of directions at once. These telescopes are solving many of the problems required to find extraterrestrial broadcasts because problems like dispersion and surveying large parts of the sky are needed for astronomical observations.

Previous efforts to find extraterrestrial radio broadcasts have only studied one millionth of the galaxy to a depth where a civilization like our own would be detectable. A dedicated search with the Square Kilometre Array could expand that search to cover almost one-quarter of the entire galactic disk. Given the number of planets in that volume—likely hundreds of millions—these studies become interesting with either result. If such an effort saw nothing, we would have a good case to rule out this line of communications. If, however, we did identify transmissions, it would be one of the biggest discoveries yet in our understanding of our place in the cosmos. We are approaching a point where we can actually explore both sides of Arthur C. Clarke's two cases as they pertain to radio transmissions.

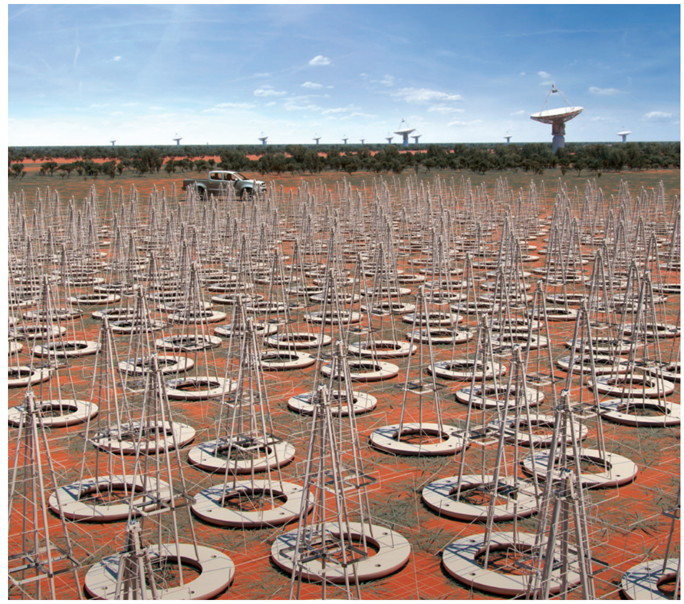

Figure 1 — Part of the Low Frequency Array component of the proposed Square Kilometre Array telescope. This part of the array would be sited primarily in the western part of Australia. The field of antennas is connected to a massive supercomputer, which produces images of the radio sky. New facilities would be well suited to conduct a thorough search of the radio sky for extraterrestrial signals. Image Credit: SKA Organization.

Searching for other life in the galaxy is becoming less a question of idle speculation and more a question of science. The abundance of planets and the rich chemistry of space all point to having the right setting for life as we know it to emerge repeatedly over time. However, there is a myriad of possible reasons that there could be intelligent life still not detected or detectable through a search of radio frequencies. Perhaps a galaxy teeming with the chatter of civilizations is lurking in hidden physics we do not yet understand. Or perhaps a species like us really is rarer than our science currently leads us to believe. Searching for other civilizations is high-risk science, since there are many reasons why it might not work. However, I personally believe it important that we at least ask this question of the Universe because the answer may surprise us. ✶

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

Meteorite Archive

The Records of the NRC's Associate Committee on Meteorites (ACOM), and the CSA's Meteorites and Impacts Advisory Committee (MIAC)

by R.A. Rosenfeld, RASC Archivist
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Abstract

With the creation of ACOM, meteoriticists in Canada had a formal body to coordinate their efforts at meteorite recovery, sample characterization, collection management, fireball reporting and recording, public outreach, and advocacy directed toward the government. It also provided a generally collegial forum for the presentation and discussion of recent work. MIAC fulfilled a similar role in succession to ACOM. This paper briefly describes the documentary record of ACOM & MIAC activity, the creation of the ACOM & MIAC Archive, and suggests several research avenues that can be pursued through the Archive. An extensive finding aid for the Archive is also presented.

Stars Fall Over Canada

Objects dramatically descending from the sky can have interesting impacts on the societies below. The Ensisheim (LL6) fall of 1492 November 7 (old style) was greeted as a wonder inviting pillage and interpretation, and became a civic ornament, an ecclesiastical relic, and an auspicious symbol of the bestowal of divine favour on the King of the Romans, Maximilian I, according to the learned doctors who spun words for remuneration (Marvin 1992; 2006, 16-22). Ensisheim proved a lucky stone in one regard; it is now the earliest witnessed fall in Europe for which a substantial portion of the meteorite is still extant (Marvin 1992, 27; 2006, 15). As an object of continued scientific enquiry (Szurgot 2016), and singular social liturgies (Soergel 2012, 185), it continues to play a role in modern meteoritics writ large.

Nearly half a millennium after Ensisheim, in the early morning of 1960 March 4, a bright fireball was witnessed over southern Alberta, resulting in a shower of meteorites near Bruderheim (L6), north of Edmonton (Millman 1960; Whyte 2009, 57-91). Fireballs had lost nothing of their impressiveness during the ensuing centuries, but their impact among the learned had changed. They were no longer primarily seen as a sign of divine favour, or alternatively, the start of a very bad day, but rather as a research opportunity. One societal result arising directly from the impact of Bruderheim was the creation of the Associate Committee on Meteorites (ACOM) of the National Research Council of Canada (NRC). This was indeed auspicious, for in the words of its prime mover, Peter M. Millman:

> *The fall of…Bruderheim made clear the need for a national organization to direct and co-ordinate the recovery efforts when new meteorites land in Canada. The Associate Committee on Meteorites was established at the National Research Council, Ottawa, late in 1960 under the able chairmanship of S.C. Robinson of the Geological Survey of Canada. This committee, with representatives in all the major areas of the Dominion, has developed a uniform system of reporting bright fireballs, and has circulated a number of travelling displays to instruct the general public concerning the appearance of genuine meteorites… (Millman & McKinley 1968, 292).*

The membership of ACOM included all the major figures in Canadian meteoritics, many of whom were RASC members, nor was it unusual for several highly competent and respected amateurs to be elected to the ranks of the committee. The regular annual meeting that took place in the fall provided an excellent opportunity for the members to take stock of the year's discoveries, projects, and research, to discuss topics of mutual interest, seek advice, to share knowledge of developments elsewhere, including new techniques and bibliography, and to decide strategy when dealing with funding agencies. ACOM lasted till 1990-1991, when NRC funding was severely compromised by the government of the day, forcing the defunding of all the NRC's associate committees.

In what may have been the last scientific act of his career, shortly before he died, Peter Millman contacted Larkin Kerwin, a physicist and former President of the NRC, and then the inaugural President of the Canadian Space Agency (CSA), and suggested the utility for the country of having ACOM transferred under the aegis of the CSA. Kerwin agreed, and from 1991 to about 2006-2007, ACOM became the Meteorites and Impacts Advisory Committee (MIAC) of the Canadian Space Agency. Towards the end of that period MIAC, along with the other CSA advisory committees, became unfunded. The meteoritical community met the challenge of the CSA's new funding models by regrouping as the Astromaterials Discipline Working Group (ADWG) (cms.eas.ualberta.ca/adwg/), and latterly as the Astromaterials Training and Research Opportunities (ASTRO) Cluster (www.astromaterials.ca). MIAC, although unfunded, still fulfills two of its original roles; one as a medium for EPO, and the other as a fireball reporting centre for potential meteorite-dropping events over Canada (www.uqac.ca/miac/). The normal operation of any scientific body generates a documentary record, and ACOM and MIAC were no exception. The act of producing documents, however, does not in itself insure either the documents' survival, or their rational arrangement. That the ACOM-MIAC Archive exists at all is due to the foresight and hard work of three researchers.

Creation of the Archive

The person primarily responsible for gathering and preserving the documents that now form the bulk of the ACOM-MIAC Archive is Stephen Kissin, now an emeritus professor of geology at Lakehead University. Professor Kissin, a still active expert on the characterization of iron meteorites, pallasites, and terrestrial impact structures, was a long-time member of both ACOM and MIAC, and served in various executive positions on both committees. The archive also contains contributions of documents via Professor Peter Brown of Western's Meteor Physics Group from Dr. Ian Halliday (a former RASC National President well-known for his work on the flux rates of meteorites, and spearheading the Meteorite Observation and Recovery Project, MORP), and from two historians of meteoritics, Professor Howard Plotkin of Western, and the late Professor Richard Jarrell, formerly of York University.

Professor Plotkin went through the boxes of loose papers he had received from Professor Kissin, and ordered and arranged the Archive. He grouped associated documents, devised coherent file classes, determined the order of documents within the files, and then devised a logical and workable succession for the files.

The third person involved in the work is Professor Phil McCausland, also at Western, a meteoriticist with an interest in the history of his discipline, who has participated in and organized several Canadian meteorite-fall recovery expeditions. Phil and Howard were responsible for contacting the RASC to see if the ACOM-MIAC Archive could be accommodated in the RASC Archives, and both were responsible for the transport of the archive to the RASC.

Calendar of the ACOM-MIAC Archive

The RASC Archivist has written a fairly detailed calendar of the ACOM-MIAC Archive[1], which describes the contents, physical nature, and state of preservation of each document in the files. The documents are cross referenced, where possible. The intent of this work is to provide a resource for exploring the archive, enabling a considerable amount of preliminary work to be done before the researcher consults the actual documents in situ. The *ACOM-MIAC Calendar of Documents* is publicly accessible at: www.rasc.ca/sites/default/files/ACOM-MIAC_Calendar_of_Documents_3.pdf. To arrange a consultation of any of the ACOM-MIAC documents at the RASC Archives, or for any other inquiry regarding the ACOM-MIAC Archive, please contact the RASC Archivist at the address given above.

A Resource for the History of Meteoritics in Canada

The ACOM-MIAC Archive is a rich resource for exploring many facets of meteoritics in Canada during its efflorescence over the last 50 years. Among the topics that could be explored are:

- the workings and achievements of ACOM and MIAC, and the changing interactions of the meteoritical community with government patrons over time;
- the impact on Canadian meteoriticists of world-wide changes both within the discipline—new techniques for characterization, new platforms for publication, and communication—and without, such as changing market and collecting pressures;
- the Canadian Fireball Reporting Centre;
- meteorite recovery campaigns (for an example see the paper by Plotkin in the April issue of the *Journal* on the St-Robert [H5] meteorite recovery campaign. Additional

topics could be the recovery of the Tagish Lake [C2-ung] meteorite; MORP; and the Prairie Meteorite Search program);

- pro-am cooperation in meteoritics (the work of RASC members and amateur astronomers Dr. Roy Bishop, Denis Pagé, and Damien Lemay as part of MIAC was outstanding);
- the Canadian Arctic Meteorite Search (few people know about this effort, spurred by the success of the Antarctic searches. The Canadian Arctic program was ultimately unsuccessful because of the absence of the geological and meteorological conditions in the Antarctic which enable the transport processes which concentrate the meteorites; on the Antarctic program see Righter et al. 2015);
- education and public outreach (this would include the public lectures presented during the annual MIAC meetings, the education materials in various media, and the meteorite/meteorwrong identification clinics).

Perusal of the *ACOM-MIAC Calendar of Documents* will suggest other possible avenues of inquiry. Many of the stories of Canadian meteoritics have yet to be written. Some of them in their own way are as remarkable as those that occurred in the wake of the fabled fall of Ensisheim half a millennium and an ocean away. ✶

Acknowledgements

The author wishes to thank Howard Plotkin and Phil McCausland for improvements to this article. Any remaining errors are the author's sole responsibility.

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Endnotes

1 The archive is approximately 2.5 linear feet in extent.

John Percy's Universe

Happy Birthday, Canada!

by John R. Percy, FRASC
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As you read this, Canada will be starting its sesquicentennial celebrations. It's a good time for Canadians to reflect on their accomplishments, and their blessings. Here, I reflect *briefly* on our *astronomical* accomplishments, which have helped to build our country. I hope this will encourage you to reflect, also. For a comprehensive and scholarly account, and the details, see Jarrell (1988) and, in the case of the RASC, Broughton (1994). For a brief and purely Torontocentric perspective, see Percy (2014).

Astronomy has been part of our country for millennia. Our indigenous peoples used the sky as a clock, calendar, and compass. The first European explorers (probably including the Vikings) used the Sun and stars for navigation, and settlers used them for surveying. Across the country, small observatories were set up for practical astronomy, for teaching, and probably for pleasure (e.g. Bishop 2012).

People and Places

Astronomy literally helped to build our country, through its applications to timekeeping and surveying. That is exemplified by the work of Sir Sandford Fleming (1827–1915) who, among many other things, successfully promoted the concept of Standard Time. At the turn of the 20th century, the "co-fathers of Canadian astronomy"—both born at the dawn of Confederation— raised Canadian astronomy to a new level. John S. Plaskett (1865–1941) convinced the Canadian government to support observational astrophysics, and to construct the Dominion Astrophysical Observatory (DAO) in Victoria, with a 1.83-metre telescope. Clarence Augustus Chant (1865–1956) established a Department of Astronomy at the University of Toronto. Its graduate program trained a significant fraction of Canada's 20th-century astronomers. His outreach work led to the construction of the David Dunlap Observatory (DDO), with a 1.88-metre telescope. When it opened in 1935, Canada had two of the three largest telescopes in the world!

These telescopes were eventually supplanted, for front-line research, by partnership in the Canada-France-Hawaii telescope (1979), and the Gemini North (1999) and South (2000) telescopes. [The sale of the DDO lands has made possible a new Dunlap Institute at the University of Toronto. The DAO is still active in some aspects of research and outreach.] Canadian expertise in radio science led to a highly regarded program of long-term solar radio-flux monitoring, which, in turn, led to the building of the Dominion Radio Astrophysical Observatory in Penticton, B.C., and the Algonquin Radio Observatory in Ontario. These two observatories were "virtually" linked in 1967 to carry out the first successful experiment in Very Long-Baseline Interferometry (VLBI). Canada subsequently became a partner in the submillimetre James Clerk Maxwell Telescope (JCMT), and now the Atacama Large Millimetre Array (ALMA) and the future Square Kilometre Array (SKA). And we should not forget the Canadian Institute for Theoretical Astrophysics, a jewel in Canada's scientific crown that effectively complements our observational facilities.

With *Alouette* (1962), Canada was one of the very first countries with a satellite in space. Space activity, including the Canadian astronaut program, has continued vigorously since then. Space science and technology benefit our country in many ways. Space *astronomy* in Canada has a long and complex history, dating back to the 1980s, involving extensive discussion and planning, participation in landmark missions such as the *International Ultraviolet Explorer* (IUE), *Far-Ultraviolet Spectroscopic Explorer* (FUSE) and, more recently India's *AstroSat,* as well as the launch of two successful Canadian-built missions—MOST in 2003, and the BRITE constellation in 2013. With our partnership in the future *James Webb Space Telescope*, we look forward to being at the forefront. Canada's astronomical activities on the ground and in space have led to important spinoffs, in computing, communication, and other branches of engineering. These spinoffs, along with the intrinsic value of astronomy, strengthen astronomers' arguments for continued support.

With these facilities, Canadian astronomers made significant contributions, first to stellar astronomy, and then to galactic astronomy and observational cosmology. Our contributions to planetary astronomy have been more modest, but Canada has contributed to several recent planetary missions, most recently OSIRIS-REx. Thanks to the pioneering work of Carlyle S. Beals (1899–1979), we have become internationally known for studies of impact craters—of which we have 31. Peter M. Millman (1906–1990) established a strong reputation in meteor astronomy.

Just as Chant and Plaskett built astronomy in the first century of our history, others have built it since. There are Nobel laureates Gerhard Herzberg (1971) and Arthur McDonald (2015), and winners of the prestigious Gruber Cosmology Prize: Richard Bond (2008), Sidney van den Bergh (2014), and expatriate Wendy Freedman (2009). Other notable professional astronomers are recognized on the CASCA awards page[1]. See also the RASC's *Encyclopaedia Uranica*[2], which includes some mid-20th-century astronomers overlooked by CASCA's and RASC's award system.

Amateur Astronomy

In earliest times, when educations were less specialized, there were undoubtedly a few educated Canadians who dabbled in astronomy. In the 19th century, they may have gathered in organizations such as Mechanics' Institutes, the Royal Canadian Institute (1849), and the Toronto Astronomical Club (1868) to discuss astronomy. Ironically, one of Canada's most noteworthy amateur astronomers, J. Miller Barr (1856–1911) never attended such gatherings (Percy 2015). Since then, Canadians such as Paul Boltwood, Damien Lemay, David Levy, and Jack Newton have appeared on international lists of notable amateurs, and many more are included on the RASC's *Encyclopaedia Uranica*[2]. The RASC created the Chant Medal and the Ken Chilton Prize to honour outstanding research contributions by amateurs, and other awards to recognize service, writing, and outreach, both at the national and Centre level. In my own field of variable-star astronomy, several Canadian amateurs have made significant observational and/or administrative contributions.

Getting Organized

It's interesting that the RASC traces its history to one year after Confederation, and I'm sure that we will hear much more about its history and accomplishments next year, when it celebrates its own sesquicentennial. For a century, its voice was the voice of Canadian astronomy. It remains, in my experience, exemplary in its balance between local and national activities. Then in 1971, Canada's professional astronomers established CASCA (Canadian Astronomical Society/Société Canadienne d'Astronomie) to provide a stronger voice for planning and government liaison. The professional and amateur communities drifted apart, but there was still collaboration at the local level. The International Year of Astronomy 2009 (IYA) partnership, under the inspired leadership of Jim Hesser (2010), illustrated the possibility and value of collaboration in mutual areas of interest—in this case, between CASCA, RASC, and FAAQ (Fédération des Astronomes Amateurs du Québec).

Education

Astronomy has had a rather tenuous place in the school system in Canada but now, in most parts of the country, it is in the curriculum in both elementary and secondary school. Unfortunately, few teachers have any background in astronomy, or astronomy teaching. Canadian astronomers, both professional and amateur, are now devoting effort to supporting school

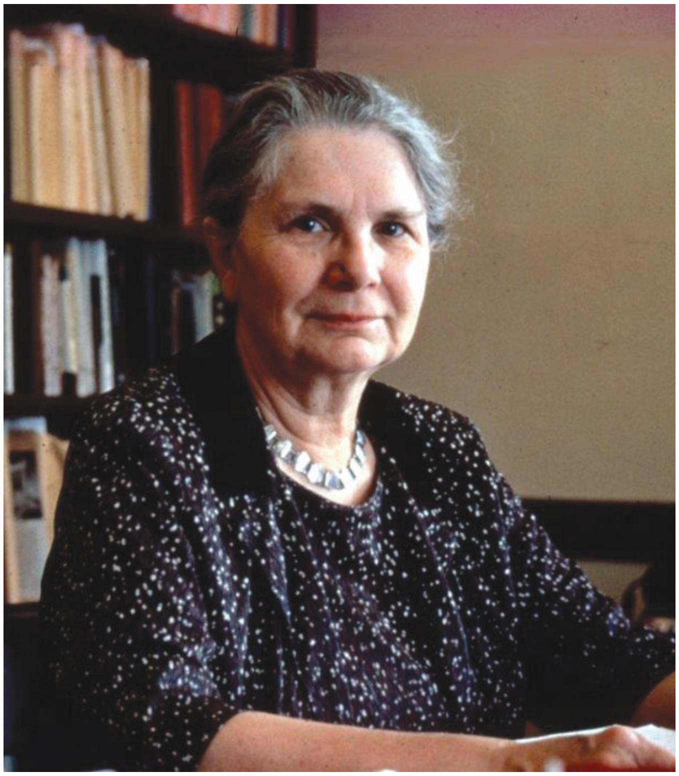

Figure 1 — I struggled to decide on a single image to represent astronomy in Canada, 1867–2017, and eventually decided on Helen Sawyer Hogg, Canada's best-known and most beloved astronomer. She excelled in research, education, outreach, and leadership. She served CASCA as Founding President, and the RASC and other organizations as president also. She was a pioneering woman scientist, and a mentor and friend. Though not Canadian by birth, she received Canada's highest honour—Companion of the Order of Canada. Photograph: University of Toronto.

education through programs such as the national bilingual *Discover the Universe*. This program, which built on the success of IYA in Canada, was developed and is delivered by Julie Bolduc-Duval. At the university level, astronomy is taught across the country. Introductory astronomy for non-science students is the "bread and butter" course. Hundreds of thousands of these "astro 101" students have gone out into a variety of non-science careers, armed (we hope) with a positive image of astronomy, and astronomers. Several universities offer major programs in astronomy, and most of these also offer graduate programs. At the other end of the age spectrum: the growing demographic of later-life learners are attending astronomy courses and lectures by the thousands.

Communication and Outreach

Astronomy is an exciting frontier science that is also deeply rooted in our many cultures. It is therefore an excellent vehicle to develop public awareness, understanding, and appreciation of *science,* not only astronomy. This is yet another way that astronomers contribute to our country. Canadian astronomers, both professional and amateur, have always been at the forefront of public outreach. Outstanding communicators such as Clarence Augustus Chant, Alan Dyer, Helen Sawyer Hogg, and Terence Dickinson have been inspirations for a new generation, including Pierre Chastenay, Dan Falk, and Ray Jayawardhana. The RASC was a recipient of the national *Michael Smith Award* in 2003, for excellence in science outreach. Several astronomers have received the Royal Canadian Institute's prestigious Sandford Fleming Medal, for excellence in science communication, most recently Ivan Semeniuk in 2016.

In the Future

There is still much to be done. Among the public, astronomical misconceptions, and pseudoscientific beliefs are rampant—astrology, space aliens, young-earth creationism. Astronomy is in the school curriculum, but many teachers are unable or unwilling to teach it; we must help. Our outreach does not always reach the underserved, or visible and invisible minorities. Women and some minorities— including Aboriginal people—are still under-represented among professional and amateur astronomers. Yet interest in astronomy is high, among people of all ages, and of all cultures. Our job is set out for us.

Canadian astronomy is alive and very well. We have much to be proud of. The enthusiasm and talent of my young colleagues, for teaching and outreach as well as research is inspiring to me in my "retirement." I'm proud to be a Canadian astronomer, as well as a Canadian. ✶

Acknowledgement

I thank Jim Hesser for comments on a draft of this article.

John Percy FRASC is Professor Emeritus, Astronomy & Astrophysics and Science Education, University of Toronto, and Honorary President of the RASC.

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1 casca.ca/?page_id=97

2 www.rasc.ca/encyclopedia-uranica

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2016 Awards

Simon Newcomb Award jointly to Martin Hellmich and Halley Davies

Qilak Award to Doug Cunningham

Service Awards to Andy Blanchard, Chris Teron, Gary Bennett, Hugh Pett, and Paul Gray

Fellowship Awards (FRASC) to Alan Batten, Doug Hube, Franklin Loehde, Pat Kelly, and Jay Anderson

President's Award to Terry Dickinson

Simon Newcomb Award, jointly to Martin Hellmich and Halley Davies

For their European Space Agency's award-winning video *"Ode to Hubble – Hubble's Universe,"* that they co-wrote and co-produced.

A video is not, strictly speaking, a piece of writing, but it cannot happen without a lot of writing in the background.

In Martin and Halley's case, the final product is of exceptionally high quality. Its story-telling is remarkable in its simplicity, elegance, and eloquence. It is utterly charming while maintaining scientific accuracy. It is broadly appealing because it is humorous and respectful of astronomical history at the same time. The video tells its story effectively, and is highly engaging for viewers of all ages and knowledge levels.

"*Ode to Hubble – Hubble's Universe*," has already won a significant international award. The originality, literary merit, scientific accuracy, and the educational value of the work ensure its eligibility for the Simon Newcomb Award. It promotes the Society's objectives by bringing its story to audiences around the world.

"Ode to Hubble – Hubble's Universe," is a global astronomy outreach success story, and an inspired piece of astronomy writing deserving of the Simon Newcomb Award.

Qilak Award to Doug Cunningham

As an educator at Bruce Peninsula District Secondary School, Doug's enthusiasm for the sciences, particularly astronomy, was infectious, and many of his pupils won local and national science fair awards.

Doug embraced protection of our dark skies, and the importance of maintaining their natural integrity, and he has been invited to speak on the subject at many public events across Grey and Bruce Counties and other jurisdictions. His "dark skies" advocacy really caught public attention, and the Bruce Peninsula is now one of this country's most valued dark-sky locations.

After Doug retired, he was able to devote more energy to spreading the word about astronomy and dark skies, and got not only local politicians on board, but also provincial and federal representatives. Working with the Bruce Peninsula Biosphere Association, a public outreach program was put in place, a special observation platform was built at Lion's Head, and a university student was hired each summer to manage the weekly program of talks and observing. In the three years the program has been in place, several thousand people have now been treated to dark-sky observation, and awareness of the importance of the preservation of these dark skies.

Doug's importance as a champion of astronomy and dark-sky preservation programs is inestimable. His enthusiasm and unceasing work have ensured that entire communities are now on board and actively taking part in dark-sky preservation.

Service Award to Andy Blanchard

Andy Blanchard has been an RASC Hamilton Centre member for over 15 years and has made many significant contributions at the local level, to neighbouring Centres, and to the public. He has over 12 years of service at the Hamilton Centre, having numerous executive roles, and he also is the driving force and a founder of the AstroCATS. He has served as a guest speaker at other Centres.

Andy began learning and volunteering almost immediately. In 2006, he took on the position of Treasurer, where he reviewed and reduced many operating costs, renegotiated terms of service and fees with the Centre's bank, and then began his focus on revenue. Andy led the effort to replace the underused Observatory dome with a better roof, some storage, and a classroom space.

A major cultural change happened during Andy's years on the board, with a strong focus on fun. People became more engaged, and enjoyed Centre events. Andy also initiated programs for youth outreach with Scouts Canada.

Andy's two years as President included many innovations and new ideas, but his most remarkable may have been in 2013, with the two major events being AstroCATS and his collaboration with seven other Centres to set up the David Levy Speaking Tour.

AstroCATS originated as Andy's vision of how to generate revenue for Hamilton Centre with an annual fundraising and astronomy event open to the public. In the late 2000's past presidents Roger Hill, Colin Haig, and board members were searching for fundraising ideas to pay the high costs of insuring and operating the Centre Observatory. Colin envisioned an event like a swap-meet with conference talks, but Andy's vision was for a high-calibre event, combining the best ideas from the North East Astronomy Forum, club talks, and a trade show. He put together a team of Hamilton Centre members and volunteers from the surrounding area to create the first AstroCATS event in 2013. This annual event is being held again here at the General Assembly.

Service Award to Chris Teron

Chris has been the Ottawa Centre Secretary for more than 15 years and his wealth of knowledge and professionalism in his position has never let us down.

Chris had a huge involvement in construction of SmartScope (our millennium project) in 2000 and even up to now. He is always seen helping at star parties and Astronomy Day but his main asset is working with the meeting chair to arrange slides and videos shown at our monthly meeting. He then runs the AV equipment during the night of the Centre meetings at the Canadian Aviation and Space Museum, and previously at the Canada Science and Technology Museum.

Any organization runs smoothly with the help of its volunteers. Chris has been a valuable part of our Centre and we would be honoured to present him with the Service Award.

Service Award to Gary Bennett

Gary's nomination is based on his sustained contribution to the Hamilton Centre since 2004. Gary has served eight terms as the Vice-President for Hamilton Centre, and is now the President. As key contributor to our Centre's growth, Gary leads meetings and delivers segments reviewing current astronomical news, a highlighted observing object, and a featured topic for the evening. He also oversees many activities and promotes RASC through social media and on the Centre's website.

Gary has chaired and co-chaired AstroCATS, resulting in substantial funding for Hamilton Centre outreach programs, and the acquisition of many club assets.

He saw the membership of the Hamilton Centre increase from 34 members to its current level of over 120 members. He maintained our website for 10 years and there is no doubt by any member of Hamilton Centre as to his value, contribution, and continued benefit.

Under his leadership the Centre is embarking on a five-year plan to deliver a world-class planetarium to Southern Ontario. Although in the early stages, the plan has received unanimous support from the board members. When completed the Hamilton Centre will launch the best outreach program of the Society in many years.Gary is the very definition of an RASC member giving many years of service.

Service Award to Hugh Pett

Hugh Pett transferred from Ottawa to the Okanagan Centre with a flourish of active participation in volunteer opportunities in 2006. He served two terms as Vice President of the Centre, which involved organizing and promoting speakers at our monthly meetings, as well as giving several well received talks himself. In 2009 Hugh became editor of the Centre's monthly newsletter, a duty he still holds as of this writing.

In 2009 Hugh became a key volunteer in the committee that advances the progress of the Centre's "Okanagan Observatory." Hugh is involved, and his opinions are highly valued, in all aspects of the observatory development for which he has received two Member of the Year awards from the Centre. He was instrumental in planning and installing all of the electrical power assets of the observatory. Hugh personally designed, and led a team in the installation of the security system that utilizes a wide variety of devices to protect the rurally located Okanagan Observatory.

This is not Hugh's first pass at helping build a Centre observatory. Before coming to the Okanagan Centre Hugh Pett served as one the most dedicated team members on the Ottawa Centre SmartScope project. He designed and built many of the observatory systems including the electrical and UPS systems, lightning protection and grounding systems, webcam systems for overseeing operation of the telescope and dome, and a watchdog computer to monitor critical components and ensure an orderly shutdown during power failures. In recognition of the contributions by Hugh and his father Bradley, the Ottawa Centre named the facility The Pett Observatory.

Service Award to Paul Gray

Paul Gray joined the Halifax Centre of the RASC in 1988 as a teenager. During his early years as a member, he served on the Centre's executive as Observing Chairman and as a Councillor. He was actively involved in most Centre initiatives, and was an enthusiastic observer.

In 1998, Paul moved to the United States for work, interrupting his RASC involvement, but becoming an active member of the Delmarva Stargazers until 2002. In 2003 he returned to Canada and again took up RASC membership in the Halifax Centre in 2003, then in the Moncton Centre in 2004. He has maintained an active role in the Society ever since.

His Moncton, then the New Brunswick Centre contributions include severeal executive positions. He was instrumental in starting and running the Centre's annual star parties. He led the effort to achieve Dark-Sky Preserve designation for both Mount Carleton Provincial and Kouchibouguac National Parks in 2009, and was involved in the designation process for Fundy National Park in 2011.

At the national level, besides serving on several committees and on the Board Pilot Committee, he is a contributor to the *Observer's Handbook* Dark Nebulae Section—13 editions this year.

Paul returned to the Halifax Centre in 2012 and has been an active member ever since, most recently as treasurer of the 2015 GA, and he is currently in his second term as the Centre President.

His energy, commitment, and enthusiasm contributed enormously to the growth and strength of the New Brunswick Centre (he put it on the map, so to speak). Paul is a natural leader, inspiring others into action.

As chair of the Observing Committee, he raised the profile of the Society's observing program and increased the uptake on the certificate programs. His *Observer's Handbook* Dark Nebulae section has brought a whole new area of observing to many amateur astronomers, not just in Canada, but beyond. His many solar-filter-building workshops conducted at various star parties have contributed to the skills, abilities, and observing success of dozens of RASC members.

Paul Gray has been an active member of the RASC for 22 years, minus a four-year interruption. He has given substantial and significant service of an exemplary nature to the Society in many roles, at his two home Centres and nationally, for twelve consecutive years. That exemplary service continues now.

Fellowship Award to Alan Batten

Dr. Alan Batten joined the Victoria Centre in 1962, three years after his 1959 arrival in Canada as a postdoctoral fellow at the Dominion Astrophysical Observatory (DAO) following his undergraduate (St. Andrew's University) and graduate (University of Manchester) studies in astrophysics. After a highly productive scientific research career, Dr. Batten retired from the DAO as a Senior Research Officer in 1991 to pursue very actively his interests in promoting the development of astronomy and astronomy education in developing countries, studies in the history of science with emphasis on astronomical topics, and the intersections of science and religion in society at large.

His scholarly works over 60 years have been numerous and well referenced (>2,400 citations according to NASA's ADS). His 89 JRASC contributions span a 47-year period from 1961 to 2008. Besides numerous original research findings on multiple stars and stellar astrophysics, Alan documents many contributions to astronomy by Canadians, as well as the major issues faced by the Society during his leadership years.

Throughout his DAO research career Dr. Batten was an active life member of the Victoria Centre, which continues to this day. He served as Centre president in 1972 and his most recent turn as a featured speaker was December 2015. His experiences at the local level were then elevated to the national level where Dr. Batten served as the RASC President (1976-1978) and then as Editor of the Journal (1980-1988), for which he was recipient of the national Service Award (1988). Reading his many JRASC contributions on Society affairs in those years provides unique insight into the evolution of Canadian astronomy. That 20 of his 89 JRASC contributions were published following receipt of the 1988 Service Award is testimony to his ongoing respect of, and support for, the Society's publications. That support includes contributing The Nearest Stars section to 40 editions of the *Observer's Handbook* (1970-2009). His appointment to a four-year term as the Society's Honorary President (1993-1997) highlights the Society's high regard for Dr. Batten.

His presentations are exemplary expositions on his most recent studies in history of astronomy and his reflections upon developments in society at large as viewed from the unique perspective of a distinguished astronomer. He also delivers lectures on astronomy-related topics organized through other organizations to the benefit of members of the Victoria Centre and the public at large. Dr. Batten's generosity has been a great benefit to many with whom he has willingly shared his time and expertise over nearly six decades of active participation in, and leadership of, Canadian astronomy.

The experiences of leading both CASCA and the RASC as national, bilingual, astronomy organizations in a geographically challenging country prepared Dr. Batten well for representing Canadian astronomy in the broadest sense during subsequent decades of forefront service to the International Astronomical Union (IAU). Following his role in organizing the first-ever IAU General Assembly to be held in Canada (1979), he served as an IAU Vice President (1985-91). During that period and for many years subsequently, Dr. Batten shared his accumulated experience from RASC, CASCA, and scientific research collaborations to promote the development of astronomy education and research in countries previously missing it from their educational systems. Over a decade he travelled extensively to work closely with national leaders and extensively documented the lessons learned. His success reflects his abiding interests in people, their diverse cultures and worldviews.

Fellowship Award to Douglas Hube

Douglas P. Hube began his long association with the RASC first as a member but also as President of the Edmonton Centre and then of the Society, dedicated to a life of the promotion of astronomy and related sciences to its members and the general public.

At the local level no outreach program like our numerous Star Nights, Open Houses, and Star Parties throughout the province failed to list him as a speaker that the public would enjoy and learn much about the cosmos. Frequently he would address the Centre's monthly meetings with the latest advancements in astronomy.

Currently Doug is the Centre's Honorary President; in 1982 he received the Society's Service Award and continues to assist in planning Star Nights, General Assemblies, Open Houses and special sky events. At the National level he provides editorial guidance for the Journal.

From the late 1970s, a major link was forged between the RASC and the Edmonton Space and Sciences Foundation with Doug being a Founding Member, then President, and helped to establish a wealth of collaborative programs at the Telus World of Science-Edmonton especially with its magnificent Observing Deck and Speaker Program.

At the professional level including teaching and research, Doug contributed much to his students and colleagues with over 65 research papers and 200 citations at the level of the I.A.U., the publications of the RASC, and the Natural Sciences and Engineering Research Council of Canada.

Fellowship Award to Franklin Loehde

Franklin Loehde has been a member of the RASC for more than six decades, joining while still a high school student. During that time, he has provided exemplary leadership and service to the Society at both the local and national levels. In serving the Society he has served the needs of the general public.

In 1959, Franklin was a member of the committee proposing that a planetarium be constructed as recognition of a visit by Queen Elizabeth. That proposal was accepted, and the Queen Elizabeth Planetarium was officially opened in Coronation Park in 1960. The QEP was the first public planetarium in Canada. It set the precedent for public planetaria opened subsequently across Canada. The QEP was one of the first steps in bringing science and appreciation of the astronomical Universe to the general public.

It was recognized that a facility more substantial than the QEP was needed, and Franklin was among the first to volunteer his services to what became the Edmonton Space Sciences Foundation (ESSF). Franklin served the foundation in several formal capacities during the development of the Space Centre, now known as the TELUS World of Science—Edmonton (TWOSE), one of the world's major science centres. After 38 years, Franklin is one of the two founding members of the foundation who is still active.

He has served in several offices within Edmonton Centre and he is a frequent contributor to monthly meetings and to the Centre newsletter. Franklin was the Society President from 1982 to '84.

For many years he served as casino manager, a role not found in other Centres. The money raised has made possible the purchase of a large array of telescopes and auxiliary instruments at the TWOSE observing deck. The money also went to the purchase of portable telescopes for schools and may be borrowed by the public. In addition, casino funds support the SkyScan program that places radio telescopes in Edmonton schools.

Franklin's contributions to the RASC at both the Society and Centre levels have been recognized in several ways, including the Society's Service Award, the creation by the Edmonton Centre of the *Franklin Loehde Award for Project of the Year*, and the IAU has named asteroid 85121 (1976KF3) in his honour.

Fellowship Award to Pat Kelly

Pat Kelly joined the Halifax Centre in 1981. By 1985, he had joined the Centre council, he has been a council member continuously to the present day—30 years of service, with several officer roles, except for a brief rest in 2011.

He was also a key member of both the 1993 and 2015 GA committees.

Pat has participated in every Centre event, working long and enthusiastically to promote public awareness of science and astronomy. A highlight was his many years of volunteering in the small Halifax Planetarium. Pat was also a board member and treasurer of the Atlantic Space Science Foundation for 10 years. This organization worked to promote the establishment of a new planetarium for Nova Scotia. While that goal did not succeed, its work led to a major increase in astronomy programming at the Discovery Centre (Nova Scotia's science centre).

Pat began his extensive Society contributions by becoming Editor of the National Newsletter in 1990, which he changed into the more substantial bi-monthly publication known as The Bulletin with its first issue in February 1991. He remained editor until the beginning of 1997, when its content was merged into the new, large-format Journal. Pat ushered in a new mode-of-operation whereby volunteer editors also started doing the production work (design and layout) for our publications. That substantially reduced the cost to the Society. During these years he also produced the Society's Annual Report, for some years as a separate publication and later replacing an issue of The Bulletin.

In 1996 and 1997 Pat was a member of the Publication Revitalization Committee which developed and launched the new revitalized *Journal* of the RASC in 1997. This was a major effort considering that those involved, including Pat, still had to produce the *Bulletin during the development year. Pat then served as Associate Editor of the Journal* from 1997-2000, and for the past 16 years, he has been an Assistant Editor of the Journal.

In 2006, he took on being *Observer's Handbook* Editor for five editions. Pat filled the role admirably! Being an editor of four Society publications over a span of 25 years has to be some sort of RASC record.

Pat continues to devote his time, knowledge, and abilities at the Society level. At the 2015 GA, he was elected by National Council as its Co-Chair.

Fellowship Award to Jay Anderson

Jay began his national contributions to the work of the Society as the eclipse *Weather Prospects* section contributor to the 1990 edition of the *Observer's Handbook*, which has expanded into the current *Frequency of Nighttime Cloud Cover.* The current edition is his 27th. Also, Jay provided additional weather articles for the transits of Venus in 2004 and 2012.

Of special note is Jay's highly successful decade-long tenure as *Journal* Editor. When he assumed the role, the *Journal* was in the midst of a major shift in format, focus, and volunteer staff. Jay continued with the many changes needed, updating and transforming the *Journal* into a vibrant and attractive publication of interest and value to the Society's membership. Jay's leadership, management skills, and grace under the pressure of so many challenges, is an inspiration to all.

Although he began his work with the RASC in 1990, he has been writing about weather conditions along eclipse tracks since 1978, with NASA's "Mr. Eclipse," Fred Espenak. According to Fred Espenak's eclipse website:

"Jay Anderson is a meteorologist, formerly with the Meteorological Service of Environment Canada. Astronomy has been a large part of his life since his mid-teens, and it was only after graduating with a degree in Physics and Astronomy from the University of British Columbia that he adopted meteorology as a second pastime. He has written on the climatology of places along eclipse tracks since 1978, when a solar eclipse was predicted to pass over his hometown. He still lives in that hometown—Winnipeg…"

Given Jay's Editorship of the *Journal*, his more than a quarter century of weather predictions in the *Observer's Handbook*, and in NASA publications with Fred Espenak, he has made major, long-term contributions to the RASC. Those contributions have been at the Centre, national, and international levels. According to his Service Award citation, he has been a member of the RASC continuously since 1990.

Jay Anderson's extraordinary eclipse weather predictions constitute a major, long-term contribution to the work, credibility, and international stature of the RASC. He is acknowledged as a global expert on eclipse weather and eclipse chasers the world over turn to Jay's work when planning eclipse observations.

2016 President's Award

Terence Dickinson became an RASC Life Member in the Toronto Centre in 1959, when the cost was something like $25. He was a McLaughlin Planetarium lecturer shortly after it opened and later moved to the Strasenburgh Planetarium in Rochester, New York. When *Astronomy Magazine* started up in 1973, Terry was first a contributing editor, then executive editor of the magazine until 1975. Returning to Canada, he became a full-time science writer in 1976. Nearly 20 years later, he established *SkyNews Magazine* in its current format, recently acquired by the RASC. He continues as Editor Emeritus from his home in Yarker, Ontario. Terry is the author of more than a dozen books on astronomy, countless newspaper columns and articles, and is a frequent speaker at astronomical gatherings. His books *Nightwatch* and *The Backyard Astronomer's Guide*, co-written with Alan Dyer, continue as bestsellers after many years and several editions.

Terry has been a tireless supporter of Canadian astronomy for several decades. His books continue to inform readers about the contributions of both amateur and professional astronomers. He has been recognized for his astronomical education and outreach with numerous awards, including the Royal Canadian Institute's Sandford Fleming Medal (1992), appointment as a Member of the Order of Canada in 1994, and the Klumpke-Roberts Award of the Astronomical Society of the Pacific in 1996. Asteroid 5272 Dickinson honours his name.

At Terry's Order of Canada investiture in 1995, the citation reads as follows:

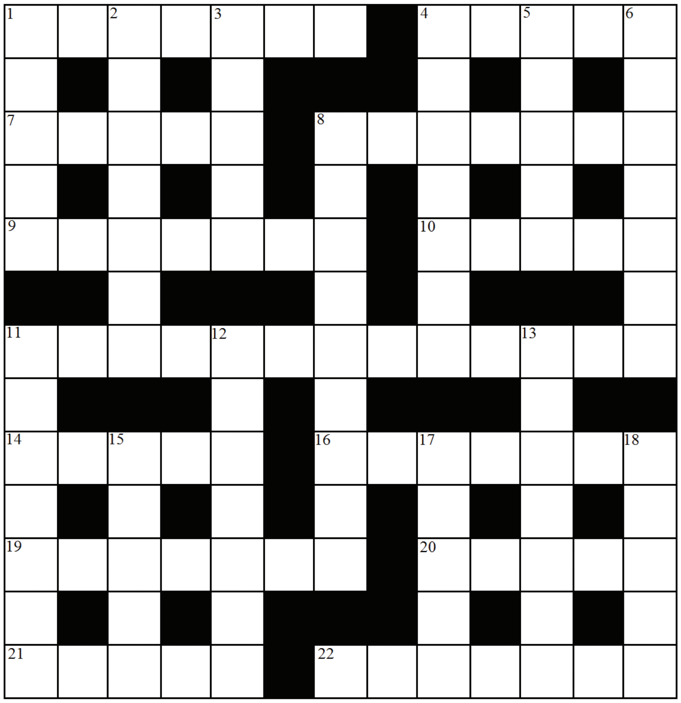
Many Canadians have developed an interest in the wonders of astronomy thanks to his popular books on the subject. His guide for backyard astronomers, Nightwatch*, is one of many books he has written for both children and adults. As a commentator for CBC radio's Quirks and Quarks, an author and a columnist, he has unveiled a world of discovery for thousands of amateur astronomers.*

Terry's unstinting encouragement of astronomy education is evident in his writing, through *SkyNews*, his outreach activities, his skillful astroimaging, and his long-time support of the RASC. I can think of no other member more worthy to receive the 2016 President's Award.

James Edgar,
Past President

Astrocryptic

by Curt Nason



ACROSS

1. It is butchered in a tale of an air pump (7)
4. Broad oxygen line seen in spectra of Kochab and the Sun (1,4)
7. Guys return to East Africa to visit Leo's mythological range (5)
8. He developed a comet theory while going around very quietly (7)
9. Despite his cluster he was not a closet astronomer (7)
10. Gingerich's valley with Caltech's dishes (5)
11. A gap X-ray is all asunder in describing 8 Down (1,6,6)
14. Gas giant concern for some homeowners (5)
16. Camera mount (7)
19. Society's membership goal is real new inside (7)
20. UK satellites launched around Uranus (5)
21. Three hot stars typically within a light-year of the hotel desk (5)
22. Facing Taurus, Orion turns to drama to act as one (7)

DOWN

1. Henden led second grade, becoming a Hare Star (5)
2. Cat led jazz at piano, co-founding a highlight in 1995 (3,4)
3. Newton is a current name (5)
4. Return an ounce after Onassis declared a state of crater formation (7)
5. Program the French made of a possible trigger of gravitational theory (5)
6. Race back to Kentucky for some faint fuzzy observing (4,3)
8. Northern target to spin loop back off the handle (9)
11. Short charioteer began doctorate exam concerning colourful highlights (7)
12. Shannon's tune of high velocity stars (7)
13. Technological physics degree program was not truthful (7)
15. Look first east-northeast between Draco and Boötes for a hind star (5)
17. What makes it rise east after end of day? (5)
18. Note a redhead in our system (5)

Answers to December's puzzle

ACROSS

1 DENIM (d(EN)im); **4** SERPENS se(RP)en+s; **8** UMBERTO (Foucault's Pendulum); **9** BETEL (-geuse); **10** LABEL (an(a) ag); **11** MENKENT (men+Ken+t); **12** TUNGUSKA EVENT (anag); **16** CLUSTER (c+luster); **18** ARRAY (a+r+ray); **20** THIRD (a(h)nag); **21** EPICURE (2 def, hamburger); **22** STARSKY (star+sky); **23** HYDRA (anag (Hardy))

DOWN

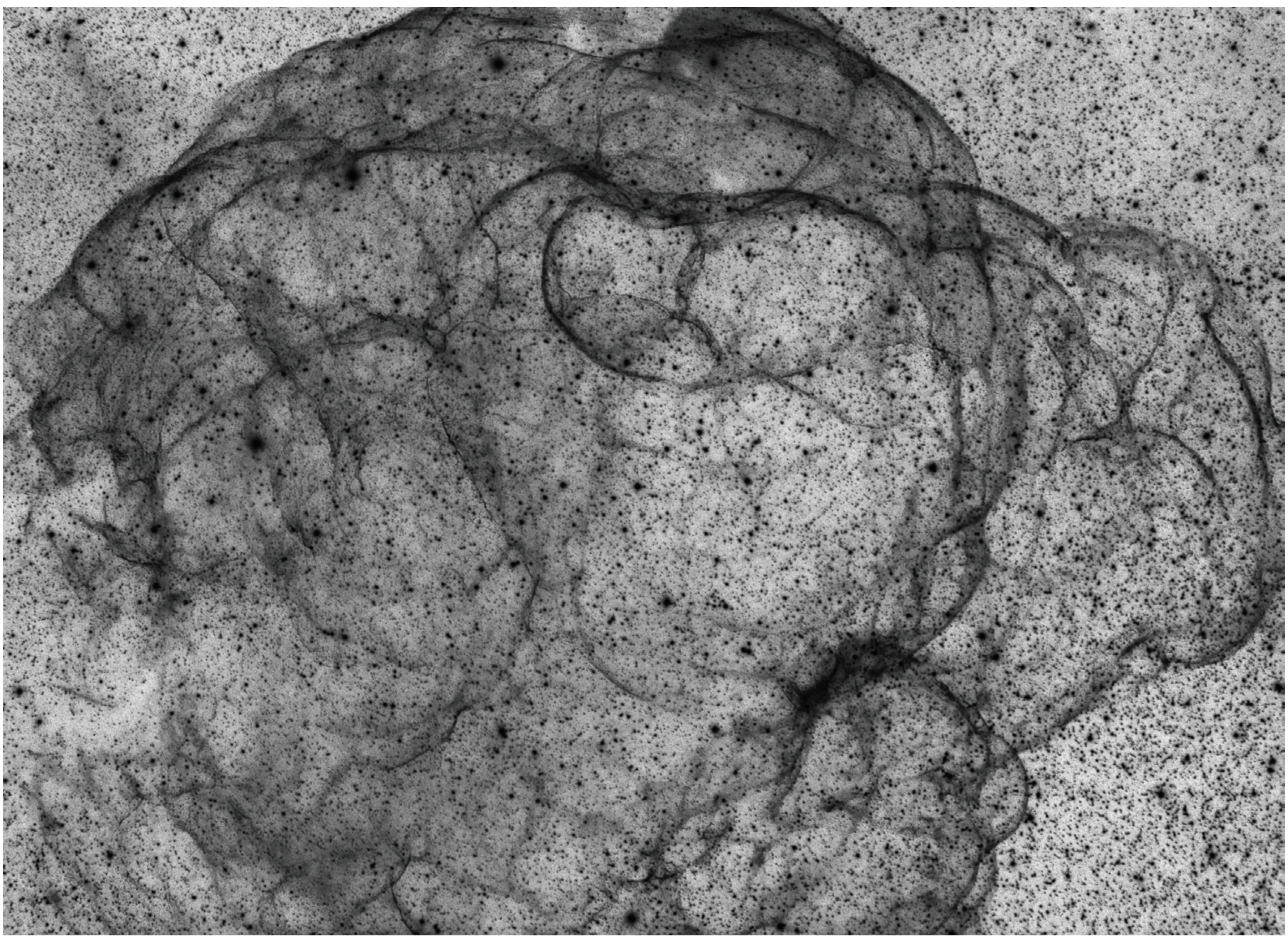
1 DOUBLET (doub(le)t); **2** NABOB (NA (Neb)+Bob (Peel)); **3** MARY LOU (2 def, book title);**4** SHOEMAKER-LEVY (2 def); **5** RUBIN (rub in); **6** EXTREME (ex+anag); **7** SPLIT (2 def); **13** NAUTICA (anag); **14** EDASICH (an(I)ag); **15** TAYGETA (anag); **16** CETUS (anag-rl); **17** TIDES (T+anag); **19** ROUND (ro+under-er)

It's Not All Sirius

by Ted Dunphy

Great Images

by Lynn Hilborn



Lynn Hilborn imaged supernova remnant Simeis 147 (SH 2-240) at his WhistleStop Observatory in Grafton, Ontario. Hilborn used a Tokina ƒ/2.8 300-mm lens with an FLI ML8300 camera and Baader narrowband filters. $H\alpha$ 11 × 30 minutes 1×1, OIII 11 × 30 minutes 3×3, SII 6 × 30 minutes 2×2, for a total of 14 hour's exposure.

Journal

Great Images

This image of the Heart Nebula (IC 1805) was taken by Michael Watson from Algonquin Provincial Park. Watson used a Nikon D810a camera body on Tele Vue 101is apochromatic refracting telescope, mounted on Astrophysics 1100GTO equatorial mount with a Kirk Enterprises ball head. There are 15 stacked images at a focal length of 540 mm. He then stacked and processed the images in Photoshop CS6.