The Journal of The Royal Astronomical Society of Canada

Journal

Le Journal de la Société royale d'astronomie du Canada

PROMOTING ASTRONOMY IN CANADA

February/février 2018
Volume/volume 112
Number/numéro 1 [788]

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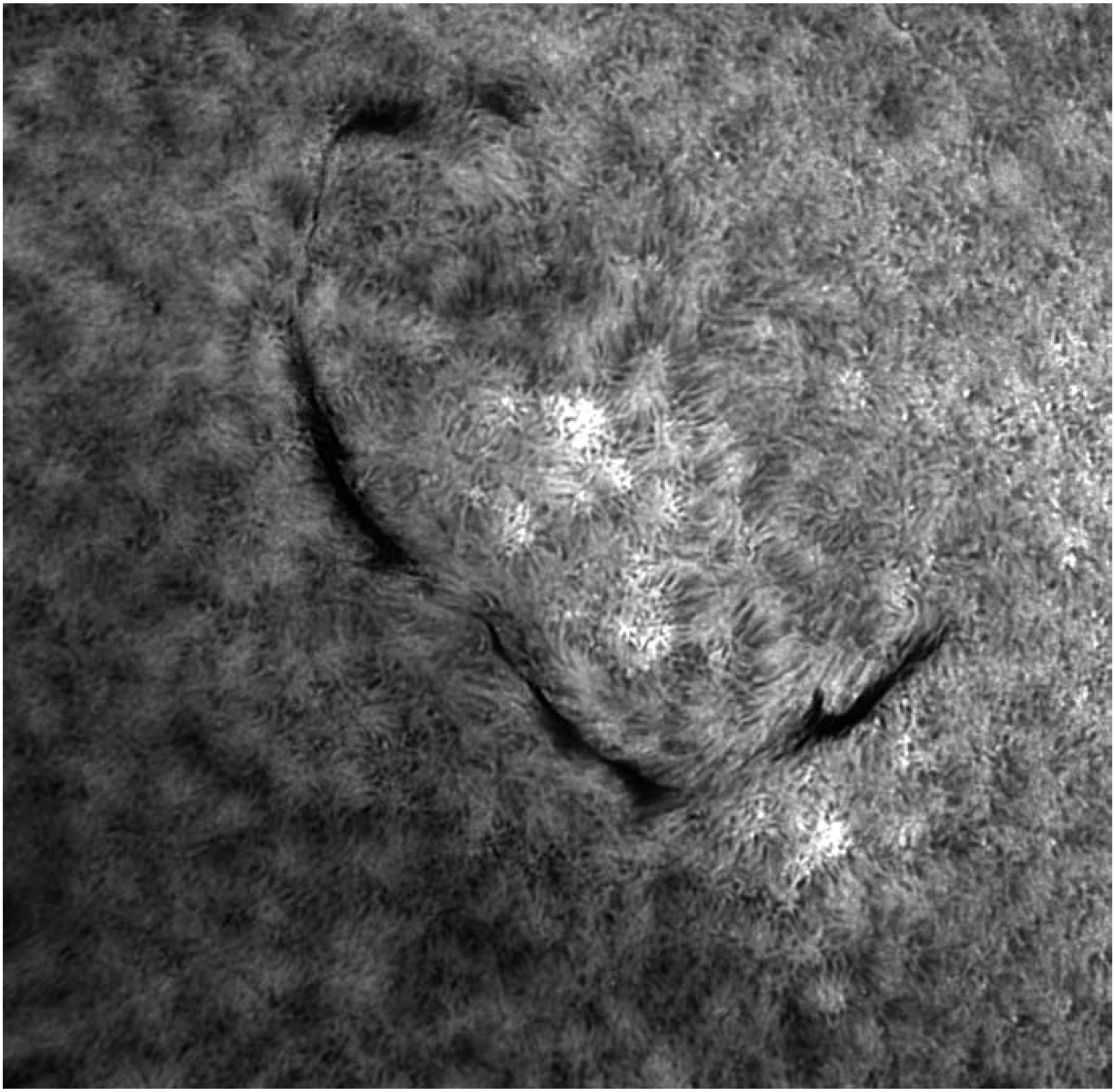
Under the Geminids

The Best of Monochrome.

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



A large filament stretches across the face of the sun. The image was captured by Gary Palmer using a Lunt 100-mm double-stacked with a Quark Hypercam 174M Sharpcap.

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Royal Astronomical Society of Canada

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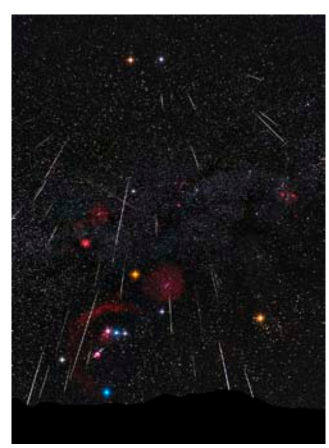

Malcolm Park took this composite image of December's Geminid show in Arizona. He used a Nikon D800 @24mm 15x3 minutes, unguided and tracked on Sky Adventurer. He used a QSI 683WSG 15x3 minutes of Ha at 14mm unguided and tracked on Sky Adventurer. He replaced the red channel in the D800 data with the Ha data from the CCD and shot the same D800 @24mm ISO 2500 ƒ/2.8 40-sec exposures, tracked on Sky Adventurer. These are the brightest meteors, layered in Photoshop.

Journal

The *Journal* is a bi-monthly publication of The Royal Astronomical Society of Canada and is devoted to the advancement of astronomy and allied sciences. It contains articles on Canadian astronomers and current activities of the RASC and its Centres, research and review papers by professional and amateur astronomers, and articles of a historical, biographical, or educational nature of general interest to the astronomical community. All contributions are welcome, but the editors reserve the right to edit material prior to publication. Research papers are reviewed prior to publication, and professional astronomers with institutional affiliations are asked to pay publication charges of $100 per page. Such charges are waived for RASC members who do not have access to professional funds as well as for solicited articles. Manuscripts and other submitted material may be in English or French, and should be sent to the Editor-in-Chief.

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The *Journal* of The Royal Astronomical Society of Canada is published at an annual subscription rate of $93.45 (including tax) by The Royal Astronomical Society of Canada. Membership, which includes the publications (for personal use), is open to anyone interested in astronomy. Applications for subscriptions to the *Journal* or membership in the RASC and information on how to acquire back issues of the *Journal* can be obtained from:

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Canadian Publications Mail Registration No. 09818
Canada Post: Send address changes to 203 – 4920 Dundas St W, Toronto ON M9A 1B7

Canada Post Publication Agreement No. 40069313
We acknowledge the financial support of the Government of Canada through the Canada Periodical Fund (CPF) for our publishing activities.

President's Corner

Colin A. Haig, M.Sc.
(astronome@outlook.com)

Have you been to a local astronomy event, RASC Centre meeting, or travelled a bit further to visit an observing site or neighbouring astronomy club? How about attending an astronomy lecture at a nearby University? Or perhaps you've been the presenter or a volunteer at an event. I'd love to hear about it. As your Society's president, I've had the opportunity to do all the above, and it has been fun and satisfying. We have a great team of Board members, literally from the Arctic, to the Pacific, and the Atlantic, and their collaboration, engagement, and hard work is helping us achieve new things, and reach more people than ever before.

I find Centre visits are a lot of fun, even if I hear a few concerns or have to drive a few hundred kilometres. A recent highlight for me was a visit to Niagara Centre, to present long-overdue Service Awards to two outstanding contributors to astronomy in Canada, Dr. Brian Pihack and Mr. Stan Sammy. I think I first met Brian at the 1998 Victoria GA, during a trip to Jack Newton's home.

Another pleasure was a low-key visit to Belleville Centre held at Loyalist College. A young lady of elementary school age presented me with a fine crayon drawing of the Solar System, and I presented her with a Moon projecting flashlight. A few eclipse slides and a lot of good conversation ensued.

My next adventure could be described as Curry and Urry in a Hurry. A fast trip to London from my home west of Toronto brought me all three. London Centre's Annual Banquet was held at Brescia College, and we enjoyed a fine talk by Dr. Chris Gainor on the history of the *Hubble Space Telescope* and a fine meal of Indian food—a little curry cleared my sinuses! Earlier in the day, I attended an excellent lecture by astrophysicist Dr. Meg Urry of Yale, held at Western. During the question period, I had the opportunity to ask her for any advice she would have for young people, particularly women, about going into the field. She was delighted with the question and encouraged young people, and young women especially, to consider careers in science, technology, engineering, and mathematics, and to consider a B.Sc. program as a gateway to meaningful work in many fields, not just astrophysics and astronomy. The audience was most appreciative of her response, including pragmatic recommendations.

As amateur and professional astronomers, we have a duty to encourage young people, women, and under-represented people to engage and enjoy our hobby and profession. This is critically important, to provide a welcoming, safe, and inclusive environment for all people. To that end, your Board of Directors held a two-day meeting in Toronto on November 4 and 5. Items in our strategic plan, revitalization of committees, and the culture of the Society were all on the agenda.

Our culture is a top priority—although generally healthy, it is our hope to bring out new guidelines in early 2018 to ensure that everyone understands that harassment of any form, whether on-line, over the phone, or in-person, is unacceptable and will not be tolerated. In the daily news, North American media stars, politicians, and prominent men are all learning that sexual harassment can cost them their jobs. These lessons are being learned at great cost to the victims and in some cases, the alleged perpetrators. The RASC will not tolerate this behaviour. The new guidelines will help deal with these situations. It is also important for us to be able to have healthy conversations on these topics, so that people can learn from past experiences, share their opinions, and do so in a constructive, civil fashion. This extends to social media, the RASClist email list, and any other place our members interact. All of us—you and your friends, your Centre leadership, the National Council, the Board, committees, and staff—create the culture. We need to ensure it improves, and can gently let people know when their behaviour isn't helping. This will take time. My hope is that this will help decrease member attrition in some parts of the country, and will welcome a wider range of people with different backgrounds to our Society, so our membership is representative of Canada as a whole.

I've prepared an article giving you a bit of background on the role of several of the key people in our Society, including our Board, and you will find it later in this issue.

Over the past two months, I've reached out to several committee chairs to ask for their adoption or recommendations on how to approach items outlined in the strategic plan. David Chapman, chair of the Observing Committee, is making great strides with his team in promoting the observing certificates programs. I'm looking forward to hearing about many new certificate winners. Tenho Tuomi and the Astroimaging Committee have recently recognized several members for their outstanding images, which you can see showcased on the RASC Zenfolio site at http://rascastroimaging.zenfolio.com.

It is with great sadness that I must inform you of the passing of Eric Kujala of the Ottawa Centre. He was 53 years old. Some of you may have met Eric at the Ottawa General assembly. For years now, Eric, an audio-visual wizard, has worked with his wife Eunice to record Ottawa meetings and events, and to share the video on DVDs. Gordon Webster of Ottawa shared that "recently he started broadcasting our meetings live as well as posting the results to YouTube so those who couldn't make it to the meetings could still enjoy our presentations and speakers." A tribute for Eric was held at the December meeting of the Ottawa Centre.

Last issue, I challenged you to "Dream Big," and as a result, it looks like our Society is getting ready to move forward with a Remote Telescope fundraising effort, and is going to consider a nano-satellite project with partners, and some other new ideas. We've kicked off a fund-raising drive to support Education and Public Outreach, as well as other needs of our Society. I made a donation, and hope that you will join me by making a contribution as well.

Without a doubt, and with your help, at *the RASC, our business is looking up!* ✶

News Notes / En Manchette

Compiled by Jay Anderson

Sculpting the Sculptor

Astronomers from the Kapteyn Astronomical Institute and Leiden Observatory, both in the Netherlands, used data from the NASA/ESA *Hubble Space Telescope* (HST) and ESA's *Gaia* space observatory to measure the motions of stars in the Sculptor Dwarf Galaxy. The dwarf is an elliptical galaxy orbiting the Milky Way, 300,000 light-years distant.

The measurements were made by comparing observational datasets from the two satellites separated by 12.27 years. The earlier was acquired by the HST's Advanced Camera for Surveys (ACS) in 2002; the second, more recent, was from the initial catalogue of stellar positions provided by *Gaia.* The research team found 126 stars in common, computing their proper motions from the difference between the *Gaia* and HST positions, divided by the time interval. When combined with radial-velocity measurements, a precise three-dimensional motion of several of the stars was obtained.

Davide Massari, lead author of the study, describes the precision of the research: *"With the precision achieved, we can measure the yearly motion of a star on the sky, which corresponds to less than the size of a pinhead on the Moon as seen from Earth."* This kind of precision was only possible due to the extraordinary resolution and accuracy of both spacecraft. Also, the study would not have been possible without the large interval of time between the two datasets which made it easier to determine the movement of the stars.

Central to the achievement was the research group's control of intrinsic and systematic errors in the two sensors. For the *Hubble* images, the team had to evaluate distortions introduced by the filters (about 0.01 pixel), chromatic refraction, charge readout from the CCD chip, and a number of poorly understood factors. Only the geometric distortions introduced by the filters were found to be important. Two background galaxies were used to establish the zero point of the reference frame.

Of the initial 126 stars, 15 of the brighter ones with the most accurate proper motions were selected to study internal motions and the distribution of dark matter in the Sculptor Dwarf. The three-dimensional motions can be directly translated into knowledge about how the dwarf's mass is distributed. The results show that stars in the galaxy move preferentially on elongated radial orbits, indicating that the density of dark matter increases towards the galaxy centre instead of flattening out. These findings are in agreement with the established cosmological model and the current understanding of dark matter, taking into account the complexity of Sculptor's stellar populations.

As a side effect of the study, the team also presented a more accurate trajectory of the Sculptor Dwarf Galaxy as it orbits the Milky Way. Their results show that it is moving around our galaxy in a high-inclination elongated orbit that takes it much further away than previously thought. Currently, it is nearly at its closest point to the Milky Way, but its orbit can take it as far as 725,000, light-years away.

"With these pioneering measurements, we enter an era where measuring 3-D motions of stars in other galaxies will become routine and will be possible for larger star samples. This will mostly be thanks to ESA's Gaia mission," concludes Massari.

Prepared, in part, with content supplied by the European Southern Observatory.

Cassini's last photo

In a fitting farewell to the planet that had been its home for over 13 years, the *Cassini* spacecraft took one last, lingering look at

Figure 1 — The Sculptor Dwarf Galaxy, a satellite of our Milky Way, imaged with the Wide Field Imager camera on the 2.2-metre MPG/ESO telescope at ESO's La Silla Observatory in Chile. Located around 300,000 light-years away, it was the first dwarf galaxy to be discovered orbiting the Milky Way by astronomer Harlow Shapley in 1937. Credit: European Southern Observatory.

Figure 2 — After more than 13 years at Saturn, and with its fate sealed, NASA's Cassini *spacecraft bid farewell to the Saturnian system by firing the shutters of its wide-angle camera and capturing this last, full mosaic of Saturn and its rings two days before the spacecraft's dramatic plunge into the planet's atmosphere. This view is constructed from 42 of those wide-angle shots, taken using the red, green, and blue spectral filters, combined and mosaicked together to create a natural-colour view. This view looks toward the sunlit side of the rings from about 15 degrees above the ring plane.* Cassini *was approximately 1.1 million kilometres (698,000 miles) from Saturn, on its final approach to the planet, when the images in this mosaic were taken. Credit: NASA/JPL-Caltech/Space Science Institute.*

Saturn and its splendid rings during the final leg of its journey and snapped a series of images that has been assembled into a new mosaic.

On September 13, *Cassini*'s wide-angle camera acquired a series of red, green, and blue images, covering the planet and its main rings from one end to the other. Imaging scientists stitched these frames together to make a natural-colour view.

"*Cassini*'s scientific bounty has been truly spectacular—a vast array of new results leading to new insights and surprises, from the tiniest of ring particles to the opening of new landscapes on Titan and Enceladus, to the deep interior of Saturn itself," said Robert West, *Cassini*'s deputy imaging team leader at NASA's Jet Propulsion Laboratory in Pasadena, California.

The *Cassini* imaging team had been planning this special farewell view of Saturn for years. For some, when the end finally came, it was a difficult goodbye.

"It was all too easy to get used to receiving new images from the Saturn system on a daily basis, seeing new sights, watching things change," said Elizabeth Turtle, an imaging team associate at the Johns Hopkins University Applied Physics Laboratory, Laurel, Maryland. "It was hard to say goodbye, but how lucky we were to be able to see it all through *Cassini*'s eyes!"

For others, *Cassini*'s farewell to Saturn is reminiscent of another parting from long ago.

"For 37 years, *Voyager 1*'s last view of Saturn has been, for me, one of the most evocative images ever taken in the exploration of the Solar System," said Carolyn Porco, former *Voyager* imaging team member and *Cassini*'s imaging team leader at the Space Science Institute in Boulder, Colorado. "In a similar vein, this "Farewell to Saturn" will forevermore serve as a reminder of the dramatic conclusion to that wondrous time humankind spent in intimate study of our Sun's most iconic planetary system."

Prepared with content supplied by The Hubble European Space Agency Information Centre.

Milky Way centre gets curiouser and curiouser

The centre of our galaxy, in the immediate vicinity of its supermassive black hole, is a region wracked by powerful tidal forces and bathed in intense ultraviolet light and X-ray radiation. These harsh conditions, astronomers surmise, do not favour star formation, especially low-mass stars like our Sun. Surprisingly, new observations from the Atacama Large Millimetre/submillimetre Array (ALMA) suggest otherwise.

In an November 28 paper in the *Astrophysical Journal Letters*, a team led by Farhad Yusef-Zadeh of Northwestern University in Evanston, Illinois, announced the discovery of 11 bipolar outflows from protostars within 1 parsec (3.26 light-years) of our galaxy's centre, known as Sagittarius A* (Sgr A*). At this distance, tidal forces around Sgr A* should be able to rip apart clouds of dust and gas before they can form stars. However, the team of researchers identified the new protostars by the classic "double lobes" of material that bracket each of them. That cosmic hourglass-like shape and radial velocity measurements that show opposing outflows in the lobes signal the

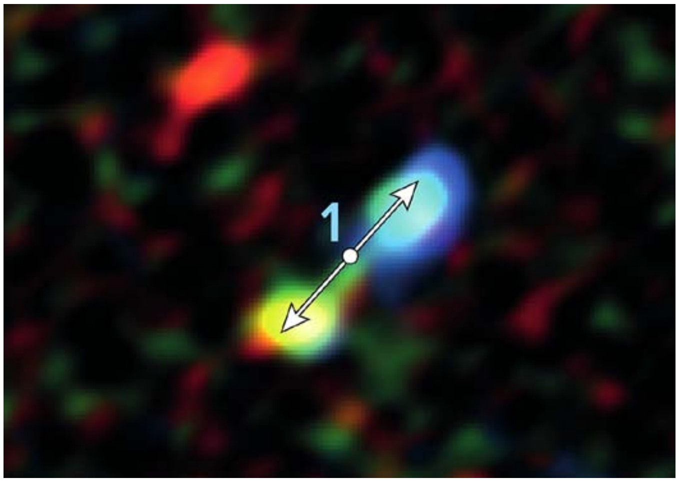

Figure 3 — Double-lobe feature produced by jets from one of the newly forming stars. ALMA discovered 11 of these telltale signs of star formation remarkably close to the supermassive black hole at the centre of our galaxy. Blue shades in the image are flows toward the telescope; red shades are flows away. Credit: ALMA (ESO/NAOJ/NRAO), Yusef-Zadeh et al.; B. Saxton (NRAO/AUI/NSF).

early stages of star formation (Figure 3). Molecules in the lobes, such as carbon monoxide, glow brightly in millimetre-wavelength light, which ALMA telescopes can observe with remarkable precision and sensitivity.

Protostars form within interstellar clouds of dust and gas when dense pockets of material collapse under their own gravity and then grow by accumulating more and more star-forming gas. A portion of this infalling material, however, never makes it onto the surface of the star. Instead, it is ejected as a pair of high-velocity jets from the protostar's north and south poles.

Extremely turbulent environments can disrupt the normal ingestion of material onto a protostar, while intense radiation—from massive nearby stars and supermassive black holes—can blast away the parent cloud, thwarting the formation of all but the most massive of stars.

"Despite all odds, we see the best evidence yet that low-mass stars are forming startlingly close to the supermassive black hole at the centre of the Milky Way," said Yusef-Zadeh. "This is a genuinely surprising result and one that demonstrates just how robust star formation can be, even in the most unlikely of places."

The ALMA data also suggest that these protostars are about 6000 years old. "This is important because it is the earliest phase of star formation we have found in this highly hostile environment," noted Yusef-Zadeh.

Prior ALMA observations of the region surrounding Sgr A* by Yusef-Zadeh and his team revealed multiple massive infant stars that are estimated to be much older, about 6 million years old. These objects, known as proplyds, are common features in more placid star-forming regions, like the Orion Nebula. Though the galactic centre is a challenging environment for star formation, it is possible for particularly dense cores of hydrogen gas to cross the necessary threshold and forge new stars.

"This discovery provides evidence that star formation is taking place within clouds surprisingly close to Sagittarius A*," said Al Wootten with the National Radio Astronomy Observatory in Charlottesville, Virginia, and co-author of the paper. "Though these conditions are far from ideal, we can envision several pathways for these stars to emerge."

For this to occur, outside forces would have to compress the gas clouds near Sgr A* to overcome the violent nature of the region and allow gravity to take over and form stars. The astronomers speculate that high-velocity gas clouds could aid in star formation when they are compressed as they force their way through the interstellar medium. It is also possible that jets from the black hole itself could be plowing into the surrounding gas clouds, compressing material and triggering this burst of star formation.

"The next step is to take a closer look to confirm that these newly formed stars are orbited by disks of dusty gas," concluded Mark Wardle, an astronomer at Macquarie University in Sydney, Australia, and co-investigator on the team. "If so, it's likely that planets will eventually form from this material, as is the case for young stars in the galactic disk."

A new camera on the block—with BIG eyes

A new robotic camera with the ability to capture hundreds of thousands of stars and galaxies in a single shot has taken its first image of the sky. The recently installed camera is part of a new automated sky-survey project called the Zwicky Transient Facility (ZTF), based at Caltech's Palomar Observatory located in the mountains near San Diego. Every night, ZTF will scan a large portion of the northern sky, discovering objects that erupt or vary in brightness, including supernovae, stars being munched on by black holes, asteroids, and comets.

"There's a lot of activity happening in our night skies," says Shrinivas ("Shri") Kulkarni, the principal investigator of ZTF and the George Ellery Hale Professor of Astronomy and

Figure 4 — ZTF took this "first-light" image on 2017 November 1, after being installed at the 48-inch Samuel Oschin Telescope at Palomar Observatory. The full-resolution version is more than 24,000 pixels by 24,000 pixels. Each ZTF image covers a sky area equal to 247 full Moons. The Orion nebula is at lower right. Computers searching these images for transient, or variable, events are trained to automatically recognize and ignore non-astronomical sources, such as the vertical "blooming" lines seen here. Image credit: Caltech Optical Observatories.

Planetary Science at Caltech. "In fact, every second, somewhere in the Universe, there's a supernova that's exploding. Of course, we can't see them all, but with ZTF we will see up to tens of thousands of explosive transients every year over the three-year lifetime of the project."

The two hearts of the ZTF are the 1.2 m (48-inch) Samuel Oschin Telescope (a Schmidt design) and a state-of-the-art, 576-megapixel survey camera. This combination can capture a 47-square-degree image at one time, the equivalent area of 247 full Moons, to a depth of 20.5 magnitude. The images are so huge that they are hard to display on computer screens at full resolution. Roger Smith, the team's technical lead at Caltech, has calculated that it would take 72 ultra-high-definition monitors to display one of ZTF's images at full resolution.

To complement ZTF's capabilities, the instrument will also be used to survey more limited areas, and so it will scan the entire sky over three nights and the visible plane of the galaxy twice every night.

The ZTF images will be adjusted, cleaned, and calibrated at Caltech's astronomy and data centre known as IPAC. IPAC software will also search the flood of data generated by ZTF for light sources, in particular those that change or move. These data will be made public to the entire astronomy community. The Samuel Oschin Telescope is co-located with the 8-m (200-inch) Palomar telescope and a 2.4-m (60-inch) telescope,

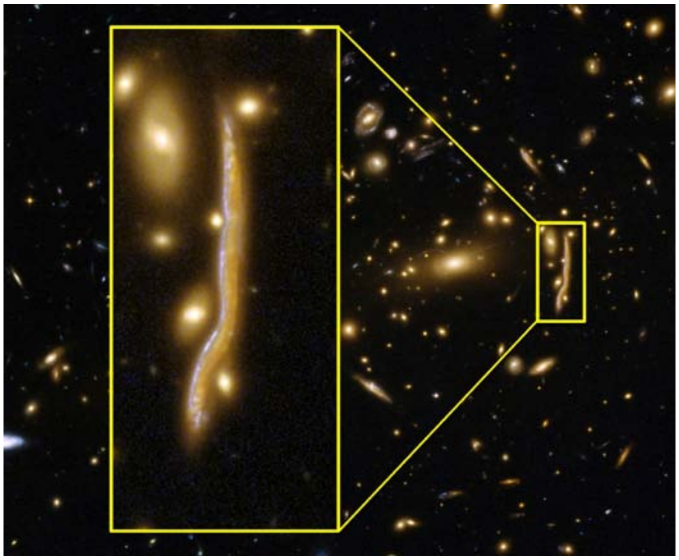

Figure 5 — The Cosmic Snake as seen by Hubble. *Image: ESA/Hubble, NASA*

so that interesting events captured in ZTF images can be passed to the other two for higher-resolution observation.

By scanning the sky more often, astronomers will discover not only a greater number of transient objects but also will be able to pick up the more fleeting events: those that appear and fade quickly. "The data archive will grow by 4 terabytes of data each night," says George Helou, the executive director of IPAC and a co-investigator on the NSF grant. "This is a unique project promising new types of discoveries."

Designing and building ZTF to capture such large images was particularly challenging given that the camera has to fit into a relatively small 70-year-old telescope tube. "The camera obstructs the light passing through the telescope toward the primary mirror, so we had to keep its size down while also maximizing the amount of sky it can observe," he says.

ZTF's science survey phase is scheduled to begin in February of 2018. The project will be completed by the end of 2020.

Compiled with material provided by Palomar Observatory.

A twisty worm from *Hubble*

The NASA/ESA *Hubble Space Telescope* has taken a picture of the "Cosmic Snake Galaxy," an extremely distant galaxy peppered with clumpy regions of intense star formation. The Snake Galaxy is actually behind a massive galaxy cluster called MACS J1206.2-0847, but thanks to this cluster's gravity, we can see it from Earth. Light from the distant galaxy arrives distorted into its twisted shape by the gravitational influence of the intervening cluster.

Instead of making it more difficult to perceive cosmological objects, such strong lensing effects improve the resolution and depth of an image by magnifying the background object. Sometimes gravitational lensing can even produce multiple images of the object as light is bent in different directions around the foreground cluster. In the case of the Snake, we actually see four separate images of the galaxy, twisted and lying end to end, each one magnified a different amount. A fifth image lies off to the side.

Using *Hubble*, Dr. Antonio Cava of the Université de Genève and co-authors looked at several such images of the Cosmic Snake, each with a different level of magnification.

"The amplified images are more precise, luminous, and allow us to observe details up to 100 times smaller," says Dr. Antonio Cava of the Université de Genève. "The fact that the image of the Cosmic Snake is repeated five times at different spatial resolutions allows, for the first time, to perform a direct comparison and to establish the intrinsic structure—and size—of the observed giant clumps."

The *Hubble* images revealed that giant clumps in high-redshift galaxies are made up of a complex substructure of smaller clumps, which contributes to our understanding of star formation in distant galaxies.

Compiled with material provided by NASA and the ESA. ✶

Feature Articles / Articles de recherche

Life in the Cosmos: When, Where, and How?

by Klaus Brasch

> *There are infinite worlds both like and unlike ours.... We must believe that in all other worlds there are living creatures and plants and other things we see in this world. Epicurus (341–270 BCE) in Letter to Herodotus*

Abstract

The origin of life on Earth remains one of the major unanswered issues in science. The question is as old as humanity itself and explanations have ranged from special creation, to abiological chemistry, to propagation across the Universe by natural forces and even deliberate transmission by technologically advanced civilizations. Although we are no closer today to a final answer, the ongoing discovery of potentially habitable exoplanets and the possibility of finding life elsewhere in the Solar System, have drawn renewed focus on this question. This article reviews some of the key issues involved and the notion that panspermia or the viable transfer of organisms between planets and beyond may have played a role.

Introduction

Thanks to spectacular discoveries in recent years of Earth-size exoplanets, as well as detection of organics and water ice in the interstellar medium and several Solar System bodies, the search for extraterrestrial life is now the focus of much astronomical and space research (Impey, 2011). Paradoxically, however, and despite over a century of scientific inquiry, our understanding of the origin of life on Earth remains unclear. Apart from its scientific interest, the answer to this question has broad philosophical, even spiritual implications, in terms of our place in the Universe and whether life is rare or ubiquitous in the cosmos.

The question of how and where life came about is as old as humanity itself (Sullivan and Carney, 2007; Samiksha, S. 2017). Although most ancient cultures had their own origins sagas, usually invoking supernatural powers, some early Greek and Egyptian philosophers, proposed that living things arose by spontaneous generation. Simply put, they held that life originated *de novo* from non-living things, like fish from Nile River mud, maggots from rotting meat, fleas from dust, and so forth.

These views persisted well into the 17th and 18th centuries until progressively debunked by scientific investigation. In 1668, Francesco Redi, a founder of experimental biology, showed conclusively that maggots came from fly eggs and not spontaneously from spoiled meat. A century later, Lazzaro Spallanzani showed that sealed bottles of boiled broth did not harbour microbes, but similar vessels exposed to air did. Lastly, in 1859, Louis Pasteur dealt a final blow to spontaneous generation with a series of definitive experiments showing that life did not arise from non-life but only from pre-existing organisms.

Panspermia: Life from Space?

Although the suggestion that life may have come from space goes back as far as the 5th century BCE, when Greek philosopher Anaxagoras coined the term "panspermia" or seeds everywhere, it was not really framed scientifically until the 18th and 19th centuries. Thus, in 1865 Hermann Richter proposed the "cosmozoic" theory of the origin of life, thereby outlining it as a potentially testable hypothesis, by arguing that it arrived in the form of microbial spores in cosmic dust (Figure 1).

To quote Lord Kelvin in 1871:

> *Hence and because we all confidently believe that there are at present, and have been from time immemorial, many worlds of life besides our own, we must regard it as probable in the highest degree that there are countless seed-bearing meteoric stones moving about through space. If at the present instant no life existed upon this Earth, one such stone falling upon it might, by what we blindly call natural causes, lead to its becoming covered with vegetation.*

In 1908, Svante Arrhenius suggested a potential mechanism for panspermia, proposing that bacterial spores could be driven through space by radiation pressure from stars. Noting that spores are highly resistant to desiccations, temperature extremes, and can survive for long periods of time, he posited that since they are also small enough to drift to Earth slowly, they would not be subjected to the fiery temperatures encountered by fast moving meteors (Arrhenius, 1908). This idea drew serious attention at the time, since spontaneous generation had

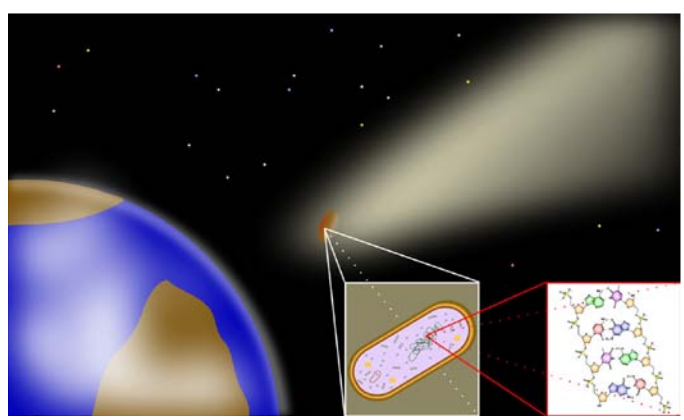

Figure 1 — Artist's rendition of microbes in cosmic dust seeding the young Earth (NASA)

been discredited and no clear scientific alternatives explaining life's origin had surfaced. Unfortunately, panspermia has one major weakness; intense solar ultraviolet and other radiation, which even the hardiest spores are unlikely to tolerate for extended periods.

Primordial Soup

In part to address the serious limits of panspermia, Alexander Oparin and John Haldane independently proposed the "primordial soup" theory in the 1920s (Sullivan and Baross, 2007). It postulates that life arose through progressive chemical evolution from simple to more complex organic molecules in aqueous ponds. For this to occur, however, the Earth's early atmosphere had to be "reducing" or oxygen-free, to prevent oxidative breakdown of complex organic molecules into simpler units again.

This proposal gained experimental support in 1953 by the work of Stanley Miller and Harold Urey (Miller, 1953) who subjected mixtures of gases like methane, ammonia, and hydrogen to spark discharges in a totally sterile, oxygen-free apparatus (Figure 2). This scenario was intended to simulate pre-biotic conditions on the young Earth, and resulted in rapid formation of mixtures of organic molecules, including amino acids, the building blocks of all proteins. Similar experiments since have produced precursors to nuclei acids, including DNA and RNA, as well as sugars and lipids, important energy and structural components for living cells (Service, 2015). Despite these encouraging findings, the primordial soup scenario has so far failed to account for the most important final step, namely the origin of cells, the autonomously replicating units of all life on Earth.

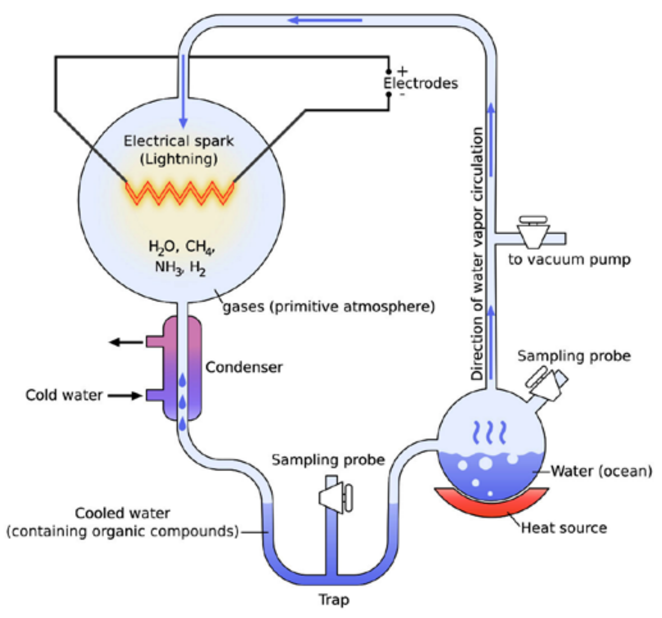

Figure 2 — Schematic of the 1953 Miller–Urey experiment, illustrating the synthesis of amino acids and other complex organic compounds from simple gases and water vapour in an oxygen-free, totally sterile recycling apparatus. Electric sparks simulating lightning provide the requisite energy. (Wikimedia)

A variety of other life origin scenarios have since emerged, particularly in light of the vast domain of organisms known as extremophiles (Baross, Schrenk and Hubert, 2007). These fascinating and highly varied organisms, comprised mainly of microbes, thrive under extreme environmental conditions, including hot springs, highly acidic and alkaline media, salty settings, below freezing and, most exciting, in deep-ocean hydrothermal vents. Might they include some of the earliest life forms on Earth? Most likely, but again do not as yet explain the origin of cells.

Further complicating this picture is that over 100 complex organic molecules have been detected in the interstellar medium, circumstellar disks, and the Orion Nebula among other locations (en.wikipedia, 2017) (Figure 3), and recently the biologically important amino acid, glycine, was detected in two well-known comets, Wild 2 and 67P/Churyumov-Gerasimenko (Lewin, 2016). Equally unexpected is evidence for organic material and water ice on the dwarf planet Ceres and, most exciting, recent evidence from the *Cassini Mission* of organic molecules in the emission plumes of Saturn's moon Enceladus (Sneed, 2016) (Figure 4). Enceladus, along with Jupiter's moon Europa and other Solar System "water worlds," contains a subsurface ocean which periodically vents and releases icy jets of its contents. Collectively such findings suggest that since early Earth and other Solar System bodies were probably seeded with various pre-biotic organic precursors, these may have provided a head start for the formation of life, but again also offer indirect support for some form of panspermia. This has been termed "soft" or pseudo-panspermia.

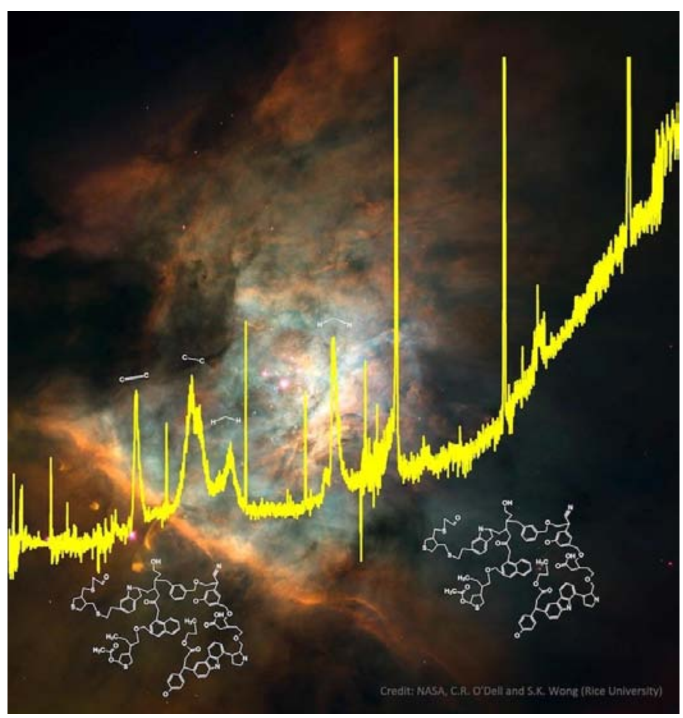

Figure 3 — Spectra of complex organics discovered in the Orion Nebula (NASA)

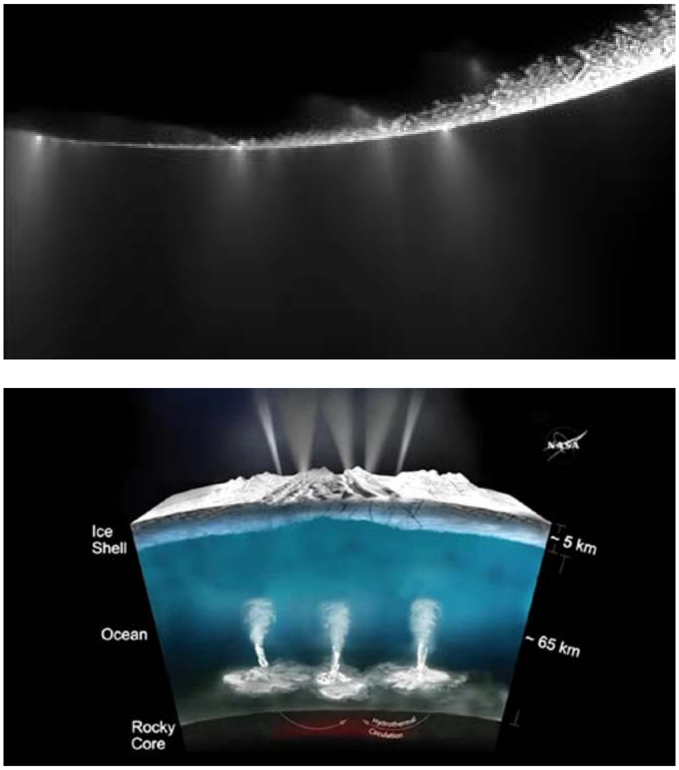

Figure 4 a, b — Cassini images of icy jets emanating from the south pole of Saturn's moon Enceladus (top), and schematic representation of subsurface activity giving rise to them (bottom). If life exists in such an ocean, future space-mission sampling of the icy jets might be able to detect its signature. (NASA/JPL)

Microfossils and related isotopic markers are some of the earliest geologic signs of life on our planet, generally between 3.4–3.8 billion years ago. Among the best documented are sedimentary mats of microbes called stromatolites (Figure 5 a, b, c). Living examples of these grow in the intertidal zone of Shark Bay in Australia and elsewhere, and are nearly identical to fossil stromatolites dated back to 3.5 billion years ago (Bennet and Shostak, 2017). In addition, several as-yet controversial studies, based on zircon crystals, may push that date back even further, possibly to 4.1 billion years ago. Since the Earth itself is about 4.5 billion years old, this suggests that life gained a foothold here very early indeed and conceivably through seeding by organics and even microorganisms from space.

Proposed Mechanisms of Panspermia

Three broad types of panspermia mechanisms have been proposed: 1. Random microbial transport by stellar radiation; 2. Transport within rocks or ejecta (lithopanspermia) from one planet to another, and, perhaps most intriguing, 3. Directed or purposeful propagation by advanced civilizations. Let us examine each of these possibilities in more detail.

The first hypothesis was seriously advanced in 1974 by astronomers Fred Hoyle and Chandra Wickramasinghe. Predicated on the notion that life did not originate on Earth, they proposed that it permeates the Universe and spreads from stellar system to stellar system essentially continuously. They even suggested that microbes continue to seed the Earth at present and might be sources of new diseases. Whatever the merits of panspermia, the "pathogens from space" idea is untenable for many reasons, including genetic incompatibility with humans and other animals. Known viruses and bacteria mutate faster than most other terrestrial life forms, yet only rarely jump from one species to another because of genetic and immunological barriers. Consequently, the probability that a totally alien pathogen could overcome those barriers is next to nil, even if its genome were nucleic acid-based.

Many obstacles face the proposed passive migration of microbes across interstellar distances, including the vacuum of space, huge variations in temperature, various types of deadly radiation, and progressive degradation of biomolecules over eons of time involved. Nonetheless, given ongoing discoveries of novel extremophiles, this type of panspermia cannot be totally ruled out. For example, bacteria like *Deinococcus radiodurans*, not only survive extreme cold, dehydration and high vacuum, but also ionizing radiation doses 1,000 times higher than what humans and most other known organisms tolerate (Figure 6). They accomplish this through multiple copies of their genome and the ability for rapid DNA repair. Equally intriguing are bacteria that stay quiescent within structures called endospores. The latter can survive almost indefinitely under extreme conditions of desiccation, high temperatures, UV radiation, and chemical damage (Figure 7). These are but some examples of organisms adapted to extreme conditions on Earth, and many more await identification

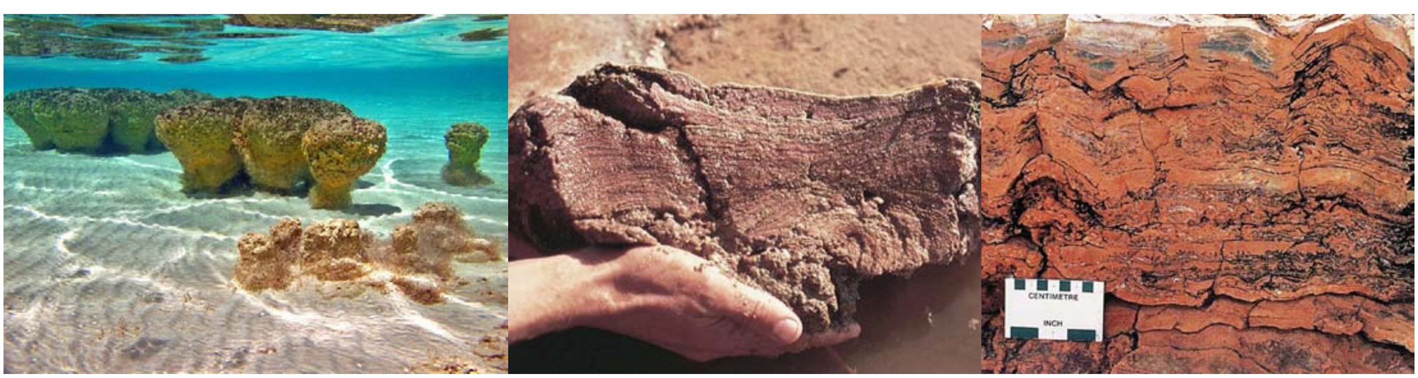

Figure 5 a, b, c — Living stromatolites (left), living bacterial matts (centre) and 3.5 billion-year-old fossilized stromatolites (right). (All public domain).

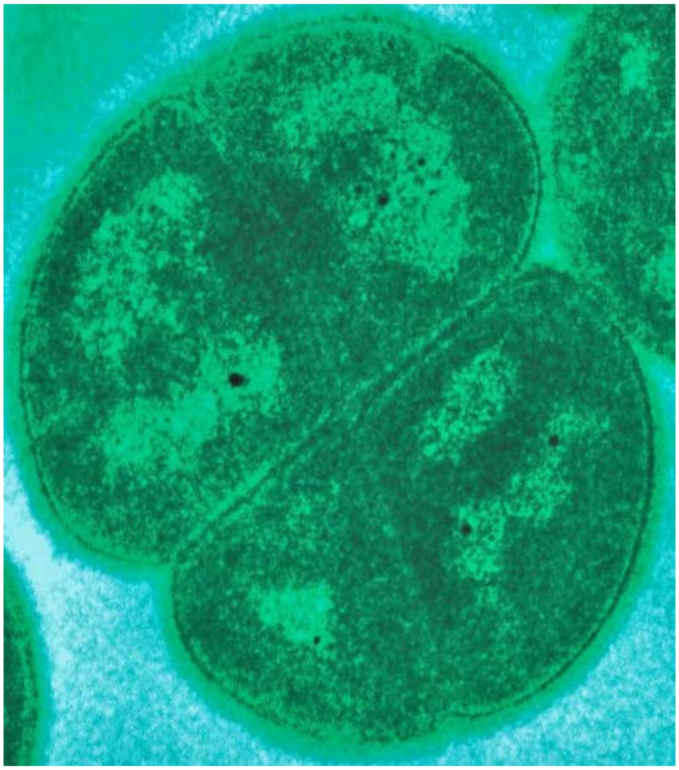

Figure 6 — Electron micrograph of the extremophile **Deinococcus radiodurans**, which has evolved to withstand ionizing radiation 1,000 higher that what most other known organisms can tolerate. (Wikicommons)

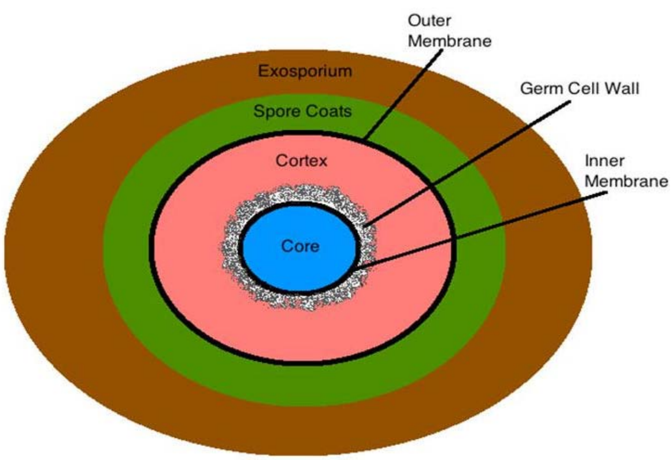

Figure 7 — Schematic illustration of a bacterial endospore, containing a dormant cell encased in protective layers resistant to desiccation, high and low temperatures, chemical damage, and UV radiation. (Microbewiki)

(Baross and Schrenk, 2007; Impey, 2011). Whether variants among these might withstand the rigours of space travel is of course an open question.

Still, as we have learned, nature continues to surprise. Several recent studies with selected extremophile bacteria, and even complex organisms like tardigrades or "water bears," indicate that some can survive for long periods in space environments. For example, halophilic or high-salt-tolerant bacteria, aboard the *International Space Station*, were exposed for nearly two

Figure 8 — Scanning electron micrograph of a water bear (Tardigrade), the smallest and most resilient class of animals known (public domain).

years to space vacuum, light and dark, and various types of ionizing radiation (Mancinelli, 2015). Survival rates compared to ground controls varied, depending on the intensity and type of UV radiation, but some exhibited limited survival. Samples kept in the dark but exposed to space vacuum had around a 90% survival rate.

Experiments with water bears (Figure 8) are even more surprising (see: Zell). Although microscopic in size, these remarkable invertebrates (Tardigrades) are among the oldest and most resilient animals known; with some species resistant to temperature ranges from –272 °C to +150 °C, extreme desiccation, the vacuum of outer space, and ionizing radiation at doses hundreds of times higher than the lethal dose for humans and other organisms.

The consensus among researchers today is that microbial spores, seeds, and possibly other forms of resilient terrestrial life could survive extended periods or dormancy and travel through space if they are adequately shielded against UV and other ionizing radiation, as for example within meteorites (en.wikipedia, 2017b; Horneck, Klaus, and Mancinelli, 2010).

In a recent publication, two astronomers (Lin and Loeb, 2015) propose a statistical model to assess whether primitive life could spread between other planetary systems and whether that might be theoretically observable. They propose to do this by looking for clustered distribution of Earth-like exoplanets exhibiting spectroscopically detectable biosignatures in their atmospheres. These might include water vapour, high levels of oxygen and methane, and possibly other molecules produced by and/or associated with life. For example, the disproportionately high levels of oxygen (21%) in the Earth's atmosphere are a direct result of continuous photosynthesis. As the authors state "…a smoking gun signature of panspermia would be the detection of large regions in the Milky Way where life saturates its environment, interspersed with voids where life is uncommon."

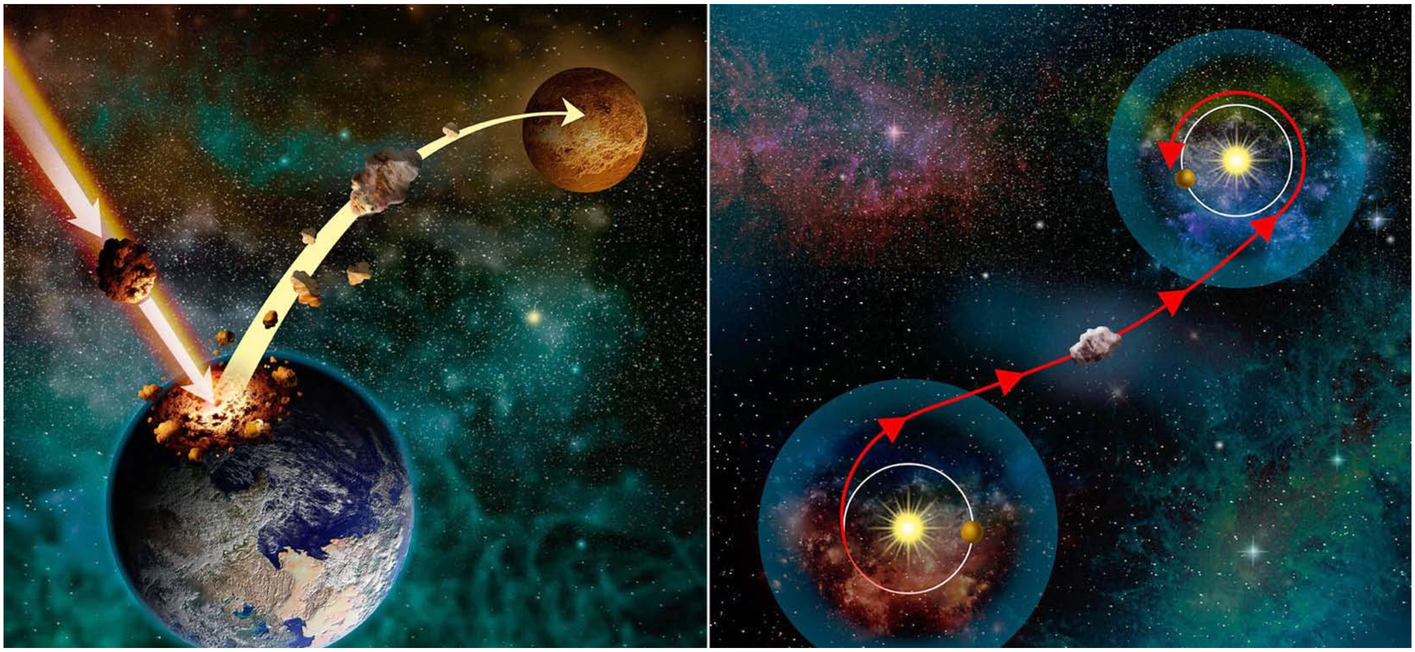

Figure 9 — Lithopanspermia illustrating potential microbial transfer from Earth to Mars and vice versa (Litrapix.com-Google public domain)

Lithopanspermia

This proposed type of panspermia rests on relatively firmer ground (panspermia-theory.com, 2017). One version goes something like this: Suppose life originated or infected Mars early on when its atmosphere was thick enough to support liquid water, as recent findings strongly suggest. Next, if high-energy asteroids or comets struck the Martian surface, chunks of material containing microbes might have been flung into space, some along trajectories transferring them to other planets including Earth (Figure 9). We know this has happened, as over 100 presumptive Martian meteorites have been recovered here, including most famously ALH 84001 (Figure 10 a, b). This atypical, igneous rock is thought to be over 4 billion years old and contains what appear to be microfossils. The jury is still out on whether these are true fossils and if so, indigenous to Mars or simply terrestrial cross-contaminants.

Tantalizing puzzles like these make it all the more pressing that future missions to the Red Planet fully characterize or, better still, return Martian rocks and soil samples to Earth for analysis. Suppose such samples did indeed provide direct evidence of past or even present microbial life on Mars, what could that tell us? If such Martians are nucleic-acid- and protein-based like terrestrial life, it would certainly imply that interplanetary panspermia is possible. Of course, this would again not tell us how or where life originated, only that some form of cross-contamination between the two worlds occurred in the distant past.

Possibly more intriguing though, would be to find that Martian life is not nucleic-acid- and protein-based but exhibited significantly different biochemistry. For instance, instead of DNA or RNA as their genetic material, what if they

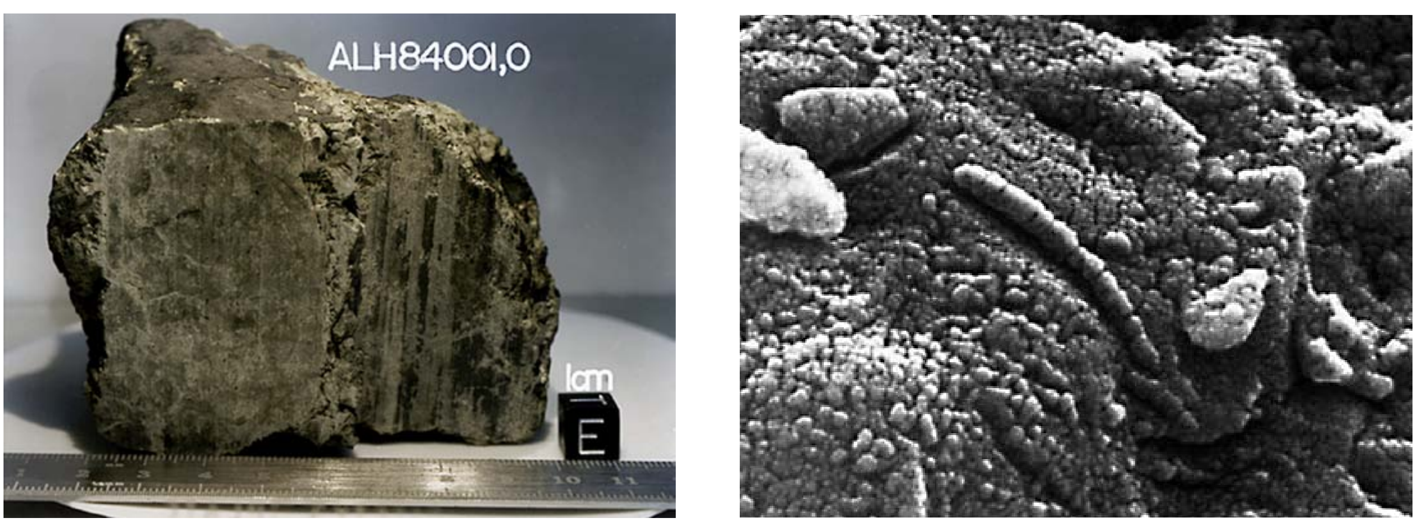

Figure 10 a, b — The famed Martian meteorite ALH8001 (left) and a scanning electron micrograph of putative microfossils present inside it (right). (NASA)

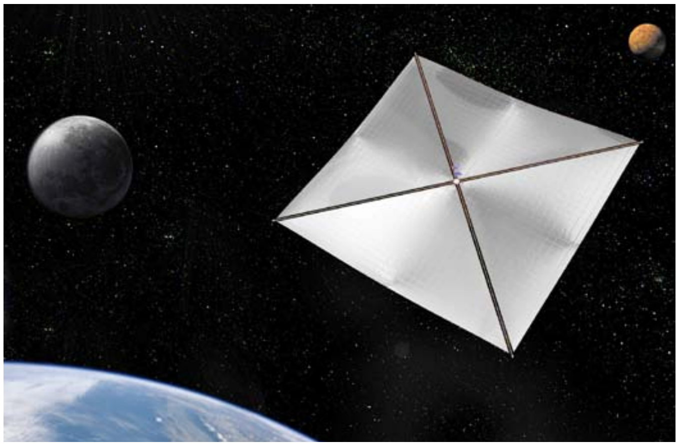

Figure 11 — The light sail concept for interstellar travel as proposed by the Breakthrough Starshot and similar projects. (NASA)

were solely protein-based? We do have examples of such life on Earth in the form of prions. These enigmatic infectious agents composed entirely of protein have been linked with neurodegenerative and other diseases in both humans and animals.

Should any alien organisms we might encounter in the Solar System differ markedly in structure and composition from terrestrial life, that would imply they arose independently. This would hold true even if all alien life were carbon-based, which seems likely given carbon's abundance in the cosmos and its chemical versatility. In short, any evidence of life past or present in the Solar System would answer some questions but, as so often happens in science, raise a whole bunch more.

Directed Panspermia?

Though initially suggested in 1930 by science fiction writer Olaf Stapleton, this theory was seriously deliberated by Iosef Shklovskii and Carl Sagan in their seminal work *Intelligent Life in the Universe* (Shklovskii and Sagan 1966). They delineated the many hurdles and hazards facing any type of microbial propagation through our galaxy, and, while considering success highly improbable, did not rule out directed transfer by an advanced civilization.

By the 1970s, since no solid scientific explanation of the origin of life seemed forthcoming, Francis Crick and Leslie Orgel published a paper in the journal *Icarus*, formally outlining a theory of directed panspermia (Crick and Orgel, 1973). Among other things, they discussed how and why an advanced civilization might try this and whether there is any evidence this has actually happened.

With regard to motivation, the authors asked what might persuade us to, as they put it, "pollute" another planet with terrestrial organisms? Since they saw no obvious advantages for us to do that, they surmised we might try it to show our technical superiority, or through some form of missionary zeal. They go on to suggest that, in view of our precarious situation on Earth, "we might well be tempted to infect other planets if we became convinced that we were alone in the galaxy." Clearly these assertions ring as true today as they did 45 years ago.

That raises the intriguing question as to whether life on Earth might have arisen through some form of external infection. Several authors have considered that possibility and what sorts of signs we might look for. Davies (2011) and others advocate looking for "weird" life forms on Earth that don't fit the known parameters common to all organisms we have studied so far. For instance, looking for extremophiles not based on the familiar DNA/RNA/protein trilogy, or even cryptic code sequences in our own or other animal genomes. Might that sort of finding hint at possible multiple starts for life on Earth or a past panspermia-like event? Possibly, but we have, as yet, no evidence of such "shadow" life.

Much has changed since Crick and Orgel's 1973 paper. For one thing, we now know that exoplanets abound in our galactic neighbourhood, including many Earth-sized candidates in the putative habitable zones of nearby stars. Notable among these are, Proxima Centauri, the red dwarf TRAPPIST-1, as well as developing planetary systems with accretion disks, including Alpha PsA (Fomalhaut) and Beta Pictoris. Given their relative proximity to us, might they be candidates for a future directed panspermia experiment?

Interstellar travel has intrigued us for centuries. The problems of course are the vast distances involved even to the nearest stars and the absence of any current technology in reaching them within reasonable periods of time. Fortunately, this has not stopped visionaries from coming up with novel ideas that just might work. Notable among these is the Breakthrough Starshot project recently announced by entrepreneur and physicist Yuri Milner, who has committed $100 million toward development of a light-sail fleet of tiny spacecraft capable of reaching about 20% the speed of light propelled by giant Earth-based lasers (Figure 11). Endorsed by such luminaries as Steven Hawking and Mark Zuckerberg, this proof-of-concept project could lay the foundation for a first launch to the Alpha Centauri system within a generation.

Should efforts like this prove feasible, it would, possibly, provide us the capability for directed panspermia. The question then becomes, would we, and if so, why? Given our insatiable curiosity and urge to explore, it seems likely that we would, if for no other reason than that we can. That still of course does not resolve the conundrum as Martin Line pointed out in his 2002 article titled: *The enigma of life and its timing* "…an origin of life on Earth appears highly improbable, an origin elsewhere is highly conjectural." Still, we may be closer today than we have ever been to finding the answer. ✶

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Feature Articles / Articles de fond

Astronomy in Philately

by Rick Stankiewicz, RASC member, unattached

For decades, countries around the world have been coming up with weird and wonderful ways to make postage stamps visually unique and appealing to collectors and the public alike. There have been embossing techniques for a 3-D effect, the use of metal foils, odd-shaped stamps, and the ever-popular holographic imaging.

In the 1970s, thermochromic inks or special dyes were developed as temperature-sensitive compounds that temporarily change colour with exposure to heat. A leuco dye (from the Greek leukos: white) is a dye that can switch between two chemical forms, one of which is colourless. Reversible transformations can be caused by heat; resulting in an example of thermochromism. The colourless form is sometimes referred to as the leuco form, and with this came its application for thermoprinting. Since at least 2001, when Britain used this technology to celebrate the centenary of the Nobel Prize using thermochromic ink, various countries have taken their turn to try out this unique and flexible means to create two stamps for the price of one.

This year was the first time that the U.S. Postal Service issued a thermochromic postage stamp design. Issued June 20, in time for the August 21 total solar eclipse, this square-shaped non-denominated (49-cent valued) "Forever" stamp depicts a black, round silhouette that covers the face of the Sun, surrounded by a ghostly grey corona shooting out into space (Figure 1). When the stamps surface is warmed by the pressure of a finger or a warm breath, the black ink covering the silhouetted full Moon, melts away revealing the craters of the lunar surface (Figure 2). As the stamp cools, the thermal ink once again conceals the lunar disk and the silhouetted Moon again covers the Sun, as was to be witnessed on the afternoon of totality, August 21 (Figure 3).

Care must be taken to not overexpose these stamps to the ultraviolet rays of the Sun or the inks may breakdown and fail to work as intended. For a premium, a custom black protective sleeve was offered with the stamps, when a pane of 16 stamps was purchased. A map of the August 21 total eclipse path across the continental U.S. is printed on the reverse of the stamp pane. The design for the stamp was based on a photograph taken by famous astrophysicist Fred Espenak (Mr. Eclipse), from his trip to the total eclipse in Jalu, Libya, 2006 March 29.

This stamp issue has proved very popular with the public, resulting in many sold-out locations around the U.S. by the time the day of the eclipse came around. I made arrangements to secure my sheet of stamps with local residents who I connected with in advance of my eclipse travels down to Hopkinsville, Kentucky.

However, the United States was not the only country to issue a thermochromic stamp for the eclipse in 2017. In order to get in on the action and potential philatelic success of the

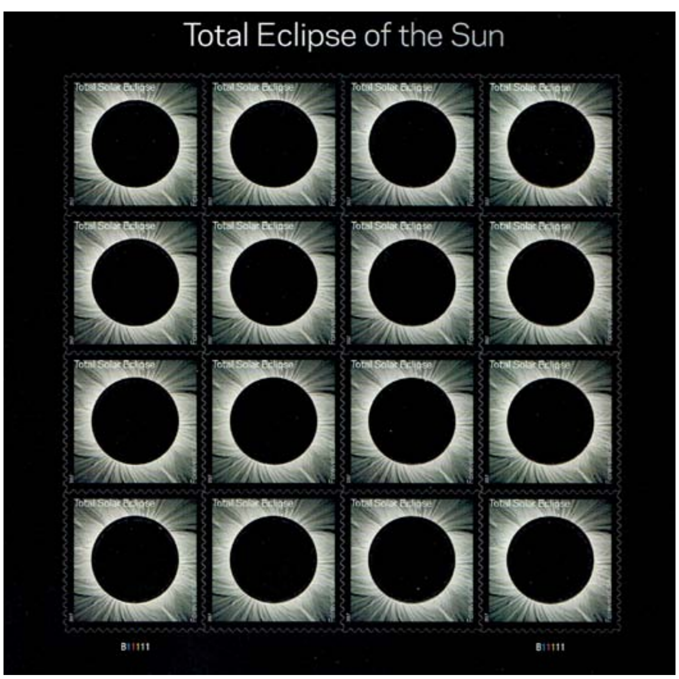


Figure 1 — United States Postal Service eclipse stamp "pane," in the cooled state.

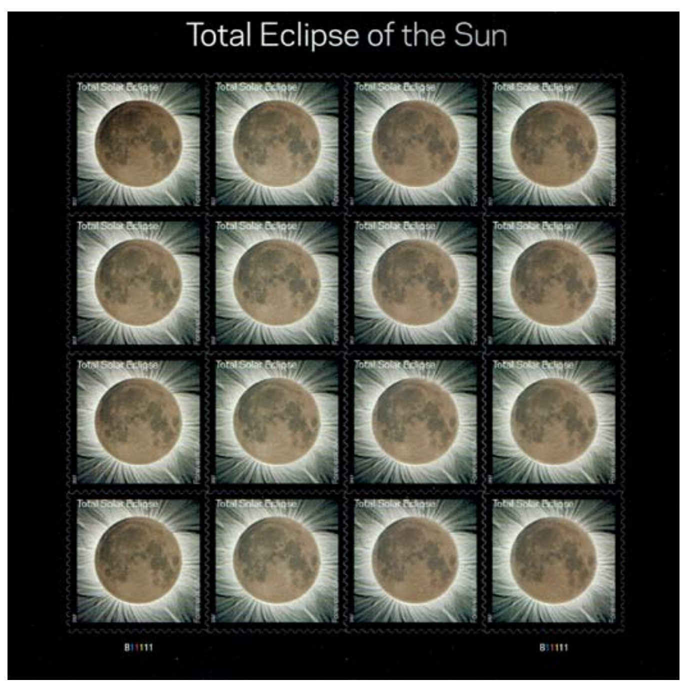
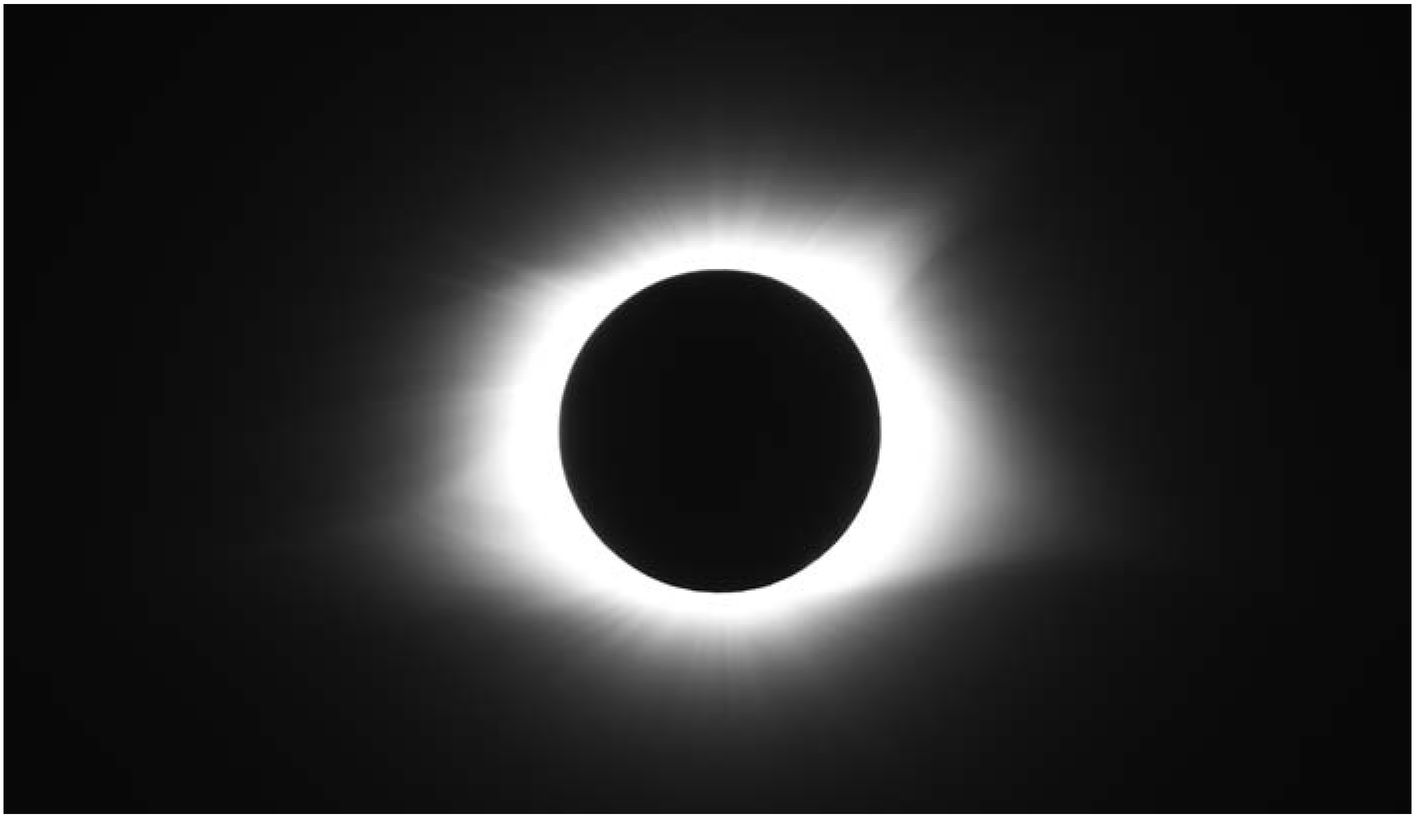
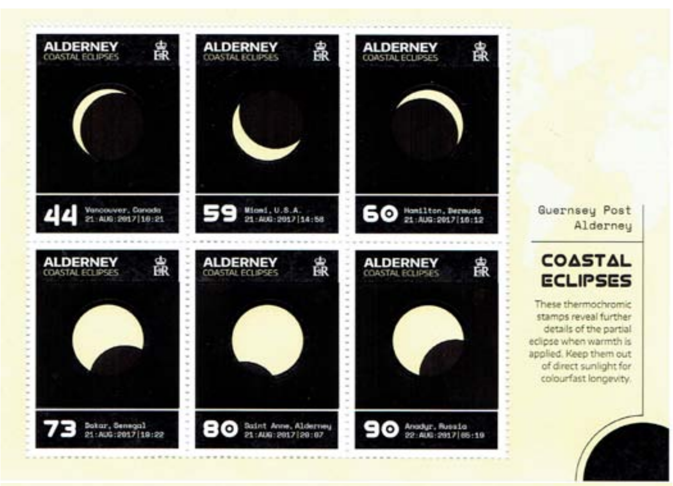


Figure 2 — United States Postal Service eclipse stamps in the warmed state.





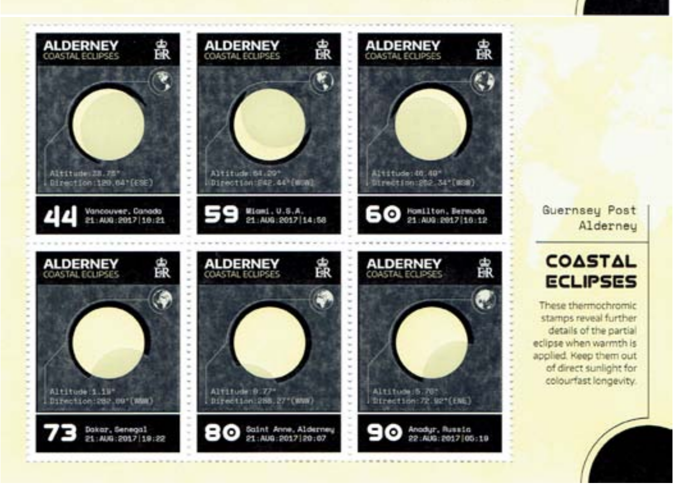


Figure 3 — Image of totality by author, August 21 (Hopkinsville, Kentucky)

Figure 4 — Guernsey Post, Alderney eclipse stamps "mini-sheet," in the cooled state.

Figure 5 — Guernsey Post, Alderney eclipse stamps in the warmed state.

Great American Eclipse of August 21, Guernsey Post issued a mini-sheet of six commemoratives at their standard definitive rates, for the island of Alderney, on July 19. Alderney is the northernmost of the inhabited Channel Islands. It is part of the Bailiwick of Guernsey, a British Crown dependency. This was a novel idea because it was a means by which the island of Alderney could work themselves into this astronomical event and a way to market their unique stamps to an international market.

This set of stamps features six different "coastal eclipse" locations, which were to be treated to a partial eclipse on the day of totality in the United States. The 44-pence denomination was for Vancouver, Canada; 59-pence was for Miami, U.S.A.; 60-pence for Hamilton, Bermuda; 73-pence for Dakar, Senegal; 80-pence for Saint Anne, Alderney (of course), and the 90-pence for Anadyr, Russia. The stamps in their cooled state depict a yellow solar disk depicting the maximum eclipse for that location. The time and date of the depiction is also part of the design (Figure 4). When warmth is applied, the Sun's disk is fully exposed and the altitude and direction as well as a tiny map for each locale are presented to the viewer (Figure 5).

As a first-time eclipse chaser and a philatelist, this year's offering of unique stamps to commemorate this astronomical event was a thrill and made for a great collection of related souvenirs. You have to wonder though, "What will they think of next?" ✶

RASC Outreach: Endless Opportunities for Creative Engagement with Novice Observers

by Tony Schellinck

Over the last eight years I have taken an amazing journey. I began as a novice observer hardly knowing where to find a globular cluster; now, I literally teach hundreds of people a year how to observe the night sky. My initial efforts at outreach were motivated by Paul Heath, the 2017 QILAK Award winner. I attended one of his events for children at the Discovery Centre in Halifax and saw how he taught by having his audience members participate in various activities. For example, he had children creating Moon craters by dropping nuts of various sizes into a box full of cinnamon-covered flour. I was very inspired by the impact and novelty of his presentation and decided immediately that I wanted to give outreach a try. I thought that the best way to master a subject would be to teach it and I had a lot to learn.

My first presentation was at the Dartmouth Library for beginner telescope users. A fellow RASC member, Chris Young, attended and gave me excellent feedback on my performance. Most of the slides were provided by others who had given the talk before (thanks to Andrea Misner). Over time as I became more knowledgeable, I expanded my repertoire to include a talk on the Moon, and on travel from Earth to the far reaches of the Universe. Most of these slides now featured photographs I had taken of the night sky and deep-sky objects (DSOs). I was making progress.

About this time, I was completing the Messier 110 and one of my goals was to find as many objects on the list as I could with binoculars. I did manage to find over 60 of them with binoculars, which gave me an appreciation of how they could be used to introduce the novice observer to night-sky viewing. I started taking several pairs of binoculars to outreach events such as the annual Nova East Star Party and the Kejimkujik Dark Sky weekends. I spent the evenings showing people how to find the brighter and easily located DSOs, such as Andromeda and the globular cluster M22.

Figure 1 — Here the audience at the flat-screen planetarium show sit at the back of the Astor Theatre and develop their skill at finding deep-sky objects through binoculars. (Photo: Heather Schellinck)

Then came the big move. I was invited to give several shows at the Halifax Planetarium. I saw this as an excellent learning experience. I had big shoes to fill with the likes of Quinn Smith, Chris Young, Patrick Kelly, and Dave Lane, past and present hosts there. I brought my own flavour to the shows when Stephen Payne, the planetarium's administrator, helped me to set up a data projector to display my photographs and PowerPoint slides on the dome. Now I could show the audience how to find the DSOs I was describing. This made the presentation more interactive and kept the audience attentive, i.e. awake, in the dark planetarium.

I really enjoyed these planetarium events and started introducing people to binoculars at the beginning of each show and explaining how they could use them to find the objects I discussed in the presentation. If the sky was clear, Stephen Payne and I would take those interested to the roof of the Sir James Dunn building in which the planetarium is located on the Dalhousie campus. I would take the binoculars up so the folks could practice finding the objects I identified during the show. Most attendees left enthusiastic about how they could view the night sky.

I began thinking it was a shame that those who lived outside of Halifax were missing out on the opportunity to visit the planetarium. I decided to try to make a portable one by drilling holes in an aluminum bowl and using a parachute as the dome but that proved to be futile. I had to think of something else. So, I came up with the idea of creating a flat planetarium show that I could put on in the smaller movie theatres around the province. I started by taking fisheye images of the night sky that could be displayed on the screen as a substitute for the dome of the planetarium. I also took time-lapse photographs so that the audience could see the movement of the stars just as they would in a planetarium. I took a series of photographs for each DSO where I started with a wide-field shot akin to what they would see with the naked eye, followed by a close-up of the constellation where the small grey smudge that was the target DSO could be seen. I then had another photograph that had the same field of view as most binoculars (5° – 7°). This is where the audience participation part came in.

Prior to the show I invited attendees to bring their binoculars from home, although I noted that I would need quite a few pairs to lend out as well. Once there, I had the audience sit at the back of the theatre as I had adjusted the scale of some of my images so that those looking through binoculars from that distance saw a view much like what they would actually see

Figure 2 — Here I am with my binocular table. (Photo: Heather Schellinck)

in the sky. After showing them how to star hop and having them practice finding the DSOs, I would show them a new image different from those I had used to train them. Then, they would have to find the DSO on their own. It was very rewarding to see 50 people staring through their binoculars and then many shouting out excitedly "I found it!" I concluded the demonstration with a close-up colour shot of the object photographed through my telescope. At this point I spent time describing the objects in detail so that the audience could appreciate the nature of what they would be viewing.

After the show, I took the people out to a nearby field where I showed them how to use the binoculars. I was usually accompanied by my friend, Wayne Mansfield, who showed them what the DSOs look like through his 8″ Dobsonian. Thus far, I have given flat-screen planetarium shows in Liverpool, Bridgewater, and Shelburne. There is usually a $5 charge or donation required at the door that goes to supporting the local community theatre where the show takes place. I am continuing to look for and contact community theatres or large meeting halls in other communities in rural Nova Scotia that can be used to present these shows.

It was becoming clear that everyone was really enjoying looking at DSOs with binoculars. I concluded that I needed to get more organized when conducting outreach in the field, and had the idea of creating a Binocular Table. I visited most of the Canadian Tire stores in Halifax and asked if they had display binoculars they wanted to sell off for a good cause. I obtained several pairs at ~$40 and augmented these with others I purchased on sale there. I found mostly the Outbound brand to be very suitable for the novice observer. In the end I had 15 pair of binoculars including 7x35, 8x40, and 10x50s. I found that even with 7x35s people could see the DSOs and they are more suitable for children as well as those having difficulty holding heavier sets up for an extended time. The Binocular Table has evolved and now includes overturned storage containers to cover a dozen pairs of binoculars and handouts so that they do not dew up. People are very helpful to put them back under cover after they have used them. I also made glow-in-the-dark boards that illustrate the constellations and show how to find the target DSOs.

At an outreach event, I gather anywhere from 10 to 25 people around the table. I have them take a binocular and ask them to share with someone if I have more than a dozen participants. In the late summer and fall I usually start with those objects about to set in the west, often this is the objects around Sagittarius such as M8, M21, M22, M16, and M17. We then turn our attention to the Double Cluster, M31, and M33. Depending on the crowd, the number of easily observed objects in the night sky that time of year, and time of night, I may show them how to find other less obvious deep-sky objects. I usually do three to five "shows" in an evening. If there is no one waiting for the next show, I invite the participants to take the binoculars out into the field and teach someone else how to find the DSOs. I have gone for half an hour or more without a single binocular in sight as people spread out into the field to show others how to use the binoculars to find the DSOs. I believe that teaching is the best way for these people to learn, as well.

In 2016, I decided to give these presentations more structure and purpose and I created the Ace Amateur Astronomy (AAA) Program. At the Binocular Table, I hand out to those

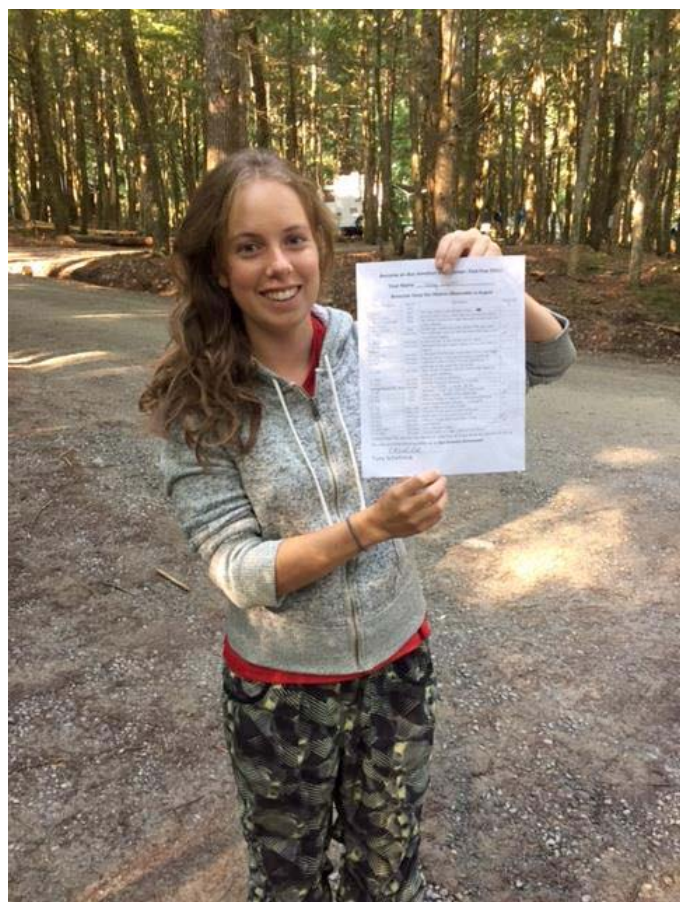


Figure 3 — Halley Davies proudly displays her Ace Amateur Astronomer (AAA) Certificate proving she could find five or more deep-sky objects using binoculars. (Photo: Dave Chapman)

Figure 4 — The SCANS class learns to sketch a DSO while using binoculars. (Photo: Tony Schellinck)

interested a sheet of paper with about 20 DSOs described that can potentially be found and observed by novice observers that month. I first show them how to find the objects and then explain that, if they find five or more of these objects on their own, I will sign the sheet designating them as Ace Amateur Astronomers. (For those who may not recall, an ace fighter pilot is somebody who shoots down five or more enemy aircraft.) I chose the low threshold of five objects so that more participants could achieve AAA status and hopefully be encouraged to continue observing. Not all participants are interested, but many are—and it is not just the younger ones who work to achieve AAA status. I have signed up to 40 sheets a night and some say (with a smile) they intend to take it home and frame it.

I have made up an AAA sheet for each of the twelve months. The ones from August to October tend to have the same DSOs listed as the Sun sets earlier each night. The sparsest month is May, with few easy-to-locate and bright DSOs. I also hand out copies of that month's Sky Map, as the location of all the DSOs listed on the AAA form are displayed on the map. These days, many participants are pulling out their cell phone or iPad and using an astronomy app they had previously installed to find the DSOs either before or after they see them through binoculars. I encourage this as I feel the two technologies (binoculars and astronomy apps) will help the novice user to observe.

I now use a Canon image-stabilized 10x42 binocular with the binocular table. After folks have found several DSOs with regular binoculars I hand them my IS binoculars and they experience a "wow" moment. With these binoculars one can clearly see Jupiter's four moons and Saturn as an oblong. They see more individual stars in open and globular clusters, more details on the Moon, and faint nebulae such as the Trifid and the Eagle are easy to spot. Finishing the viewing session with these binoculars creates considerable enthusiasm for observing the night sky with binoculars.

In the fall of 2016, I was asked to mount a six-week course for the Seniors College Association of Nova Scotia (SCANS) in Liverpool. I taught *A Practical Guide to Observing the Night Sky Using Binoculars*. We secured the Astor Theatre for the classroom and I essentially gave an expanded version of the flat-screen planetarium show to 37 seniors students over 6 weeks. I first trained them how to use binoculars for viewing. The course then covered the night sky during the four seasons as well as viewing in the Solar System with a particular emphasis on the Moon. They brought their binoculars to each class and used them to find that season's DSOs in the projected image. We also covered sketching of the DSOs they were observing. They had to view the object through their binoculars to create the sketch, thus mirroring what they would do in the field. We also had three nighttime field trips to a nearby school yard.

I taught the course again for SCANS in Mahone Bay and I added a Moon-viewing field trip and a daytime Sun-viewing field trip before one of the classes. Not every senior comes out to these field trips but those who do are very enthusiastic, and they work hard at finding the constellations and DSOs. I had not anticipated the course would be so popular, however, I am scheduled to give it in Halifax, Truro, and Chester over the next year. Much of our Centre's outreach is focused on young people so I believe it is good to provide outreach aimed at seniors, particularly focusing on binoculars.

I have combined my outreach activities with my interest in science fiction by becoming a presenter at Hal-Con, Halifax's comic convention. One of my first presentations was entitled *Everything We Know About Astronomy We Learned From Star Wars*. The premise was that George Lucas had travelled ahead many years in time and read up on astronomical discoveries before coming back to make the first Star Wars movie. Perhaps surprisingly, the series accurately did predict discoveries in astronomy. I used clips from the movies to illustrate binary stars, the possibility of life on moons, dark matter, dark energy,

Figure 5 — The SCANS class enthusiastically prepares for an evening of observing with their binoculars. (Photo: Tony Schellinck)

Figure 6 — The cast of The Night Sky According to Star Trek: Where Empires Exist. (Photo: Glenn Walton)

and so on. For my second presentation, I wrote a play titled *The Night Sky According to Star Trek: Where Empires Exist* (see www.youtube.com/watch?v=AYI7RVQR8C8 for a cut-down version of the play). The audience members take the part of Star Fleet Academy cadets and learn about the constellations and DSOs found in the Milky Way near the United Federation of Planets, as well as in the direction of the Cardassian, Ferengi, Romulan, Klingon, and Dominion empires. Besides the five brief lectures covering the Milky Way, there is much drama including a fight to the death between foes. We also put the play on at Caper-Con in Cape Breton and for a large crowd at Halifax Central Library's O'Reagan Hall on the 50th anniversary of the first airing of Star Trek (1966 September 7). When asked, members of the audience said they enjoyed the lectures on viewing the night sky as much as the dramatic action.

When planning field trips after my flat-screen planetarium shows or during the SCANS courses, I have had to search vigorously to figure out where a group of 30 to 50 people could go and safely observe the night sky. I would like to see such locations I found designated as Binocular Observatories. Just what defines a Binocular Observatory? To qualify as a Binocular Observatory, the area should be within ten kilometres of a community where the public has permission to meet during the night, and is not used by others during the evening. It must be flat with easy access with ample parking, relatively few lights and trees such that a group could stand or sit in lawn chairs and observe the sky using binoculars. When these areas are identified, I believe that the RASC Centre could then encourage groups such as various meet-up and birder groups to come out to a Binocular Observatory a few times a year and meet with one or two RASC members to work on the Explore the Universe Certificate. I hope to establish an inventory of such sites for use around Nova Scotia. During my flat-screen planetarium shows and SCANS courses, I have been building an email list of those who are interested in being informed about field trips to these binocular observatories.

I am currently compiling the Ace Amateur Astronomy material as well as creating a book on binocular observing for the novice observer that I feel would appeal to people of all ages. In order to select the DSOs, I've had people find them in the night sky using binoculars during outreach events and field trips. Only those that seem easy to discover will be included in the book. So far, I have identified 46 objects that people can easily observe throughout the year.

Membership in RASC has provided me with the opportunity to indulge my creative side, and also allowed me to continue teaching, something I enjoyed doing for 35 years as a professor.

It is very rewarding to hear from people who say that, after attending one of my talks, they have dusted off that old pair of binoculars or purchased new ones and used them to observe the night sky. Several of my seniors' students have said they are purchasing RASC memberships for their adult children for Christmas. I continue to receive requests to put on flat-screen planetarium shows and to teach the SCANS course in different communities around Nova Scotia. This year so far, I have set up my binocular table 13 times at outreach events.

People have a real hunger to learn about what is in the sky and to have the experience of finding deep-sky objects themselves. I have the ability to help them fulfill this need. Outreach provides me with satisfaction, learning, challenges, opportunities for fulfillment, and a way to give back to the communities in which I live. ✶

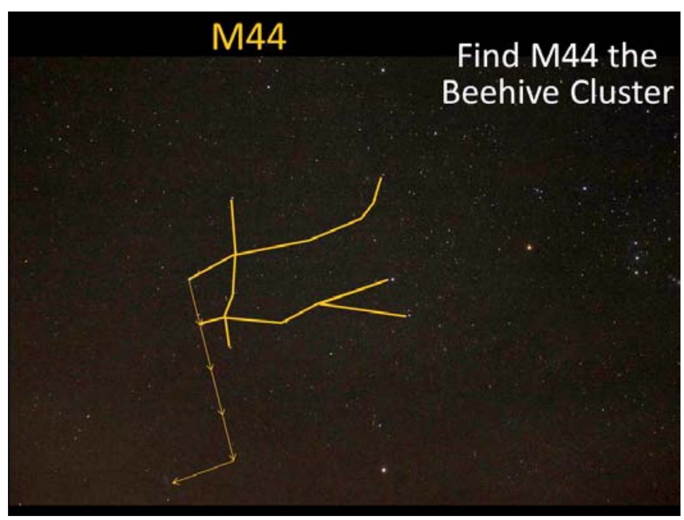


Figure 7 — This slide shows the guide stars and how to hop to M44, the Beehive Cluster. The use of my photographs makes the exercise more realistic for the students and gives them greater confidence that they can find the objects when observing on their own.

CFHT Chronicles

A Great Year at CFHT

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

SPIRou update

As you may recall from previous CFHT columns, we are expecting the arrival of a new instrument, SPIRou. SPIRou is a near-infrared spectropolarimeter and high-precision velocimeter, i.e. it is a planet hunter, optimized for the detection of Earth like planets. SPIRou maybe the most complex instrument ever built for CFHT. The SPIRou team is spread across the world, with the instrument construction in Toulouse, France.

At the end of November, SPIRou passed the acceptance tests required for shipping to CFHT. We anticipate shipping by the end of 2017 and arrival at CFHT in mid–late January 2018. As you read this, SPIRou is likely being installed and tested at CFHT! We will provide a detailed SPIRou arrival update in the next edition.

2017 Science Highlights

2017 was an excellent year for science at CFHT. Our last science update over the summer covered the work of Trent Dupuy and Mike Liu on the upper mass limit for brown dwarfs. Let's talk about what science results we saw this fall…

The GRACES project was responsible for our first two announcements. GRACES or Gemini Remote Access to CFHT's Espadons Spectrograph is a joint project between CFHT and our neighbour on the summit (and fellow Canadian telescope) Gemini North. GRACES combines the large aperture of Gemini (8 metres) with the high-resolution spectroscopy of Espadons at CFHT. A 250-m fibre-optical link connects Gemini with Espadons in our inner coude. This link allows Gemini users access to the high-resolution spectroscopic features of Espadons, but not its spectropolarimeter features.

The Little Star that Survived a Supernova

In August, an international team of astronomers led by Stephane Vennes at the Astronomical Institute in the Czech Republic announced the identification of a white dwarf moving faster than the escape velocity of the Milky Way. This high-velocity star is thought to be shrapnel thrown away millions of years ago from the site of an ancient, peculiar Type Ia supernova explosion. In addition to GRACES, the team used telescopes located in Arizona and the Canary Islands via a 250-metre optical-fibre link.

White dwarfs are the very dense leftover cores of stars like our Sun. Think of an object with the mass of the Sun, but in a volume the size of Earth. Because of gravity, white dwarfs have a very specific limit on their size. If they become larger than 1.44 times the mass of the Sun, then they explode in what astronomers call a Type Ia supernova. Because white dwarfs no longer create their own energy, Type Ia supernovae only occur when a white dwarf orbits close enough to a companion star for the white dwarf's gravity to "steal" gas from the companion.

Because of the size limit on white dwarfs, astronomers can estimate the true total brightness or luminosity of a Type Ia supernova and use that information to determine the distance. Despite astronomers' understanding of the luminosity and distance relationship for Type Ia supernovae, very little is known about the explosions themselves. It is thought that nothing survives this kind of explosion.

All astronomers ever witness from Type Ia supernovae is the aftermath of the explosion, a bright flash in the sky observable with a telescope. "But now, with the discovery of a surviving remnant of the white dwarf itself, we have direct clues to the nature of the most important actor involved in these events," said Stephane Vennes.

The team studied the white-dwarf star LP40-365 for two years with telescopes around the world. The new star was first identified with the National Science Foundation's (NSF) Mayall 4-metre telescope at Kitt Peak National Observatory in Arizona. The discovery was caused in part by suboptimal weather conditions.

"We selected this object for observation with the spectrograph at the 4-metre telescope because of its large apparent motion across the celestial sphere. Thousands of objects like this one are known, but the sky was partly cloudy on that night and we had to go for the brightest star available, which turned out to be LP40-365," said team member Adela Kawka, underpinning the importance of serendipity in astronomy. "We alerted team members J.R. Thorstensen and E. Alper at Dartmouth College, and P. Nemeth at the Karl Remeis Observatory for urgent follow-up observations."

The final data was obtained with the help of team member Viktor Khalack at the Université de Moncton using a unique instrument, GRACES on Maunakea. When GRACES is in use, CFHT's spectropolarimeter Espadons receives light fed by an optical fibre hooked to its neighbour on the summit, the 8-metre Gemini North telescope. "GRACES provides astronomers the best of both worlds, the light-collecting power of the Gemini observatory combined with a state of the art instrument like Espadons. The combination packs a powerful punch and creates opportunities for discoveries like this one," said Nadine Manset, the GRACES instrument scientist at CFHT.

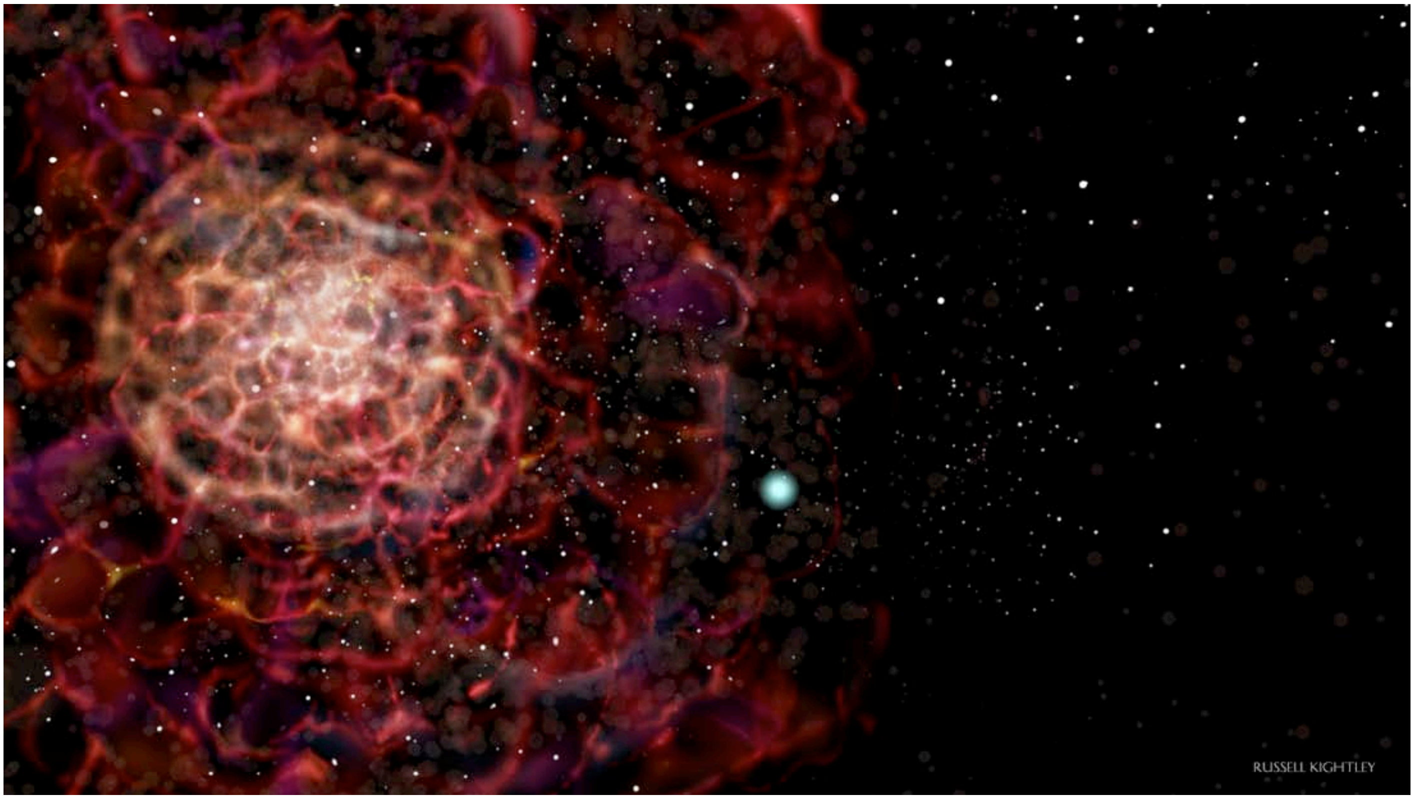


Figure 1 — An artist's rendering of the Type Ia supernova LP40-365.

After collecting the data, the team used state-of-the-art computer codes for analysis. The analysis proved the compact nature of the star and its exotic chemical composition.

"The extreme peculiarity of the atmosphere required a lengthy and complex model atmosphere analysis which [sic] crunched several weeks of computing time. But the results proved very exciting. Such a peculiar atmosphere devoid of hydrogen and helium is rare indeed," commented team member Peter Nemeth. The analysis also revealed an extraordinary galactic trajectory.

"The extremely high velocity of this star puts it on a path out of the Milky Way with no return ever," said team member Lilia Ferrario.

Supernova models and simulations did entertain the possibility of observing surviving stellar remnants in the aftermath of a supernova explosion. The unique object LP40-365 is the first observational evidence for surviving bound remnants of failed supernovae and therefore it is an invaluable object to improve our understanding of these cosmological standard candles.

Many more of these objects are lurking in the Milky Way and awaiting discovery. The recent ESA/*Gaia Mission* may well help us discover many more of these objects and help us understand how a little white dwarf star can survive supernova explosions.

Rocky Planet Engulfment Explains Stellar Odd Couple

Our second science recap for the second half of 2017 also comes from GRACES data.

A team of astronomers led by Carlos Saffe (Instituto de Ciencias Astronómicas, de la Tierra y el Espacio, Argentina) observed the peculiar binary system called HAT-P-4, which includes a confirmed exoplanet orbiting one of the stars in the pair. The GRACES spectra revealed that the star pair have markedly different quantities of heavy elements or what astronomers call "metallicity." Astronomers use a very different periodic table than chemists, one containing only three categories—hydrogen, helium and "metals," i.e. everything else. Because hydrogen and helium are the most abundant elements in the universe, the metallicity of an object is the most interesting feature to many astronomers.

The team discovered remarkable differences in the abundance of heavier elements, and the lithium content, in a binary star pair. Because binary stars are assumed to have formed from the same portion of a nebula, the metallicity of the stars should be identical. The research team speculates that difference in this case is caused by the engulfment of rocky planets early in the system's evolution, which enriched one of the stars. The work also hints at a formation scenario resulting in gas-giant planets forming relatively far from their host star.

Figure 2 — Artist's rendering of a rocky protoplanet crashing into the metal-rich star in the HAT-P-4 binary.

According to Saffe: "Both stars are believed to have formed together with the same chemical composition, which makes the difference in metallicity found in this binary system remarkable." In particular, says Saffe, the different refractory (rocky) content points toward a history of a rocky planet or planets in the system.

"We speculate that these observations can be explained by the engulfment of a rocky planet sometime during the system's evolution. This presents us with an exciting glimpse into the system's violent planet-formation history."

One star in the pair, HAT-P-4-A, also hosts a gas-giant planet orbiting at only 0.04 AU from the star. This same star also displays a higher lithium abundance than its stellar companion, which is another unexpected feature in this type of binary system. The authors use the data collected with GRACES to exclude other possible explanations, such as a peculiar composition of the stars or different rotational velocities. The team concludes that HAT-P-4-A formed the known gas-giant planet, while rocky (refractory) material accreted closer to the star, possibly due to migration of the gas giant. Saffe added: "This scenario explains the higher metallicity of HAT-P-4-A, the higher refractory abundance, and the higher lithium content."

Interstellar dust

WIRCam is having a great year. In addition to the Dupuy/Liu brown-dwarf discovery, an international team used it to look at three isolated molecular clouds to assess the reliability of commonly used dust models. The lead author, Kristi Webb is now a first-year graduate student, but the work was done during her undergraduate days at the University of Victoria. The team studied three isolated dust cores in molecular clouds and found that the properties of the cores could not completely account for their observations using state-of-the-art dust modelling.

Dust is found everywhere in the Universe and must be accounted for when studying stars and galaxies. For example,

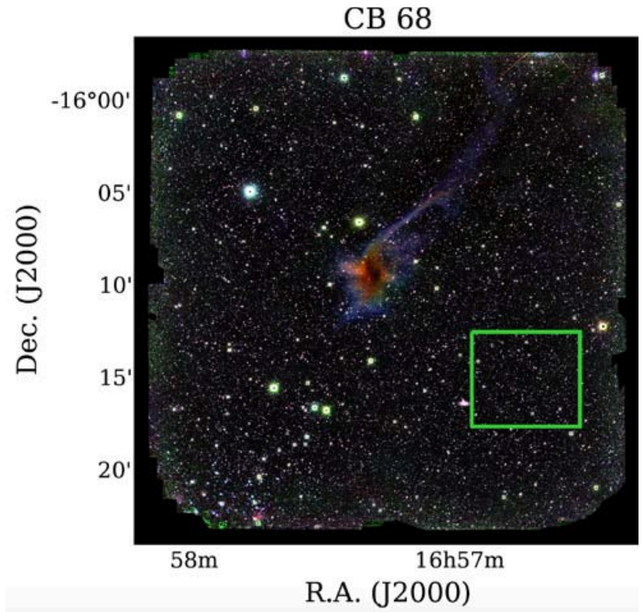


Figure 3 — Three-filter Wircam image of one of the dusty regions—CB68

dust will redden the light of a blue star and make it look red, or it will obscure a region of space making it appear starless. However, accounting for dust properties is not trivial business. The dust absorbs light chromatically meaning that the amount of light absorbed varies with colour. Also, dust emits light and can shine in the infrared or all the way down to submillimetre wavelengths. The amount of emission or absorption of light by dust depends on the physical properties of the grains. Grain size, composition, density, and geometry all factor into the absorption. To further complicate the issue, properties are also influenced by their surroundings. A nearby hot star will raise the temperature of the dust while also affecting its geometry. In short, dust is messy and difficult to model.

However, dust models are needed in the vast majority of astrophysical studies because dust affects almost every astronomical measurement. In a study aimed at assessing the reliability of such models, the team took WIRCam images of dust cores in isolated molecular clouds and determined how much the dust in these clouds was blocking the light from background stars. They then compared these results with the far-infrared emission seen in the *Herschel* data by the same dust to see if the emission was consistent with that expected from dust models used in the literature. They found consistency between dust models and the observed absorption/emission, but they surprisingly could not find a single model that was consistent for all three clouds. This result indicates that the dust in the cores is not well described by any individual dust property model considered.

Refining dust models is an important task in astrophysics. The results of this study have given pointers as to where to look to refine the models. In time, this will help astronomers have better and more accurate measurements of the quantities that rely on dust models.

A New Interstellar Friend

Possibly the biggest news out of CFHT this year involves our new interstellar friend, 'Oumuamua. A team lead by Karen Meech from the University of Hawaii used CFHT, UKIRT, and the W.M. Keck Observatory, along with Gemini South and ESO's Very Large Telescope in Chile to observe a unique object discovered by Pan-STARRS1 on Haleakala. The discovery and observations were published in the journal *Nature*.

On 2017 October 19, Pan-STARRS1 discovered an unusual object moving fast toward the west. Pan-STARRS1, a 1.8-metre telescope located at the summit of Haleakala on the island of Maui is a dedicated telescope with one instrument, the world's largest digital camera with 1.4 gigapixels. The telescope is an early-warning system designed and operated to observe Near Earth Object (NEO) candidates to determine their orbits, sizes, and whether any of them pose a threat to Earth. NEOs discovered by Pan-STARRS1 are often followed up at CFHT to establish a more accurate orbit and the nature of the newly discovered object.

Follow-up observations using CFHT on October 22 allowed the first calculation of the eccentricity or elongation of the orbit of the object. Based on the Pan-STARRS1 data, the team had an idea that the object was highly unusual. Rapid follow-up observations were essential because the object had already passed its closest point to the Sun and was moving back into space.

"Observing 'Oumuamua was demanding and exciting" said the UH resident astronomer at CFHT, Dr. Andreea Petric who was responsible for the observations that night. Special modifications were required to the standard CFHT operations, as was constant monitoring by members of the CFHT software group. The team took 60 images, adjusting several parameters of observing before the object was found. When observing fast-moving objects like 'Oumuamua, the stars do not move at the same rate as the target and appear as trails in the image. "When we were about to give up, we saw it: a dot among the trails of stars. We were thrilled," says Petric.

The elongation measurement was crucial. If the object has an eccentricity greater than 1.0, the object is not bound to the Sun, i.e. not part of our Solar System. The team calculated a value of 1.188, highly eccentric, which confirmed the unusual nature of this object. This measurement established that the object is the very first one observed that originates from outside the Solar System. Since then, the object has been observed by several observatories, refining the measurement of the eccentricity of the orbit to 1.1956. The team measured the light curve of the object and determined it was dimensionally very oblong, with a ratio of 10:1 and a mean radius of 102 metres, the size of a football field. It spins very fast with a rotation period measured at 7.34 hours. The rocky object

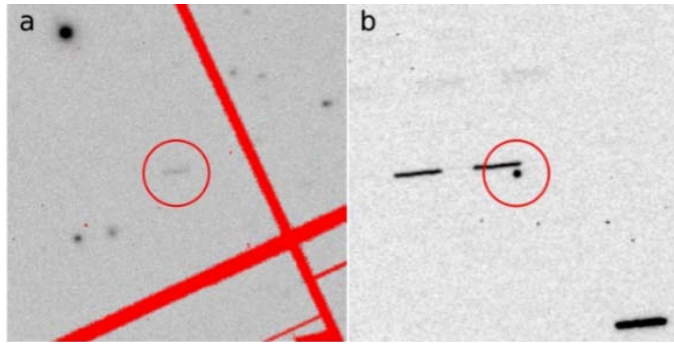


Figure 4 — The Pan-STARRS discovery image (a). The CFHT recovery images of 'Oumuamua. As a close object with a high velocity, it is a dot in a field of streaks (b). The streaks are the stars; the telescope is tracking at a non-sidereal rate.

has characteristics similar to Kuiper Belt objects, organic-rich comets, and trojan asteroids. "This thing is very strange," said Karen Meech, University of Hawaii astronomer and lead author on the paper.

"The CFHT data was absolutely critical for understanding the light curve, for our initial understanding of the orbit, and determining that this object was more like an asteroid and not a comet," noted UH astronomer Richard Wainscoat, an author on the paper.

The team decided to name the object 'Oumuamua in reference to the Hawaiian word describing a scout or messenger sent from the distant past to reach out to us ('ou means "reach out for," and mua with the second mua placing emphasis, means "first, in advance of"). The object's official name is 1I/2017 U1 ('Oumuamua). Originally denoted A/2017 U1 (with the A for asteroid), the body is now the first to receive an I (for interstellar) designation from the International Astronomical Union, which created the new category after the discovery.

The discovery of 'Oumuamua tells us that relics of the formation of other stellar systems do reach the Solar System and can be detected. This will enable direct measurement of elemental abundances in other stellar systems and testing of theories of planet formation.

Although the probability of an interstellar object hitting the Earth is fairly small, objects like 'Oumuamua would produce a larger impact since they move at a higher speed than their Solar System counterparts with the same mass. Observations to locate and characterize these objects will continue and telescopes in Hawaii will continue to play a crucial role in this effort to protect the Earth from potential destructive impact by various space objects. ✶

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.

Roman Kulesza used his AT 65EDQ ƒ/6.5 on a homemade 10-inch Newtonian and a fully modified Nikon 6D with Astronomik Luminance Clip Filter to image the North America Nebula from Tiny Township, Ontario. He took 30 sub-frames at 6 minutes each and stacked them in Deep Sky Stacker. Processing was done in Photoshop and Maxim DL.

Blair MacDonald took this spectacular image of the Helix Nebula using a Canon 60Da on an Optics Sky-Watcher Esprit 120 ƒ/7 APO refractor with a focal length of 840 mm from St. Croix, Nova Scotia, processed entirely in Images Plus.

Pen & Pixel

"This is my longest exposure to date, at 104 hr!" says Ron Brecher of his image containing the Flying Bat Nebula (Sh2-129) and the Squid Nebula (Ou 4). He used a Moravian G3-16200 EC camera (on loan from O'Telescope), Optolong Ha, O3, R, G, and B filters, and a Takahashi FSQ-106 ED IV at f/3.6 on a Paramount MX, unguided. Acquisition was done using SkyX, focused with FocusMax and all pre-processing and processing was done in PixInsight. Brecher acquired from his SkyShed in Guelph, Ontario. (right)

This great image of star trails (below) was taken by the Journal*'s Production Manager, James Edgar. He obtained this on the night of the full Moon, as the shadow on the front of the barn retreated while the Moon rose from behind the trees. If you look carefully, there's an ISS pass at the top-right corner, while an Iridium flare punctuates the middle foreground. This is a composite of nearly 400 images taken over a 2-hour period in Lorlie, Saskatchewan, at the home of RASC member, Kevin Fenwick.*

Taken on 2015 August 3, using a Canon 60Da and a Canon 8-15-mm Fisheye lens at 10 mm on an iOptron Sky Tracker mount, ISO 400 at f/4 for 13 seconds; processed with Adobe Lightroom.

Binary Universe

Finding Shadow Cones

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

The recent flyby of asteroid 1I (the first of the new Interstellar class) is an unsettling reminder that humans do not yet have a very robust planetary defence system. This fast-moving rock, originally classified as C/2017 U1 and then A/2017 U1, came out of nowhere, in a manner of speaking. Analysis of the orbital path, which only began after it whipped around the Sun, showed that it was not of this Solar System. In! Out!

If you would like to study and monitor asteroids, you can. You can contribute to the body of knowledge on asteroids by indirectly measuring their sizes and dimensions, and other characteristics, such as the presence of moonlets. You can work with others and share your results. You can help refine the orbital data of asteroids. In some cases, you can help update the star's location given its proper motion. You might conduct citizen science experiments in your backyard as a small body blocks a star. This type of celestial event is known as an asteroid occultation. While challenging, these events can be exciting and satisfying.

An occultation occurs when one object blocks another. If you were near the centreline of the August 2017 solar eclipse, you saw the Moon occult the Sun. The Earth's natural satellite regularly blocks bright stars, sometimes at the Moon's north or south pole. These events are grazes that allow further study of the Moon. Asteroid occultations occur with relatively high frequency. But given their small size, their distance from Earth (compared to the Moon), and that asteroids are blocking very distant stars (compared to the extended disk of the Sun), you need to be at a particular location on Earth to see the event. See the *Observer's Handbook* for more information on lunar and planetary occultations.

Steve Preston manages www.asteroidoccultation.com, the website which lists known upcoming events. A quick look will show you that he includes high-probability occultations around the world. If you search for the text "Canada," you will end up with a long list of candidates. Some of these won't be proximal; you may not even want to drive hundreds of kilometres. If you're serious about visually observing or making video recordings of occultations, you really want a good short list. Then you can choose the precise spot to experience the event.

For Windows users, there is an excellent solution. *Occult Watcher* (OW) is a free application by Hristo Pavlov that runs in the background scanning various data sources for new or updated occultation data. A tone will sound and a pop-up message will alert you to new listings.

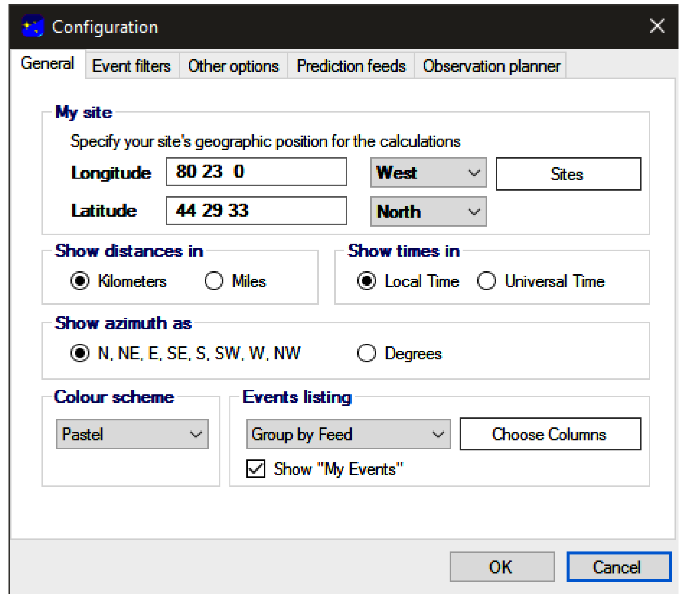


Figure 1 — Occult Watcher's *Configuration dialogue box to allow precise entry of location.*

Filters are applied that reduce the candidates to those near your preferred area. You can adjust for other criteria, such at the rank rating so that your short list has only very-high-probability events. That's useful if you are okay travelling some distance but want a hit. Some users look for events where we know little about the asteroid itself or its orbit.

Installing the software is not trivial. It seems that a formal setup program was not produced by the developer, requiring the user to deal with security issues, manually create a folder for the app, and unzip the contents of the downloaded archive to the new folder. That said, *Occult Watcher* runs on many versions of Windows. I first used it on a computer running XP, and it works fine on my Windows 10.

Observing sites can be set up via the Configuration dialogue box, using the General tab (Figure 1).

The Event Filters tab is where you set the constraints for restricting the considered events. You can indicate how far away from the centreline or sigma lines you can be, the limiting magnitude of the star, the lowest altitude for the target star, the minimum width for the shadow cast by the asteroid, and so on.

Once installed, the app will automatically launch when Windows starts. When you right-click the blue star-filled icon in the Windows notification area (Figure 2), you will be able to re-configure your settings or open the main screen.

The main display of OW lists upcoming events chronologically with newly added items showing as green on black (Figure 3). Details shown include the asteroid designation, the date of the occultation (in local time, with the day of the week, too), and the magnitude of the star to be covered. The Travel Distance

Figure 2 — The app periodically updated in the background with an icon in notification area.

column shows how far away the shadow will fall. A colour chip also helps you quickly gauge your distance. The important rank value shows. This gives you an overall sense of your chance of seeing the occultation, assuming the weather gods will be in your favour. This list can be configured for different columns and events can be grouped by source.

When you click on a row, even more detail shows at the bottom of the screen, such as the asteroid magnitude, the predicted duration and magnitude drop, and the elevation of the star at the time. You will also note the Sun's height and if you'll be contending with Luna. A custom horizon, if configured, will be taken into account. The horizontal graph indicates the predicted path and width of the asteroid. Your location is marked so you know if you're in the shadow cone or not. Observations from the 1-sigma zone can also be very useful for recently discovered objects.

Links in the bottom panel offer maps and charts. The *Show online map* hyperlink makes a familiar Google map appear (Figure 4) with lines for the centre of the path and the sigma boundaries. The *View details on the web* takes us back to Preston's site, this time directly to the specific event, where one can view detailed maps and finder charts at different zoom levels.

Within the app you can right-click to display a shortcut menu if an event sounds promising. The Additional Event Details command displays a tabbed window with technical details on

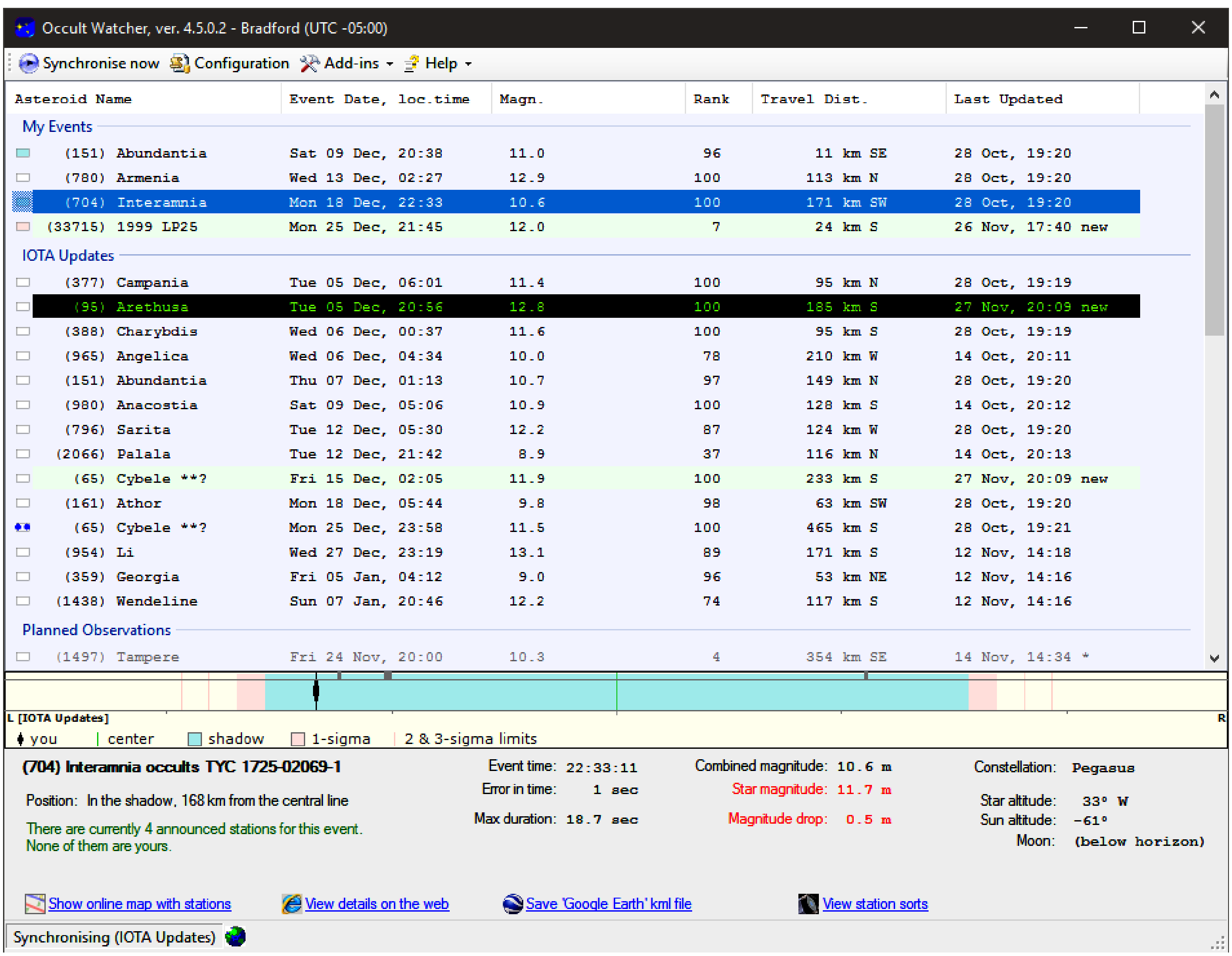


Figure 3 — Main chronological list. Interamnia highlighted (top) with details shown (bottom).

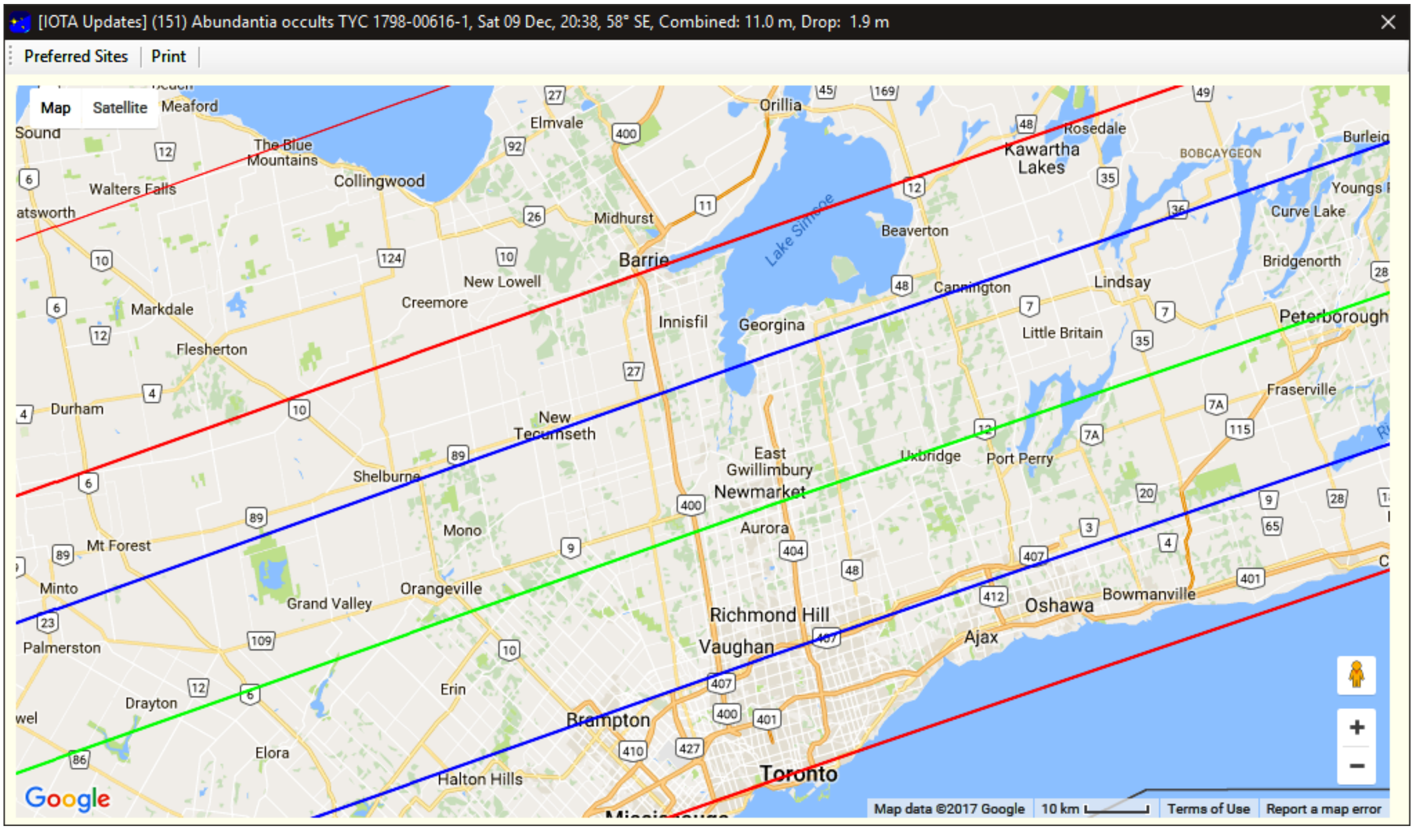


Figure 4 — Map showing centreline (green), edges of shadow (blue), and sigma lines (red).

the star, asteroid, and the event itself. If you are very interested in an event, you can mark it for "follow up," in which case it will be moved to the My Events group. Elevated items can then be "announced."

If you have configured a personal account in OW, you can notify other users of your intentions to participate in an upcoming occultation. You can indicate whether you are setting up one or several observing stations. In turn, you will be able to see other observers on your maps and where they are planning to set up. When teams collect data by coordinating their efforts, such as filling gaps in the asteroid's cross-section, a great deal can be learned about the remote small body. You can also click *View station sorts* to see more information on other stations. The International Occultation Timing Association (IOTA) may mount a campaign to gather data for a special event and you'll be able to see who is participating around the world and share your results.

OW supports a number of add-ins, which you will have to manually install. The Occult Tools add-in allows you to enhance OW with features from the Occult program (which predicts the circumstances of occultations). There is a lunar occultation plug-in I want to try, which highlights events involving multi-star systems or suspected double stars. Another you might be interested in is the Near Earth Objects add-in, which monitors close approaches. Then again, that might make you lose sleep.

I tested and took the screen snapshots from *Occult Watcher* versions 3.9.0.2 and 4.5.0.2. Updating to the latest version was straight forward. The *Occult Watcher* website (www.occultwatcher.net) has download and installation notes, online help, plus descriptions of the available add-ins. There is a *Occult Watcher* Yahoo!Group. The IOTA website (www.lunar-occultations.com/iota/iotandx.htm) has still more information on *Occult Watcher*. They also have a Yahoo!Group. For UNIX wranglers, there is a software product called LinOccult by Plekhanov Andrey. When I resurrect my Linux box, I'll try this out.

So, choose your observing site, fire up the short-wave radio, and prepare to observe a star winking out and suddenly reappearing. Out! In!

Update Bits

Meteor Shower Calendar app for Android was updated in September. The latest version is 2.4.1. ✶

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

Skyward

Early Astronomers and Their Legacy

by David Levy, Montreal and Kingston Centres

The Vatican Observatory, or *Specola Vaticana*, was bornat the direction of Pope Leo XIII, around 1891. It was a time when humanity's understanding of the Universe was moving forward, literally by leaps and bounds. The discovery of a supernova, an exploding star, within the bounds of the Andromeda Galaxy only six years earlier was proof, beyond measure, that this was a distant galaxy far away in space, and in time.

I like to think there was another, more personal reason for the Catholic Church to have an observatory. Until Pope Leo's decision, Vatican astronomy was known for the single episode of the Galileo affair. That story began innocuously enough with Galileo's discovery of four moons orbiting Jupiter. In that fateful year of 1610, Galileo instantly became the most famous astronomer in the world. He walked through the papal garden with newly elected Pope Urban VIII, who thoroughly enjoyed talking about the new astronomy with the scientist. And it is said that Urban even encouraged Galileo to publish his Dialogue concerning the two-world systems. Urban had never realized, however, precisely what the Dialogue would actually do.

Figure 1 — I grew up less than a quarter-mile from this beautiful minor basilica conceived by St. Andre Bessette and named Oratoire St. Joseph. I often enjoyed the sky from its grounds and attended some organ recitals there. Photo by David Levy.

So confident was Galileo in his theoretical argument that he named the character who objected to the new theory, Simplicio, and he did make the character out to be somewhat of a fool. Convinced that Simplicio was a parody of himself, Urban was enraged and so upset that he ordered Galileo summoned before the Inquisition and tried for heresy. In a judgement that still reverberates through history, Galileo was sentenced to life in prison. Only frantic pleas led Urban to revise the sentence; Galileo would spend the remainder of his life under house arrest. Even a young John Milton, preparing his magnum opus *Paradise Lost*, was forced to visit Galileo surreptitiously.

In this sense, Pope Leo's founding of an astronomical observatory was a sort of penance. Over the years, the institution has accomplished some wonderful science, even building a great telescope atop Mount Graham only a 160 kilometres or so east of Tucson. The institution has much of which to be proud.

In 1992, Pope John Paul II announced in no uncertain terms that the Church erred in its original denunciation of Galileo. It seemed the easiest way to handle this difficult situation. It would have been trickier to attempt a second trial; what if Galileo were to be found guilty a second time? John Paul's approach, simply, directly, and to the point, acknowledged Galileo's incredible contributions to the world as the father of modern science.

A few years ago, Wendee and I had a weekly radio program called *Let's Talk Stars* (the shows are still all available in streaming audio at www.letstalkstars.com.) The show aired on 2004 May 18, and it featured an interview of Galileo himself. In a delightful performance, Brother Guy Consolmagno—now the director of the Vatican Observatory—played Galileo. As I interviewed him, I found myself retreating back into the sands of time, deeper and deeper into a bygone era where people, not unlike us, gazed upward at the stars and asked wondrous questions about the nature of the world.

Zecharia Sitchin

Last month I visited the University of Pittsburgh at Johnstown, Pennsylvania to give a lecture. The experience was fun and intellectually enlightening. Just before the lecture, I had a good chat with the university President Dr. Jem Spectar, during which he mentioned the name of Zecharia Sitchin, a philosopher who has made some curious predictions relating to astronomy.

I decided that Sitchin was worth following up, not because he predicted that some unknown planet might come barging in on Earth someday, but because he was a student of some ancient Mesopotamian astronomy. Mesopotamia was a large area between the Tigris and Euphrates Rivers, now a part of Iran. Their astronomy dates back some 3000 years, long before the advent of modern astronomy. Some of our most ancient star names derive from them, particularly a fainter star called Almach.

Almach is far from one of the brightest stars in the autumn sky. But it, plus the modern faint constellation of Triangulum, are a part of the ancient Mesopotamian constellation called Mulapin, or the Plough. The earliest writings about the Plough are believed to date back to about 1000 BCE, which would substantially predate Greek astronomy.

Where does this leave Sitchin? He has used a rather cursory reading of the ancient texts to propose the idea that a probably fictitious planet called Nibiru, is inhabited by a race of extraterrestrials who are responsible for much of the achievements of our Earth.

There is absolutely no evidence to back up Sitchin's specific prediction. However, the general idea of planetary collisions, particularly one that took place about 4.5 billion years ago that led to the formation of the Moon—was confirmed by lunar rocks collected by the Apollo astronauts and is now widely accepted by planetary scientists.

Ancient literary predictions of modern discoveries are not confined to Mesopotamia. The famous English author Jonathan Swift, in his *Gulliver's Travels*, imagined a city in the clouds called Laputa, whose scientists had found two moons orbiting Mars. The story was published in 1723, more than 150 years before the actual discovery of the moons by Asaph Hall on 1877 August 17. He got the sizes right, and was close on their distances to Mars. Swift's idea of a cloud city is also found in "The Cloud Minders" episode of the original *Star Trek* series.

We may, and should, argue with Zecharia Sitchin. His argument is ridiculous. But his curiosity about how the ancient people of Mesopotamia pictured the night sky 3000 years ago is not. Had those people not bothered to look up at the night sky and wondered, we would not have walked on the Moon in 1969, or watched a comet impact Jupiter in 1994. Those people from half a world away, and from a distant time, observed the

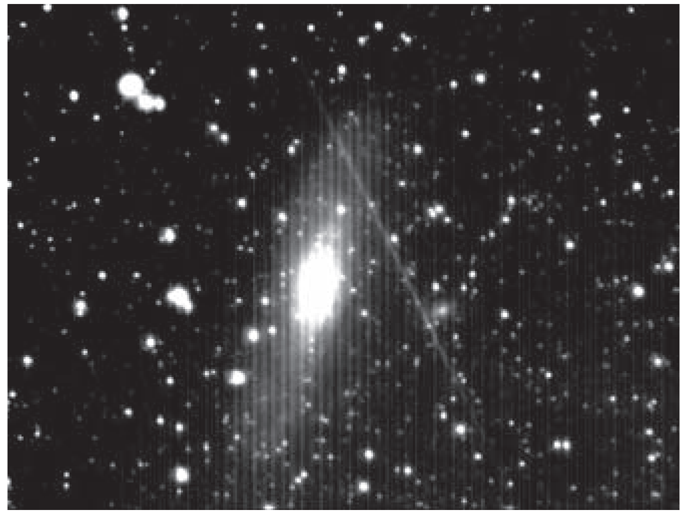


Figure 2 — The supernova in M31 was about the same time as the founding of the Vatican Observatory. An Orionid meteor is tracking right across the galaxy! Photo by David Levy; later enhanced by Adam Block.

planets and helped to cement the foundation of our modern understanding of the cosmos. This little journey into ancient astronomy was well worth a brief detour with President Spectar, and a look at the sky above the beautiful campus of the University of Pittsburgh at Johnstown. ✶

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

Observing Tips

Double-Barrelled Observing

by Chris Beckett, Regina, Saskatchewan

[Note from Dave Chapman, Chair, RASC Observing Committee: This is the third in a series of articles contributed by RASC members on observing, edited by me. For future columns I am looking for practical content contributed by active observers—please email me at observing@rasc.ca with your ideas. Our twitter handle is @RASCobserving.]

Introduction to Observing with Binoculars

Binoculars often represent our first leap beyond observing with the unaided eye, serving as a mid-point between the eye alone and the telescope we so longed to own. During those early days, the right-side-up, wide-field view facilitated the new observer attempting to glimpse a fuzzy nebula or star cluster, making the night a success. Low powers place small binoculars unique among optical instruments, as few telescopes achieve a power of 10× Unicode: U+00D7, UTF-8: C3 97 or less. While such capable small 'scopes exist, their humble double-barrelled cousins may outperform them owing to the binocular summation effect, that is, the 40% increase in contrast that makes a high-quality 50-mm binocular "feel" more like a 70-mm scope. (For more on choosing binoculars, see "BINOCULARS" by Roy Bishop, RASC *Observer's Handbook* pp. 60–63.) Beginning observers often use binoculars to help track down the deep-sky objects in the Messier Catalogue; however, most of these objects are small in relation to the large binocular field of view, and the RASC Messier observing program in fact prefers the use of larger, higher-power instruments for optimum views of the detail. Years pass, skills are honed, and averted vision sharpens—but perhaps those humble binoculars begin gathering dust, so let's take them out again.

Going Deeper with Binoculars

Freehand binocular observing means observers intuitively find the sweet spot of sensitivity in their vision, as we naturally move objects across the field of view. Because early humans relied on their night vision to pick up lunging animals, adding some motion better reveals our targets, providing a more 3-D effect and making faint objects easier to detect. Perhaps a trip, the desire to observe a greater variety of objects, or an observing article leads an observer to tackle the more obscure catalogues such as Collinder, Sharpless, Barnard, and IC, which offer some fascinating and large—though challenging—binocular targets.

More-experienced observers know to find local dark sites and to take advantage of southern travel destinations that invite the exploration of star fields normally below the horizon. However, sometimes lugging telescopes is not practical and, considering how many of us first learned the night sky, binoculars can prove handier for exploring new regions for the first time, such as that surrounding Eta Carina. Staying closer to home, binoculars allow us to see the sky anew by creating a closer link between what is seen with the naked eye and what lies just beyond. For example, Kemble's Cascade in the constellation Camelopardalis is a naked-eye strand of stars that was discovered by Lucien Kemble, a Franciscan friar (and noted RASC Calgary member) who observed near Lumsden, Saskatchewan. While sky sweeping with 7x35 binoculars, he discovered an asterism he described as "a beautiful cascade of faint stars tumbling from the northwest down to the open cluster NGC 1502" (the name "Kemble's Cascade" was bestowed in 1980 by Walter Scott Houston in his Deep Sky Wonders column in *Sky&Telescope* magazine).

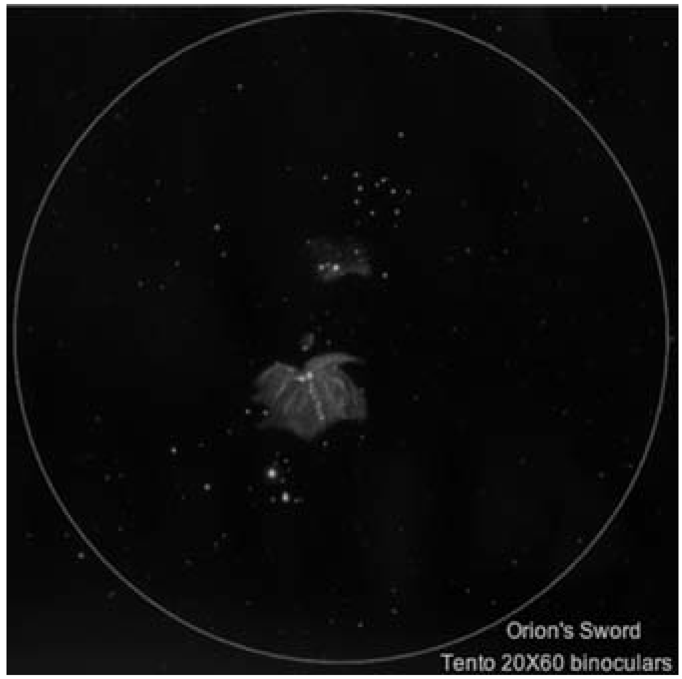


Fig 1 — Orion's Sword

From asterisms to star clouds, the variety of objects you observe helps hone visual observing skills and abilities. At the beginning of a search, an experienced observer knows that, when it comes to large diffuse objects, too much power can magnify an object beyond visibility. Therefore, the lowest powers are used to give the greatest advantage for glimpsing the object. We do this is because of the contrast effect, or the brightness of the object compared to the background sky. For example, when searching with the unaided eye at dusk for Sirius, the star blends in with the bright sky, but once the sky becomes dark enough it is easily seen. Unlike Sirius, the diffuse nature of deep-sky objects means they do not take magnification as well as pinpoint stars and often require a particular magnification to be seen at their best (for more on contrast and magnification, see "MAGNIFICATION AND CONTRAST IN DEEP-SKY OBSERVING" by Johnson & Roberts in the *Observer's Handbook* pp. 54–57).

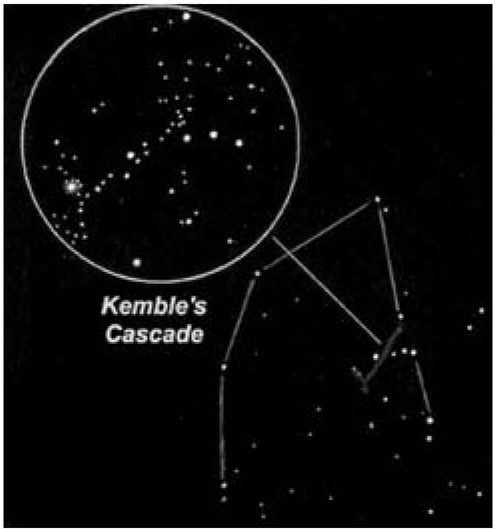


Fig 2 — Kemble's Cascade

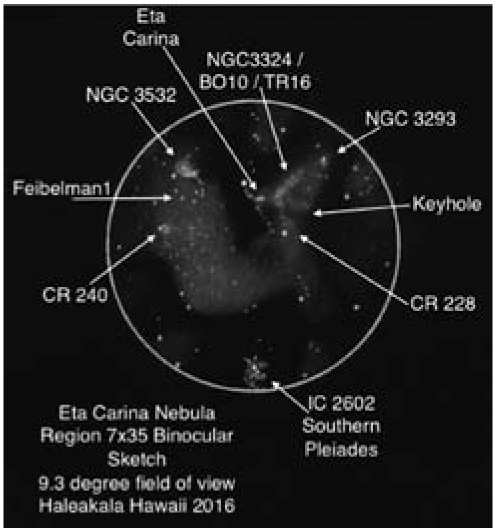


Fig 3 — Eta Carina Nebula

Binocular Advice and Techniques

If you've been observing the night sky for a while, you know that to get the sharpest views in binoculars you must adjust the focus for your own eyes. First, cover the right barrel (or close your right eye, if you can) and adjust the centre focus knob to sharpen the left-eye view; then, using both eyes together, adjust the "diopter" focuser built into the right-side eyepiece to sharpen the final, two-eyed view. For viewing comfort, the distance between the barrels must also match your eyes; to adjust the binocular, use the hinge and work them back and forth until your eyes feel relaxed. Speaking of relaxation, you will often find experienced observers "sky lounging" in their reclining lawn chairs, which makes cruising the sky with binoculars downright comfortable and imparts a real social aspect as the group circles their chairs to share views while trading binoculars around. The binoculars they use may also seem a little antiquated, as many older binoculars from past decades provide 70°–80° apparent fields of view giving 11°–13° true fields. While brands like Sears and Jason might make most people skeptical, the optics are often first-rate. These, along with exotic Zeiss models or the cold-weather-tested Russian Tento 20x60, can be purchased from online auction sites for under $100. In the same price bracket are the DIY "Constellation Binoculars" fashioned from 3-D printed parts housing old teleconverters made from excellent glass and scavenged other parts. With such binoculars you can fit the entire constellation of Orion or the Big Dipper asterism in one field with space to spare, or explore giant swaths of Milky Way from Sagittarius to Aquila, all while probing past 7th magnitude from city skies!

To get the most out of your session, head out with a list of a half-dozen or so objects. First locate each object and perform an initial inspection, then work your way through the list again, comparing back and forth. Observing fainter objects helps bring out more elusive details in the brighter ones, which in turn trains the eye, revealing further details in the fainter ones, as the session progresses. Take notes and sketch during this time (for observing records, sketches do not need to be works of art, think of them more as memory aids). Once fatigue sets in, and no more profitable observing can be done, enjoy one final relaxed view and see what remains to be glimpsed. Then maybe begin your next session warming up on these objects before tackling new ones.

If you are looking for objects especially suited to binoculars, consider the list I put together for WIDE-FIELD WONDERS in the *Observer's Handbook*, pp. 328–329. Here are a few highlights:

Orion's Sword—M42, M43 and NGC 1981 (Winter)

Coma Berenices—includes the Coma Star Cluster, i.e. Melotte 111 (Spring)

Dark Horse Nebula—a dark nebula also called the Prancing Horse (Summer)

Kemble's Cascade—near NGC 1502 (Autumn)

Eta Carinae Nebula—a southern-sky beauty barely visible from the Florida Keys in Winter

In addition, for those travelling south of the equator, Alan Whitman's SOUTHERN HEMISPHERE SPLENDOURS in the *Observer's Handbook*, pp. 330–331, includes several splendid wide-field targets, including the Large and Small Magellanic Clouds, the Coalsack in Crux, and the amazing globular cluster Omega Centauri (NGC 5139).

[Assistant Editor's Pick: I am a big fan of exploring the Scutum Star Cloud, just southwest of Aquila in the Milky Way. In binoculars. *SkyNews* Associate Editor Ken Hewitt-White profiled this region in his July 2015 article Scoping Scutum (www.skynews.ca/scoping-scutum), drawing attention to an asterism he calls the Golf Club and Golf Ball, the latter being the open cluster M11. The 2018 January/February issue of *SkyNews* is a special issue on binocular observing.] ✶

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

Astronomical Art & Artifact

Dr. Sommer's Moon: Philology, Cartography, and Oblivion

by R.A. Rosenfeld, RASC Archivist
(randall.rosenfeld@utoronto.ca)

> *"The comparatively small distance of our satellite, 240,000 miles, renders it the easiest of telescopic objects"*
> *—Rev'd T.W. Webb (1859, 46).*

> *"THE MOON…one of the first objects to which the incipient possessor of a telescope will be likely to direct his instrument and attention"*
> *—Capt. W. Noble (1886, 14).*

Abstract

A rare 19th-century map of the Moon, and its context, are explored here. This map may be the earliest issued in a Canadian publication by an amateur astronomer active in Canada. It has not thus far been noted in the literature.

Lunar attraction

The personified Moon could claim that she is the novice's favourite celestial target for first-light initiation of optical aids to astronomical sight. The reasons are not hard to seek: the Moon is easier to locate than most other astronomical objects, she displays more detail than nearly all other solar system bodies, and she is safer, less complicated, and less expensive to view than the Sun, her rival great luminary. For the beginner with his or her first telescope or binoculars, the observational accessibility of the Moon has not changed from the founding of the RASC till now. Similarly, the challenge to the experienced observer of capturing with ever greater fidelity the abundant and dramatic lunar detail seen in the eyepiece remains a challenge, whether the recording medium is pencil and paper, or an array of electronic sensors. The prolonged formative engagement of serious and recreational science with the Moon, coupled with her long, broad, and varied presence in cultures, lends an enriching resonance through recall and retelling to private, and outreach observing alike.

In the years after Confederation, the Moon interested many amateurs of astronomy, some of whom left a memorial of their activities. Not all of these figures have been written into the present narrative of astronomy in Canada. One such person is the Reverend Dr. Alfred Sommer.

Dr. Sommer

Very little information is available on Alfred Sommer. It is known that he was a native German, which probably, though not necessarily, means he was born in one of the German states (Anon. 1883, 92). His birth and death dates have thus far not been recovered, but a tentative *floruit* of 1875–1886 can be established for his activity in Canada (Sommers 1879; Anon. 1883; Cronmiller 1961, 169, 188–189). He worked as a Lutheran pastor, and school teacher. Those professions could certainly be complementary, and indeed may not necessarily have been separable, given the particular circumstances of local engagement. That he was well educated is evident from his honorific of "Doctor," although in which discipline that academic grade was awarded, and by which institution, is not known. It may have been in a branch of theology. His work on selenography shows acquaintance with many sources in diverse fields, which also implies access to a good library, or libraries.[1]

During the period 1875–1880, Dr. Sommer was pastor of St. John's, Montréal (Cronmiller 1961, 169).[2] In the late 1870s he served as Chair of the Charitable Committee, and Chair of the Law Committee of the German Society of that city (Lovell 1878–1879, 767). In 1881–1888 he transferred to the parish of Listowel, Wallace, and Trecastle, in Ontario. In 1881, he founded St. Paul's Church in Listowel, and St. James, Trecastle (Cronmiller 1961, 169, 189). Early in his time there we read that: "The Listowel high school Board have engaged a native German, Dr. Sommer, to give lessons to the pupils wishing to acquire the German language. There are 15 in the class at present, with the prospect of an increase" (Anon. 1883, 92).

The secondary sources, contemporary and later, however, make no mention of Dr. Sommer's astronomical interests. Scientifically inclined clergymen were certainly a regular part of the learned landscape. Many made real contributions to astronomy, and astrophysics (Chapman 1998, 225–241, 295–299, for a few examples). Among the membership of the early RASC are numbered Msgr. C. Choquette, the Rev'd Dr. T.C. Street Macklem, Rev'd D.B. Marsh, Bishop J.A. Newnham, and the Rev'd C.H. Shortt, among other clergy (only Choquette and Marsh were figures of any astronomical distinction). Sommer was not, however, of their number within the RASC. For what we know of his astronomy, we must turn to his paper on the Moon.

Aspiring to philology, and science

One of the periodicals founded in the wake of Canadian Confederation was the aptly named *New Dominion Monthly*. It lasted for about twelve years, not a bad run for a periodical of the day (magazine publishing was always a venture attended by risk). Typical of the quality general periodical literature of the time, like *The Edinburgh Review*, *The Quarterly Review*, and *Harper's Magazine*, the *New Dominion Monthly*

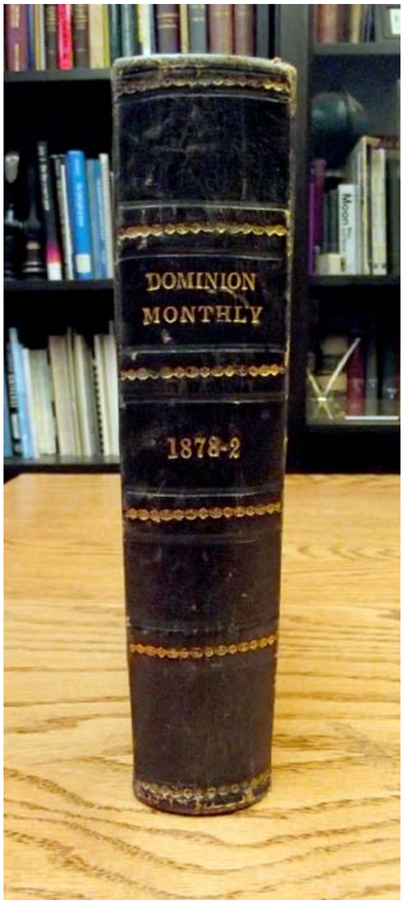


Figure 1 — The RASC Archives' rare copy of the New Dominion Monthly *(1879, January), containing what may be the earliest published lunar map of Canadian origin.*

published articles on a broad range of topics, including the sciences. Some of the articles could be quite lengthy, and, when illustrated (as was not infrequent), they always featured a greater proportion of text to image than is common now. The images, executed in media allowing only black & white, or greyscale (to use modern equivalents), offered less of a contrast with the text than do our magazine layouts (at least to the later 20th-, and 21st-century eye). All of these indicate that reading habits and expectations differed in the age of Victoria from what they are now—for those with the leisure to read.

Sommer's article, "The Moon," appeared in the "Farewell Number" of the *New Dominion Monthly* 1879, January, before it ceased publication for good. Occupying double columns on pages 58–73, even with seven images, and one fold-out map, it still has a larger word count than the longest of articles in numbers of the *Journal* in recent years (Figure 1).[3] There is no authorial or editorial indication of why this article was chosen for the final issue, but there is an internal indication that at the time of writing (and, presumably, the checking of proofs) Sommer did not expect the magazine to fold: "Perhaps time and the favor of our readers may allow us to speak at some future time about these highly interesting facts…" (Sommer 1879, 72, note). That time never came in this particular forum.

The impression Sommer's paper leaves on the reader is that of someone attempting to write a miniature treatise touching on as many scientific and cultural aspects of our relationship to the Moon as possible. The materials are not all accorded equal space. First up is a disparate selection of facts on the place of the Moon in myth, religion, and literature (58-60), followed by a smaller section on dynamics and physical characteristics (60-61). The longest section is an imaginary trip to the Moon to survey her features more closely, and experience her environment (61–72). This narrative device is not consistently maintained, frequently faltering to make room for various topics, including a sketch of the progress of selenography (63–65), a claim to possess proof of a lunar atmosphere (69–70), a discussion of Linné and observable changes on the Moon (67–70), the question of life on the Moon (72), and lunar influence on the Earth (72–73). Of interest is Sommer's introduction of evidence from his own personal observations (67–70).

To give some flavour of the quality of Sommer's handling of these topics, several will be explored further below.

His approach to myth, religion, and literature is of the type now identified with Victorian cultural anthropologists like Sir Edward Burnett Tylor (1832–1917), the evolutionary universalist, who to illustrate a point drew examples from many different cultures regardless of chronological and geographical differences. The style can be as exhilarating as it is uncritical.

On the opening page alone, Sommer introduces the Roman attitude to Jupiter, the Hindu and other "Indo-Germanic races[']" view of the Moon, the Caananite(?) Astarte, the days of the week, Old Testament Jewish Law, and biblical Jewish, ancient Roman, and Roman Catholic terms for the *Regina cælorum*, nomadic worship of the Moon, and the commonality of the nomad's(!) Moon with the Roman's Diana, the Egyptian's Upis, and the Greek's Artemis.

Citations to supporting texts are there none, justified, in the author's words, with: "In the course of this paper various English, French and German authorities are made use of, but the names are only mentioned when particular important facts and observations are referred to" (58, note). Well and good, until one attempts confirmations of the author's statements. We are told that "…the Romans held their Curia and Senate according to the moon's phases" (60). Unfortunately, modern scholarship knows nothing of this (Rüpke 2011, 149–150; Stein 2012, 204–227). One likes to think Sommer didn't go in for wholesale invention (*á la* Kellyanne Conway's "alternative facts"), but without some indication of his source it may be hard to trace.

Further on we encounter: "The Jews already called a period of twenty-eight days according to the circuit of the moon… *(Jareah)*" (60). Sommer is not quite correct. One of the poetic words for "Moon" and one of the words for "month" are very similar, sharing the same consonants, but not the same niqqud diacriticals for the vowels. The etymology he states as fact is not unequivocally established by the outstanding Hebrew lexicon of his day (Gesenius 1906, 437; the first edition appeared in 1847). And "The weeks in the month also originated in the four phases of the moon…" (60). This may be Sommer's interpretation of a passage in Philo, however the ancient author does not actually identify the lunar phases as the origin of the weeks (Philo 1937, I. 177–178, 200–201). It would seem that Sommer, while ready to delight and inform his readers with a barrage of varied facts of lunar philology, could not be relied upon to inform accurately, even by the standards of his day.

What of his lunar science? To his credit, it appears that he was concerned to provide his readers with the most up-to-date information he could find. Unfortunately, he is again dogged by errors.

We learn that the diameter of the Moon is 472 miles (61). Of the errors here, the most serious is in the order of magnitude. Sommer's 7.5961×10^2 km ought to be 3.476×10^3 km; a check of the authorities on the Moon he actually does cite ought to have shown him his error (e.g. Nasmyth & Carpenter 1874, 43. The figure is close to the modern value; Vaniman et al. 1991, 28, table 3.1). He even manages to mangle the name of one of the authorities he frequently cites (and a German, at that!); Beer & Mädler consistently appear as "Bähr & Mädler" (e.g. 62; Beer & Mädler 1837). Regarding the synodical month, one reads: "…since one day upon the moon lasts nearly twenty-eight terrestrial days" (63). It had been known for millennia that the synodical month is in fact ca. 29.5 days (Newcomb 1878, 47). Further on we are informed that Beer & Mädler's Fraunhofer telescope had a "five inch focus"! (66). The O.G. was just under 100-mm, and most refractors of that class had a focal ratio of *f*/15, which would be 1.524-metres, or five feet. Sommer's error may have been due to a simple confusion of units. None of this particularly inspires confidence, even if some of the mistakes might possibly be laid at the feet of the printers, rather than the author.

His most startling scientific claim is in regard to a purported lunar atmosphere. It is worth examining at length, both for what it reveals about the strengths, and the limitations, of Sommer's concept of the scientific enterprise.

He begins by laying out something of the history of the question, proffering strong reasons for believing that the Moon has no atmosphere, and listing the galaxy of the great and the good of selenography who argued that side: Tobias Mayer (1723–1762), John Herschel (1792–1871), François Arago (1786–1853), and Johann Mädler (1794–1874) (69). He honestly states that he can cite but a single "modern" astronomer backing the other view; Johann Schroeter (1745–1816, whose name Sommer insists on rendering as "Schroedter"). His admiration for Schroeter leads him to imagine an alternative turn to astronomical history, in which Schroeter had access to spectroscopic evidence before planetary spectroscopy(!), to bolster the acceptance of his observations of a lunar atmosphere:

> *"…we have only one modern astronomer who boldly asserted and defended the idea of a lunar atmosphere in despite of all others, and that was Schroedter [sic.] of Dresden. If this able and diligent observer had been armed with a spectro–*

scope…surely his results had been happier and would not be disregarded by his fellow-astronomers" (69).

Sommer's praise of Schroeter culminates in his support of the minority opinion affirming the existence of a lunar atmosphere. That does not, however, quite prepare the reader for what follows:

"The main argument[s] of those who still cling to the idea of a lunar atmosphere are:…5. The green spectroscopic lines in the moon's light. Impelled by comparatively new reports in the Poggendorfer Annalen on the observation of certain green lines outside the photosphere of the sun, I endeavored to find the origin of these lines, and discovered them not only in the sun's atmosphere far beyond the loftiest protuberances, but also on the moon's edge, and even on the rim of an intense kerosene oil flame I detected a corresponding line in the ultraviolet part of the spectrum, and found that these lines are coincident with the main lines of nitrogen. (Here I may state that I found it extremely difficult to detect any other lines than the solar spectrum in the sun's reflected light upon the moon. But of course this is no reason why a lunar spectrum should not exist…[69|70]…)…we cannot help concluding that the elements of the moon are and must be the same as those existing on the earth…nothing remained except a cold mass of oxidized elements, surrounded by a layer of nitrogen as a lunar atmosphere. In my opinion, as the result of many spectroscopic observations, made in Canada's clear winter nights, there is certainly a layer of nitrogen existing around the moon; but as to the thickness of layer I neither possess the suitable instruments for measuring it, nor am I sufficiently prepared to lay before the public my unfinished calculations. So much only I may remark that the density of the lunar atmosphere must be at least 1/1000 times rarer than the density of our own air; it must be perfectly translucent, and does not cause the sun's rays to diverge[!]; it must be, by force of gravity, 50,000 times denser than the surrounding cosmical air or atmosphere; and it must be free from all combinations of nitrogen known to our terrestrial chemistry[!];" (69–70).

It is unfortunate that Sommer omits all details concerning his spectroscope. Did it have a prism train or grating, was it provided with a slit or was it slitless, was it placed at the objective or the eyepiece end of the telescope? What was his source of comparison spectra, if any? Amateurs of his day who ventured into optical spectroscopy used the "star spectroscope," available in both professional and amateur formats. The star spectroscopes were equipped with prism trains (usually three prisms, but models with one, or five prisms were available), and were equipped with a collimating or line-broadening lens, or both, and sometimes a slit (Browning 1882, 24–29).

The inspiration for his spectroscopic excursion to the detection of a lunar "atmosphere" looks to be precisely cited, until one attempts to follow it up. The pages Sommer cites from Poggendorf have nothing to do with "the observation of certain green lines outside the photosphere of the sun," but are rather about mercuric bromide in the lab (Anon. 1842).

The "certain green lines…corresponding [to a] line in the ultraviolet part of the spectrum… coincident with the main lines of nitrogen" is much too vague a description to accurately identify the location of the lines, and to compare them to those of known substances. And one could be forgiven for asking what "green lines" have to with the "ultraviolet part of the spectrum?"[4]

Sommer is forced to admit that the lunar spectrum within reach of his spectroscope is in fact the reflected spectrum of the Sun, but wants to keep faith with his hypothesis of a lunar atmosphere, despite the absence of good observational evidence:

"Here I may state that I found it extremely difficult to detect any other lines than the solar spectrum in the sun's reflected light upon the moon. But of course this is no reason why a lunar spectrum should not exist… there is certainly a layer of nitrogen existing around the moon; but as to the thickness of layer I neither possess the suitable instruments for measuring it, nor am I sufficiently prepared to lay before the public my unfinished calculations…[the nitrogen-based lunar atmosphere]…must be perfectly translucent, and does not cause the sun's rays to diverge…[it] must be free from all combinations of nitrogen known to our terrestrial chemistry."

In addition to lacking the (unspecified) instrumental means to gather quality data to test his theory, he confesses his inability to complete and present a theoretical model. He characterizes his lunar "atmosphere" as incapable of refracting light, and composed of a type of "nitrogen" unlike any nitrogen known to Earthbound chemists in their laboratories. Sommer had quintessenced his lunar atmosphere, effectively rendering it unobservable, untestable, and unknowable.[5]

Sommer's approach to doing astronomy appears at its best in is his attitude to the literature. He clearly made an attempt to search out and present the main scholarly views on the cultural and scientific aspects of his subject. He claimed to be able to read the astronomical literature in the main western European languages, which, if true, was certainly an asset. It must be remembered that conducting a literature search in the colonies in the 1870s was a more difficult undertaking than it is now. The citations he provided weren't always full, or accurate, and neither was his reading (as noted above), but he deserves credit for making the effort. This, however much it is necessary, is preparatory to gathering, reducing, and interpreting data (observations)—it is a prolegomenon to doing science.

Sommer's astronomy is at its weakest when he tries to explain his methods, and interpret his data. After presenting the most likely of explanations for the resemblance of the lunar spectrum to that of the Sun, he doesn't chose this simplest of explanations, but opts for one which relies on poorly supported conclusions (e.g. we are not given the wavelengths of the green lines he believes are emission lines of nitrogen; he admits to being unable to present his mathematical model of the "atmosphere," etc.), and effects and entities unknown to the science of his day (e.g. an "atmosphere" that doesn't interact with light; "nitrogen" that is completely unlike any nitrogen then known). In Sommer's case, seeing wasn't believing, but believing bent seeing.

Observing the Moon

A few scattered details on Sommer's apparatus and observing can be extracted from his comments, but the resulting picture is most incomplete. We begin with the equipment he had at his disposal.

It emerges that his telescope is a refractor with an aperture of 101.6 mm., but nothing is stated as to its focal length (65; based on contemporary tastes, his refractor was probably an *f*/15 instrument, but it could have been *f*/10 to *f*/20). He claims to have employed "high telescopic power" at times, but doesn't tell us what those powers are, or provide the focal length of his eyepieces, or specify their design (67; Huygens, Ramsden, or Kellner designs are most likely). As noted above, Sommer mentions vague results from using a spectroscope, but a description of its construction is not offered (69). He states that he measured the width of some lunar rays, which implies the use of a micrometer (67; the most practicable micrometer design for this is the filar micrometer). The writer affirms that he has witnessed real changes on the face of the Moon, apparently following the lead (and mistake) of the superb observer Julius Schmidt (1825–1884) of Athens in regard to the crater Linné (Ashbrook 1984, 272–278; Sheehan & Dobbins 2001, 155–174).[6] This implies that Sommer made use of some recording media for his observations (most probably pencil, or pen or ink on some text support). His lunar map, if it is derived from his own observations, would also attest to this.

Regarding his observing, it is no surprise that he viewed the Moon with the naked eye, as most readers of this article have done at one time, or another (64).

He appears also to have devoted some energy to inventorying features of the lunar landscape, such as the number of "small" craters, 2,800, discernible in his telescope (65), the rays, 100, radiating from Tycho (67), and the number of mountain ranges, 5 (67).[7] One wonders why he did so. No details are given of any of this work, and it is not known if he produced catalogues of features. Competition from experienced observers internationally, some of whom had more capable instrumental means at their disposal than did Sommer, would have been considerable, and likely have limited the significance of any lists he may have produced to personal use.

Figure 2 — Dr. Sommer's lunar map, set between pp. 64 & 65.

Was Sommer in contact with members of the Selenographical Society, or the selenographically inclined correspondent-contributors to the *English Mechanic & World of Science*?[8]

He observed the Moon spectroscopically, "…the result of many…observations, made in Canada's clear winter nights" (70), as discussed above.

Sommer seems particularly sensitive to the different colours of the lunar surface revealed through a telescope (64, 68). Finally, he was capable of responding to the aesthetic dimensions of the Moon as an object of vision: "It [Gassendi] forms one of the finest views in the morning or evening of the moon, more beautiful, perhaps, than even Tycho…" (67).

The map

Sommer's article includes a 17.2-cm diameter fold-out lithographic map of the Moon (Figure 2; the medium appears to be wood engraving).[9] It is of interest for several reasons. It is rare, as few copies of the final number of the *New Dominion Monthly* are extant. It is among the earliest of lunar maps by an astronomer (amateur or professional) working in Canada, bearing a Canadian imprint. It may, in fact, be the earliest published lunar map of Canadian origin. Other points of interest are the unusual cartographic style of the map, and its equally curious textual presentation. We start with the last of these aspects.

What makes the textual presentation of Dr. Sommer's map so curious is Dr. Sommer's silence regarding his map! It is not mentioned once in the article of which it forms part of the graphic apparatus. We are not informed when or why the map was drawn, what the selenographer's intention was in presenting it, or how it was made. Was it meant to provide an accessible reference to the relative location of the lunar features discussed in the text? Did it include any data or aspects of presentation Sommer thought were novel? Was it intended for use at the eyepiece? Was it based on Sommer's own observations of the changing face of the Moon through his own 101.6-mm O.G. telescope? Or was it compiled from a combination of his observations, observations of others, and previously published maps? Was it entirely derivative from earlier maps? If he observed the Moon for this purpose, over how many lunations did he take notes and make drawings? What media were used in its making of the map? Did Sommer as selenographer employ a particular projection, and why? The author's silence effectively prevents answering any of these questions in a meaningful way.

Cartographically, the face of the map is unlike most other lunar charts from the 19th century, nor is it likely to appear normative to a modern observer. The use of hachures is not unusual (although in Sommer's hands they are crude, and approximate), and the labelling is serviceable. The strangeness of aspect of the map is almost entirely due to Sommer's use of stylized "contours" made up of chains of arcs to indicate the lunar *maria*. The arcs seem to be laid down qualitatively, rather than quantitatively (they are not constructed to convey information based on a defined unit). They give the *maria* a terraced appearance (or that of a pie crust gone terribly wrong).[10]

It must be admitted that the map is not particularly accurate—nor attractive. The shapes, relative volumes, and orientations of features fall very far short of the best of 19th-century selenography. Beer & Mädler's (1837) superb map—which Sommer cites—or Julius Schmidt's equally impressive Atlas (1878, contemporary with Sommer's map) well illustrate the high point of the art and science of representing the surface of the Moon. Even the numerous index maps such as Webb's (1859, derived from Beer & Mädler), or Captain Noble's (1883), exceed Sommer's map in standards of positional accuracy, representational fidelity to the telescopic Moon, and artistry. The earliest Canadian lunar map, if such it is, was not a product of a Baedeker, or a Bierstadt.

Accuracy is weakest in features found toward the limb, but representing features near the limb presents formidable difficulties to even experienced selenographers (Hill 1991, xix–xx, 34). Sommer is prone to reduce or ignore the full effect of foreshortening on features (compare limb features in Sommer's map to the image from the Virtual Moon Atlas in Figure 3).

Features needn't be on the limb to prove troublesome to Sommer. He represents Autolycus as larger than Aristillus, when the former should be shown as nearly half the size of the latter.

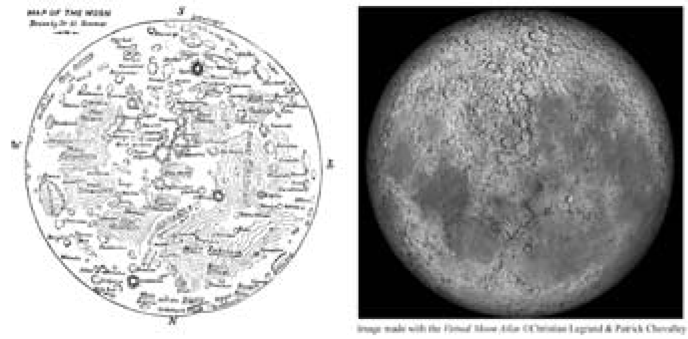


Figure 3 — Dr. Sommer's lunar map compared to a modern image of the Moon.

Another oddity of Sommer's map is the omission of features contiguous to and at least as prominent as some of those included, e.g. Gassendi is present, but Mersenius isn't; Messala is mapped, but not Lacus spei; Stadius is marked, but Eratosthenes, if included, isn't labelled (the drawing is doubtful).

Sommer also includes spurious features, such as a large fictive *valles* to the south of Arago.

Significance…

Sommer's significance does not lie in his total absence from the modern narrative of selenography, or in his present invisibility to historians of North American amateur astronomy, or his failure to enter upon the pages recounting Canada's astronomical history and heritage.

Sommer's Moon attests to the space in Canadian Journalism for a substantial piece on the Moon within a decade of Confederation, in the expectation that readers will have the capacity to consider the Moon as a cultural object reflected in Ancient and biblical philology, as a scientific object whose surface can be explained by geological science, as a dynamic body whose course through space can be mathematically modelled, and as a source of observational delight, all within the confines of fifteen pages.

Sommer's philological acumen wasn't equal to the task he set, his grasp of contemporary scientific methods was weak, and his abilities as a lunar cartographer were very amateur, yet the course of his ambition was grand. With the critical stimulation of other informed amateurs, he might have been able to better his deficiencies. Was his practice of astronomy a wholly solitary one?

Sommer's presence doing astronomy in the Montréal of the 1870s can serve to remind RASC members during their sesquicentennial year that their Ontarian astronomical ancestors were not the only ones looking up in British North America. For that matter, at no time in its history was the future RASC destined to be the only astronomical game in town. ✶

Acknowledgements

This research has made use of NASA's Astrophysics Data System.

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Endnotes

1 That access may have been at a time earlier than when Sommer was working on his lunar article. It was not uncommon for readers to create their own notebooks of extracts from their reading, which they could then turn to as a "commonplace book" when required, without returning to the library. It appears from the manuscript notebook of the Rev'd T.W. Webb in the RASC Rare Books Collection that he might have done this when writing his *Celestial Objects for Common Telescopes* (1859, and later editions; Webb n.d.).

2 Somers 1995 disappointingly casts no light on Sommer's ecclesiastical career.

3 Amusingly enough, a Montréal optician, H. Sanders, placed an ad on the inside front cover for the "Lord Dufferin Telescope, Extraordinarily cheap and powerful glass; no Rifleman or Farmer should be without one;" Sommer 1879, front cover verso.

4 There appears to be nothing in Kirchhoff 1862, Kirchhoff 1863, Roscoe 1869, or Schellen 1872 that can confirm Sommer's description of the line locations, or their elemental identities.

5 Sommer's unorthodox treatment can be contrasted with any of a number of others more representative of the established scientific opinion of the time, such as Lardner 1875, 136–138. Aimed at "those possessed of an average amount of general knowledge" (presumably the same sort of audience as *The New Dominion Monthly*), Lardner presents abundant observational proofs of the absence of a lunar atmosphere, none of which are addressed in Sommer's paper. Lardner's popularizations enjoyed a considerably greater dissemination than Sommer's.

6 The yearning desire, chiefly among amateur lunar observers, to discover evidence of contemporary change in the topography of the Moon was surprisingly persistent. Its flavour can be sampled in a treatment of Linné from six decades after Sommer's publication; Haas 1942, 258–260. The crater pair of Messier and Messier A are a similar case; Hill 1991, 210–214.

7 Neisen 1876, 68–69, gives the names of six ranges, and there is no indication he considers his list exhaustive. Beer & Mädler 1837 apply the terms *Bergkette,* and *Gebirgskette*, to considerably more than five features.

8 A quick search of the *Selenographical Journal* did not unearth his name among the contributors, or members. In the present author's opinion, Sommer's work is not up to the level of the Selenographical Society.

9 Sommer's map was not the only illustrative material accompanying his text. Some of his images raise the issue of plagiarism. Five illustrations, several of which are signed with some variant of "Dr. A.S.," appear to be very closely based on the Woodbury type prints in Nasmyth & Carpenter 1874; Sommer 1879, 65–68.

10 In a figural alternative to a Moon made of cheese!

Larger versions of Figures 2 & 3 can be downloaded from www.rasc.ca/dr-sommers-map-moon.

The Visitor from Beyond

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Fans of classic science fiction will remember the book *Rendezvous with Rama* by Arthur C. Clarke, where a cylindrical spacecraft visited the Solar System on a hyperbolic path. An asteroid looking rather similar to Rama recently passed by Earth on a distinctly odd path. It was discovered by the Pan-STARRS survey telescope on Maui on 2017 October 19, and subsequently studied by an array of telescopes around the world in an effort led by Karen Meech, of the University of Hawaii at Manoa (see the December 21 issue of *Nature*—a preliminary version of the paper was posted online on November 20: www.nature.com/articles/nature25020). A reconstruction of its path has it entering the Solar System from above, passing the Sun inside Mercury's orbit, and then going by Earth at a distance of just 0.16 au, on its way out (see Figure 1).

Ever since it became clear that planets can and do migrate in their orbits, it has been apparent that such migrations will jettison asteroids from the stellar (and Solar) systems. This means that there should be a substantial population of asteroids travelling through the galaxy, not bound to any star. These objects have been expected to be, at least initially, icy, like the Kuiper Belt bodies. It is something of a surprise that no such interstellar body has previously been detected.

In keeping with the discovery and follow-up study by Hawaiian telescopes, the object has been named 'Oumuamua, which means roughly a messenger from the past. It was originally given an IAU designation of A/2017 U1, with the "A" standing for asteroid. Once its interstellar nature became clear, the designation was changed to 1I/2017 U1, where the "I" indicates interstellar.

Follow-up observations started on October 22, at the Canada-France-Hawaii Telescope on Mauna Kea. Additional observations were made at the Gemini South telescope and the Very Large Telescope of the European Southern Observatory October 25–27. There was no evidence of any type of coma, even though it had passed within 0.25 au of the Sun, establishing its asteroidal nature. Additional observations were made at the Gemini South telescope and the Very Large

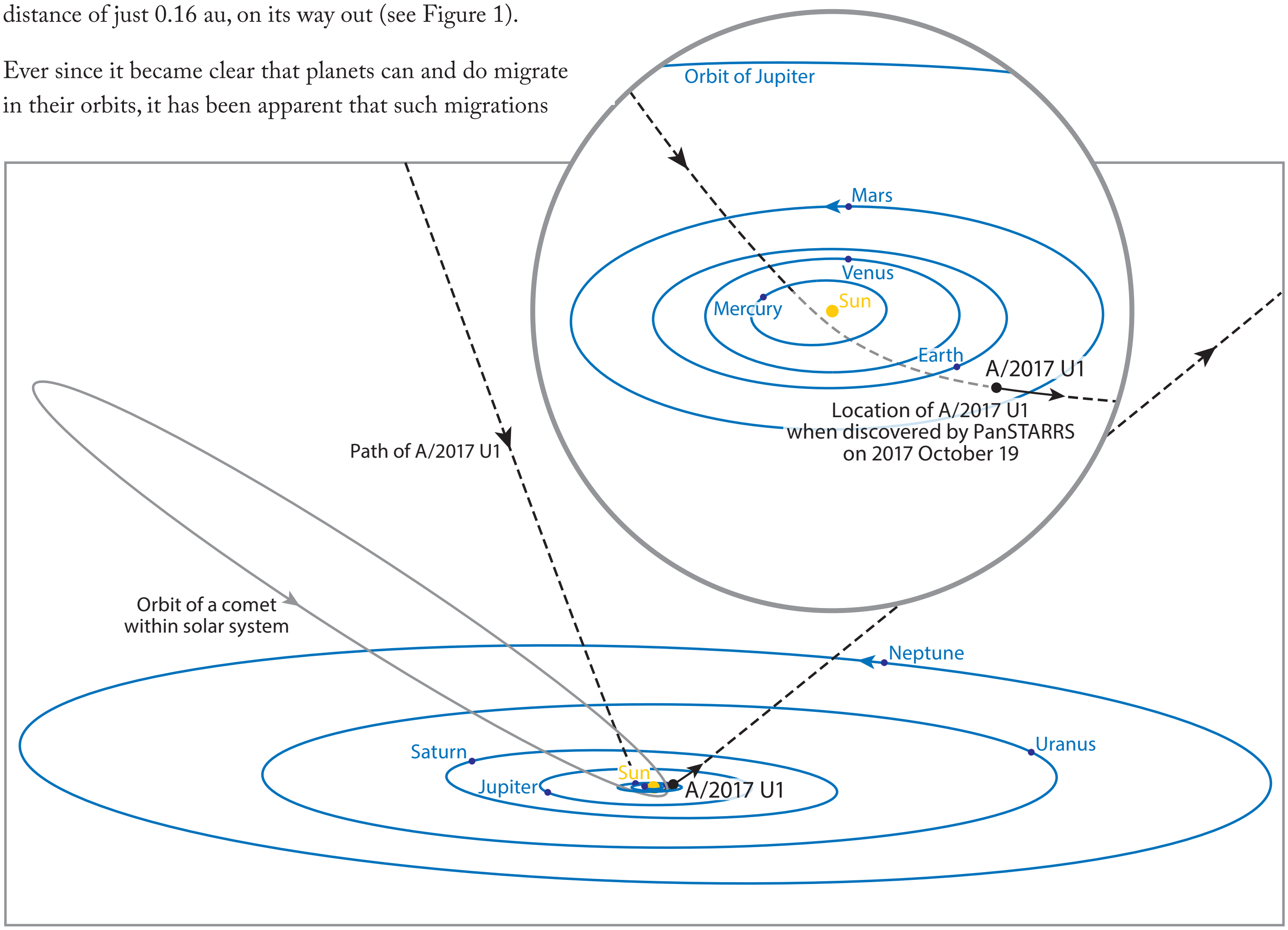

Figure 1 — The path of 'Oumuamua through the Solar System, compared to the orbit of a typical comet. Credit Karen Meech and Nature.

Telescope of the European Southern Observatory 25–27 October. The light curve has a periodicity of just over seven hours, which is fairly typical for a Solar System object of similar size.

Detailed analysis of the light curve revealed that the object is extremely elongated—its length is about ten times its width. Meech and her team estimate that it is about 800 m long, and about 80 m in diameter (see Figure 2), assuming an albedo of 0.04. The spectrum is quite red, like Solar System comets and asteroids that have a lot of carbonaceous material, organics, pyroxene, or bits of metallic iron on their surfaces.

If 'Oumuamua is cigar shaped (as shown in Fig 2) rotating around its small axis, it must be held together by material strength. Meech and her team were able to rule out a contact (or quasi-contact) binary body, because that would imply an implausibly high bulk density.

Tracing the body's path back in time does not point to any obvious source. The three-dimensional velocity is quite close to the mean velocity of stars near the Sun, suggesting that 'Oumuamua originated in a young stellar system about the time that the nearby stars were born (4–5 billion years ago), though Meech and her colleagues say that they cannot exclude that it has been orbiting in the galaxy for much longer, with multiple close approaches to other stars.

Figure 2 — An artist's conception of what 'Oumuamua might look like. Credit European Southern Observatory and Karen Meech.

That would be consistent with the lack of icy material. The ratio of icy to rocky material in the Oort cloud of comets ranges from 200:1 to 10,000:1, so a priori one might expect a body liberated from another star's Oort cloud (from which it is relatively easy to escape) to be icy and to show indications of a coma when it comes close to the Sun and the escaping gas drags dust along with it. Perhaps this is related to the distinctly odd shape.

Meech and her collaborators suggest that the frequency of such interstellar interlopers has previously been under-estimated, but believes that this does not significantly increase the risk of collision with Earth, though such collisions would be very harmful, because the incoming bodies would have much higher velocities than most Solar System bodies. The preliminary estimate is that there is almost always an interstellar body with a diameter of 250 m within Earth's orbit around the Sun.

So the next time you are out observing, give a thought to the interstellar body passing through the Solar System right now. ✶

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

Dish on the Cosmos

Star Formation with a Twist

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

The Atacama Large Millimetre/submillimetre Array (ALMA) has recently made a direct measurement of how star systems get their spins. To understand this recent discovery, we need to step back into the context of our own Solar System to understand how the physical principle of conservation of angular momentum determines so much about how stellar systems move.

The constellations of the zodiac hold a special place in our view of the heavens since they represent the regions of the sky where the planets, Sun, and Moon can be found. The zodiac is relatively small because the Solar System is flat and all of the orbits of the planets are confined to a thin region, with small tilts with respect to each other. The orbits are without exception oriented in the same direction. If you hovered above the Solar System, you would see that all the planets are orbiting around in the counter-clockwise direction (this is actually how we define which way is "up" in our Solar System). Moreover, the Sun and nearly all the planets are spinning in the same direction and most of the moons and asteroids are orbiting around their major bodies in the counter-clockwise direction. There are a few exceptions, but these are few enough that they can be attributed to having the orientations of the spins of planets changed by collisions or close encounters with other massive objects. Small moons orbiting in the wrong direction are attributed to these bodies being captured from a "normal" orbit and pulled into a backwards orbit. The dominance of this direction of spin cannot be coincidence and must be explained through our model for the formation of our Solar System.

We explain this spin through the principle of the conservation of angular momentum being applied during the formation process. Our best model for star formation holds that our Solar System formed through the runaway gravitational collapse of a cold, dark cloud of gas known as a *core*. The gas cloud falls inward as every part of the cloud pulled on every other, bringing the cloud closer together. These gravitational effects only pull two pieces of matter directly toward each other; they cannot cause one piece of matter to twist around the other. The angular momentum of a forming stellar system is a quantitative measure of how much the matter is spinning. Since the gravitational collapse cannot twist the material that is falling inward, the total amount of spin in the system must remain the same. The canonical example for the conservation of angular momentum is to describe how a figure skater can start a slow spin with arms extended, pull in their arms, and spin much faster. A similar effect must happen when a stellar system forms: gravitation pulls the material inward and the system's rotation increases. In the absence of other effects, the material can spin up and approach the orbital speed.
As material gets faster, the spin prevents the material from falling further in toward the forming star—the gas just goes into orbit.

To continue inward to build up a star, this now-orbiting material organizes itself into an *accretion disk*. The gas cloud flattens from a roughly spherical shape into a disk because material can move up and down parallel to the axis of rotation without needing to reduce its angular momentum. Once this material is organized into a disk, the material begins to exchange angular momentum through gas drag, ejecting a small amount of material with high angular momentum and allowing a large amount of gas to move inward. These disks are an essential feature of any system where the angular momentum is significant, such as spiral galaxies or the disks around black holes. The general action of disks is to slowly move material inward by redistributing the spin of the gas. Figure 1 shows an example of an accretion disk seen with the ALMA telescope. The planets of our Solar System formed as parts of this accretion disk gathered together under their own gravity. Since the disk would all be spinning in one direction the spins and orbits of the planets would come out spinning in the same way.

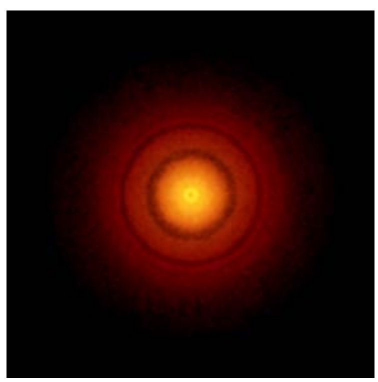

Figure 1 — A face-on view of the protoplanetary disk around the star TW Hydrae. The rings and gaps visible in the image are thought to be signature of disks and planets forming in the disk. Image Credit: S. Andrews (Harvard-Smithsonian CfA); B. Saxton (NRAO/AUI/NSF); ALMA (ESO/NAOJ/NRAO)

As material starts to get close to the forming protostar, it undergoes one final exchange of angular momentum before it can be accreted. In addition to disks, these forming protostellar systems also twist up and amplify a weak magnetic field that threads the gas. The bunched-up field lifts some material out of the disk and launches it outward at high speed in the form of a jet. The exact mechanism for jet formation and how the gas gets ejected at such high speeds remains a mystery; these jets sometimes reach speeds of hundreds of kilometres per second. However, these jets appear almost every time an accretion disk is formed. Jets from protostars can fly out into interstellar space and are frequently seen as bursts of material collide with lower-density gas. These collision knots are called Herbig-Haro objects (Figure 2).

Figure 2 — Infrared image of Herbig-Haro Object 212 in the constellation Orion. The image shows several knots of material shot out on either side of the forming protostar at the centre. The jet is not continuous, suggesting that the accretion onto the star is not steady. Image Credit: ESO/M. McCaughrean

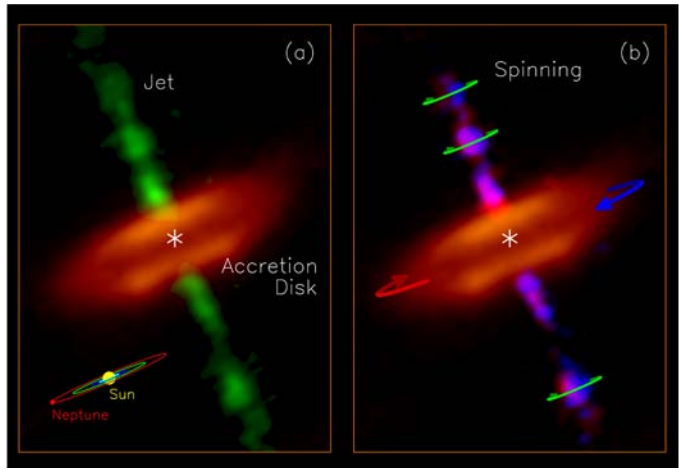

Figure 3 — Inner jet from Herbig-Haro Object 212 as observed by the ALMA telescope. Compared to the infrared image (Figure 2), this image shows the very central region of the jet, tracing where the gas is seen in molecular spectral lines. Critically, ALMA can resolve the Doppler shift of spectral lines, which shows that the jet is rotating and carrying angular momentum.

This whole picture of disk and jet formation can explain where the spins of the Solar System come from. But where did the original spin of the Solar System come from? The cold, dark core of molecular gas that forms a protostar is embedded in a larger, turbulent cloud of gas. In the vortices and shearing flows of the larger cloud, the cores are formed. The answer to where our spin direction and rate come from are ultimately set by the arbitrary flow of gas in our progenitor cloud billions of years ago. We can observe how fast these gas flows would generate angular momentum and then compare it to the angular momentum in our Solar System. Looking at the progenitor systems for stellar systems, we can measure how fast they appear to be rotating with radio telescopes and using the Doppler shift. We look at these cores and see that one side appears to be coming toward us and one side is moving away, a hallmark of rotation. The rotation is extremely slow but still measurable. The cores are huge compared to our Solar System, and with their collapse they would have a huge amount of angular momentum. In fact, the kind of core that would form our Solar System has 200 times the angular momentum that our own system does. This decrease in angular momentum is larger than accretion disks alone can explain, and the jet has long been suspected of providing another channel for getting rid of angular momentum.

Recently scientists in Taiwan and the US observed a forming protostar using the ALMA telescope. ALMA combined high spatial resolution with the ability to resolve the frequency shifts of spectral lines created by the Doppler shift. By peering deeper into a protostellar jet than had been previously possible, the research team found that the jet itself was spinning, providing the clearest evidence yet that the jets carry the excess spin of a system away from forming protostars, allowing them to build up their mass. This is visible in the map shown in Figure 3, which is shaded to show the blue and red shifted sides of the jet separately. The jet contains enough angular momentum to explain how the last stages of accretion can happen. This image is tracing the process of how a new stellar system is getting its original organization, into a thin slowly rotating disk, potentially with planets.

Read more at: https://arxiv.org/abs/1706.06343 ✶

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.

John Percy's Universe

Happy Birthday, Royal Astronomical Society of Canada!

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

In 1868, a group of astronomy enthusiasts, led by Andrew Elvins, met to form the Toronto Astronomical Club. It had its ups and downs and changes of name, as many organizations do, but it evolved into the RASC. I'm sure you will hear a lot about RASC's history and heritage this year, as the Society has excellent historians in Peter Broughton and Randall Rosenfeld. You can read about RASC's first century in Peter's *Looking Up: A History of the Royal Astronomical Society of Canada,* which is available on the RASC website, where you will also find information about the people who have been active in it over the years. In this column, I will therefore not try to write a mini-history of the RASC, but simply to offer some congratulatory comments and reflections. Here are some things that come to mind:

Our founders. It's important for organizations like the RASC to know about and appreciate those who founded the organization, and raised it through infancy, childhood, and adolescence. It's easy enough to operate a well-maintained machine, but another thing to build and test it in the first place. Through our formative years, Andrew Elvins was the stalwart. By 1890, there was a "critical mass" of amateurs and professionals. For Centennial purposes, this marked the beginning of our Society, but let's not forget the formative years!

Our "guiding light." I'm amazed that Professor Clarence Chant (1865–1956) could do this so long and so well, while creating modern astronomy courses and labs at the University of Toronto, establishing a separate budget for astronomy, founding the Department of Astronomy, which has been my home for almost 60 years, writing the best-selling *Our Wonderful Universe*, writing articles and giving lectures, which among other things, led to the donation and founding of the David Dunlap Observatory.

My own first organization. I'm an "organizations person." RASC was my first. After joining in 1961, I became National Librarian in 1965, while still a student. On National Council, I was actually working side by side with my professors, including Don Fernie, Jack Heard, Helen Hogg, and Ruth Northcott. They became role models. I also learned how interesting and diverse amateur astronomers were, and how they contributed to astronomy in so many ways. Through my professional and amateur RASC colleagues, I learned how I could enjoy, benefit from, and support pro-am astronomy, which I have done for over half a century.

History and heritage. I suspect that it was my time as National Librarian that ignited my interest in libraries, and in history and heritage. Reading Peter Broughton's history of the RASC certainly helped, as did the many articles written by Don Fernie and Jack Heard in our *Journal* and in the *David Dunlap Doings.*

From sea to sea to sea. I served as National President from 1978 to 1980, and was the first (in modern times) to visit every Centre—including one that wasn't expecting me. Unfortunately, we didn't have a Yukon Centre in my time. My family and I vividly remember attending GAs across the country. This is one way that we discovered the breadth and diversity of Canada. We also discovered the diversity of the Centres, their members, and their activities.

Citizen scientists. I soon became aware of the diverse and important contributions that amateur astronomers made—voluntarily—to astronomy: monitoring aurorae, meteors, and sunspots; discovering comets, novae, and supernovae;

measuring variable stars and lunar occultations; developing new techniques for observing and imaging; combating light pollution for the benefit of all. This undoubtedly encouraged me to begin my 40 years of collaboration with the American Association of Variable Star Observers—another exemplary pro-am organization. Equally: it was inspiring to see our members *engaged* in astronomy, whether as recreational sky observers, or armchair astronomers. That's good for their health, and that's one of the things that encourages me to continue my outreach activities in my "retirement."

Outreach. I had the great pride of co-nominating the RASC for the prestigious national *Michael Smith Award* for excellence in science promotion in 2003, and attending the presentation of the award, in Ottawa. I'm constantly amazed by the quantity, quality, diversity, and creativity of RASC outreach activities.

Partnership, leadership, and volunteerism. With CASCA, FAAQ, and other organizations, and with the inspired leadership of Jim Hesser, the RASC celebrated International Year of Astronomy 2009, with over 3600 events, reaching almost two million people face-to-face. And the RASC's activities were almost entirely organized and staffed by volunteers!

Publications! Each year, I marvel at the increasing size and comprehensiveness of the *Handbook*, compared with what it was like when I edited it in the 1970s, and the ability of the *Journal* to have "something for everyone." In my day, it was a chronic bone of contention! The *Beginner's Observing Guide*, and *Skyways* have filled important niches. And the *Observer's Calendar* is a work of art, as well as science. And bravo to the RASC for taking *SkyNews* under its wing! I use and recommend it constantly.

Governance. The last few years brought a real test—to revise our governance in accordance with new national requirements for all charitable organizations. Congratulations to our volunteer officers and representatives who pulled this off successfully!

A mature organization. In my 56 years as a member, and my many years on Toronto Centre and National Council, I have seen the challenges of satisfying amateurs and professionals, serving diverse Centres while being a national organization, in a country with vast geography and two official languages and untold cultures. And yet we still exist and thrive, with over 5000 members, 150 years later. In my travels around the world as an astronomer and educator, I have not seen a similar organization that meets such challenges as effectively as we have.

I have many other happy memories: working with Executive Secretaries Marie Fidler and Rosemary Freeman; eating "borealis baked beaver" at a western GA, and sailing the Bluenose at an eastern one; first meeting my long-time collaborator and friend Janet Mattei at a joint RASC–AAVSO GA in 1974 in Winnipeg; the 1999 joint meeting of AAVSO–ASP–RASC in Toronto (in a heat wave); chasing lunar occultations with the Toronto Centre; conveniently observing a total solar eclipse at the time of a National Council meeting in Winnipeg in the depths of winter (1979 February 26); meeting characters like Toronto Centre telescope maker Jesse Ketchum and St. John's stalwart Dora Russell; struggling to give a coherent lecture to the francophone Centres during my presidential cross-country visits (I'm sesquilingual at best); co-hosting the newborn Mississauga Centre at my University of Toronto Mississauga campus, and many more. I write about many of these things in my John Percy's Universe column in the JRASC, to share some of the interests that we have in common. I thank the Editors for allowing me to continue doing this.

Figure 1 — The author receiving the 1962 RASC Gold Medal from National President Professor Ruth Northcott.

There is still much to do. Our five-part mandate is quaintly Victorian. We need more participation from women, young people, and minorities. Teachers need our support. There is widespread public interest in astronomy that still goes unsatisfied. More RASC members could be more engaged in the Society.

But we should be proud. If we add up all of those who voluntarily run our programs each year, and contribute to our publications, the number is well up in the hundreds. And thousands of others—you, out there—contribute, through your membership, to our fundamental purpose: "advancing astronomy and related sciences." What a wonderful organization! Thank you! ✶

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

Your Board of Directors

by Colin A. Haig, M.Sc. (astronome@outlook.com)

During Centre visits, I'm asked about who is on our Board and what their role is. Here's a little background for you.

The Society is accountable to the public, as it is a federally incorporated, registered, not-for-profit charity. Your Board of Directors is accountable to the membership, and ultimately, as your President, I am accountable to you, the members. The Board is responsible for strategic direction and governance. The Executive Director, Randy Attwood, reports to the President and is accountable to the Board. The Executive Director is responsible for execution of the Board's direction, including day-to-day operations, and supervision of staff. Staff consist of two people. Renata Koziol manages financial activity, and has dotted-line reporting to Anthony Gucciardo, our Treasurer. Julia Neeser covers membership, marketing coordination, and other activity.

Colin Haig, yours truly, holds a B.Sc. in Computer Science and Systems, and M.Sc. in Computation (Artificial Intelligence) from McMaster University, and has served as an executive in the high-tech industry for over 20 years. I am a member of the Institute of Corporate Directors, and a member of the AAVSO, IEEE, RAC, ARRL, COPA, AOPA, and AMSAT. Am a life member of the Society, a frequent donor, and Past President of the Hamilton Centre. My robotic observatory is now online, and is serving as a prototype for a RASC Remote Telescope that could be available to the public, students, and our members, as funding permits. As President of the Society, I am an ex-officio member of all committees, and am chair of the Board of Directors. I find much of my time is administrative, dealing with financial matters and investments, policy matters, and dealing with issues as they come up, in addition to trying to move our plans forward. Fortunately, I have a great team of Board members, staff, and committee members to make things happen, as well as a lot of support at the Centre and Council levels.

Craig Levine is our Society's most recent Past President. A graduate of Dalhousie University in Halifax, Nova Scotia, where he is a past Centre President, Craig is a senior IT professional who currently resides in London, Ontario. He Chairs the Information Technology and Awards committees, and is a member of the Finance, Fund Raising, and Publications committees. He is focused on services and support for our Centres, strengthening the RASC as a welcoming and diverse Society, and working with our Board and Executive Director to build a solid and sustaining financial foundation, to grow our Society, and expand our capacity to serve our membership and all Canadians who have an astronomy passion.

Chris Gainor, Ph.D., is 1st Vice-President and he works as a historian. At present, he is writing a history of the *Hubble Space Telescope* for NASA. At the RASC, Chris chairs the Constitution and Publications Committees, where he is working on developing new publications. He is a long-time member of the Victoria Centre.

Our 2nd Vice-President, Robyn Foret (pronounced "For et" not "For Eh?"), hails from Calgary Centre, is an executive in the Technology Sector with "strong family values and three science-minded daughters." Robyn is Chair of the Nominating Committee and is Board Liaison for the Education and Public Outreach and Light-Pollution Abatement Committees. He is currently the Past President of the Calgary Centre, Volunteer Coordinator of the Centre, Chair of the Calgary Centre's Casino Fundraising Committee, and Chair of the GA2018 Committee. Robyn served at the national level for the past six years with a focus on supporting EPO, fostering an inclusive environment, and the Strategic Plan.

Anthony Gucciardo, RN, CD, is the Society's Treasurer and Chair of the Finance Committee. He is a very active member, and recent Past President of the Yukon Centre. His current projects include reassessing the membership fee structure; developing workshops for Centre Treasurers to help them accomplish their local/national objectives; developing a Social Media Strategy for the RASC, and a new Travel Expense Policy. Anthony is also team leader for a couple of new ideas being considered, an RASC 150th Nano-Satellite Project and a Portable Planetarium Proposal. Anthony has recently reached out to Committee Chairs for 2018 budget input, as well as preparing to work with the Auditor to prepare the 2017 financial statements. He serves as a Trustee of the RASC Walter J. Helm Fund, along with past president David Lane, and 1st V-P Chris Gainor.

Charles Ennis, our National Secretary, is a retired Vancouver Police detective and author of the RASC's *Building a Small Observatory* (and 23 other books), plus he recently spearheaded a re-write of the *Explore the Universe Guide*, now out in a second edition. He's the Special Publications Editor for the Publications Committee and serves on the Fundraising Committee. Charles is a driving force in, and serves as Past President on the Board of, the Sunshine Coast Centre. Charles organizes meetings, records minutes, and conducts much of the correspondence of the Society.

It is notable that both Charles and Anthony stepped down from their positions as leaders in their Centres, to better serve you on the Society's Board, and to be in compliance with the RASC By-Law requirements intended to prevent possible conflict of interest. We appreciate their commitment to the Society.

Heather Laird of Calgary Centre is an administrative legal assistant in the oil and gas industry, and is currently a Director, is a member of the History Committee, Chair of the Fundraising Committee, member of the 150th Anniversary Working Group, and Calgary Centre member. Heather is very humble, and is an active voice on our Board. She understands people and societal issues, and conducts herself with a great deal of sensitivity and compassion. She is helping to guide your Society in cultivating a diverse culture. Heather was instrumental in leading our Fundraising Committee, establishing a Charitable Gift Acceptance Policy, and prepared the groundwork for our new fundraising consultant, Lisa Di Veto.

At the most recent Board Meeting, Michael S.F. Watson was appointed as the Society's honorary Legal Counsel, and he serves on the Constitution Committee. He is currently working on some of the policy matters related to harassment and discipline of members. Michael is a long-time unattached member of the Society and an avid astrophotographer, known to take his large refractor to the dark skies of Algonquin Park in Ontario.

Dr. Rob Thacker is a Professor at Saint Mary's University, a Halifax Centre member, and he is also the Vice-President of the Canadian Astronomical Society (CASCA). A leader of recent national research plans, he is keen to develop stronger links between the RASC and CASCA so that both societies can learn and share best practices. He is also a strong advocate of outreach efforts and extending the RASC's membership through diversity and inclusivity initiatives.

This team brings different skills and perspective, and is committed to serve you well and to keep moving our Society forward. I truly appreciate each and every one of them, and I encourage you to thank them for their service and to invite them to visit your Centre.✶

A Word from our Fundraising Consultant

by Lisa Di Veto (ldiveto@rasc.ca)

I'm delighted to have the opportunity to introduce myself to RASC members! I've recently been engaged as Fundraising Consultant on a part-time contract and have been working with Randy Attwood, Renata Koziol, and Julia Neeser in Toronto to learn more about the organization and its plans for the future.

A bit of background: I've been helping charities achieve their goals for 20 years and have made significant contributions to the fund development and communications programs of major charities across the country including the Salvation Army, CNIB, Art Gallery of Ontario, United Church of Canada, and the Anglican Diocese of Niagara.

My role with The Royal Astronomical Society of Canada is to identify and implement strategies that will increase income and help diversify revenue sources. Additional funding will allow the organization to sustain and expand its charitable programming including increasing awareness about astronomy and the production of educational resources. As a member, you're already familiar with RASC world-class publications and receive a complimentary copy of the renowned *Observer's Handbook* and twelve *Journal* and *SkyNews* magazine issues throughout the year.

The organization has reached quite a milestone and is celebrating its 150th anniversary with opportunities to celebrate and mark this significant event throughout the year. To help strengthen RASC endeavours, several initiatives have recently been introduced to make it easier to contribute to the Society. Members can now enrol in pre-authorized giving and make a monthly gift to the organization. Donors can save capital gains of up to 50% by donating securities to RASC and receive a charitable tax receipt for the full value of the shares. Of course, online and direct-mail donation requests continue to facilitate member support of the important work of the charity.

In addition, I'll be seeking government and foundation grants and will share information about these potential sources with Centres that may also be eligible to apply. Funders often ask for details about the number of volunteer hours and how many people the organization serves in a year. That calculation could include the number attending Centre events, meetings, star parties, classroom, and public presentations. If this information is not currently compiled in your Centre, please consider doing so in order to help demonstrate community interest and participation when seeking financial contributions. I would greatly appreciate receiving this type of statistic from your Centre as available.

I hope we can exchange fundraising ideas and information with each other. I should mention that I plan to contact all RASC committee members, Centre presidents, and everyone with a role supporting the organization to learn more about your individual achievements across the country.

If your Centre successfully generates revenue, please share details with me in case other locations could benefit from your experience. Also, kindly advise me of beneficial community partnerships you've established. Similarly, please don't hesitate to contact me if I may assist you in your fundraising efforts. I may be reached at 519-754-1803 or ldiveto@rasc.ca

Thank you for your commitment and interest and I look forward to working with you and contributing to the continued success of RASC! ✶

2016 and 2017 Donors

Compiled by James Edgar

These donors support the outreach of the RASC by giving generously of their dollars. We thank them for the many ways they encourage astronomy education in Canada, through our publications, our website presence, our numerous public events and speaker talks, and to support infrastructure, Society development, and special projects.

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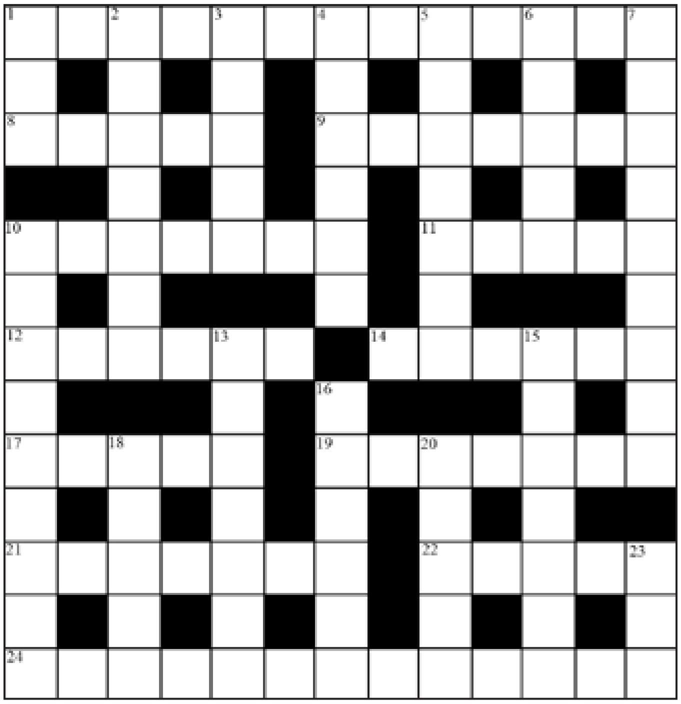
Astrocryptic

by Curt Nason



ACROSS

1. Mobile frequency changer perfected flop disarray (7,6)
8. Each little piece from strewn garbage used in his X-ray spectrometer (5)
9. Ron, coated in black, makes a hole in the Sun (7)
10. With astronomer's vision, Dave circled the short way (7)
11. Wobbling, I pass perigee, for example (5)
12. Under pressure, he crammed 100,000 in a bar (6)
14. Handy comet writer saw Kaus Australis in one billionth natural light (6)
17. Electronic agreement to use lunar tables for Easter (5)
19. Bind with gold what Sawyer's fiancé wore? (4,3)
21. OH description of Chilean facility by the National Advisory Council (7)
22. Eyepiece found at the birthplace of Artemis (5)
24. Dust reflection reaching the Pleiades (8,5)

DOWN

1. Date of birth for your little telescope (3)
2. Wanderers bent staple around a pole (7)
3. Not a heavy requirement for reading star maps (5)
4. Ebb tidings of a red shift (6)
5. Radio source detected in a furnace (6,1)
6. Our secretary for a headless menace (5)
7. Instrument put up with twisted steel at first (9)
10. Her alt-az shook with pressure in viewing crown for a princess (9)
13. NEAT has all the components for a radio receiver (7)
15. Ten to one, mathematically (7)
16. Star of the bowl won diamond in cheap setting
18. Used a Telrad for media scrum (5)
20. Unusual lodge in his strange rotating universe (5)
23. Array of similar eyepieces used when the Moon went down (3)

Answers to December's puzzle

ACROSS

1 PROXIMA (hidden); **5** GRUIS (anag+is); **8** LIBRA (Li+bra); **9** ION TAIL (i(anag+a)ll) (mistake-sorry); **10** AITKENS (anag); **11** AVIOR (2 def); **12** EMISSION LINES (anag); **16** BEPPO (2 def); **18** ZERO AGE (anag); **20** ANTARES (ant+sera(rev)); **21** SAIPH (anag); **22** GASES (anag); **23** ACADIAN (anag-n)

DOWN

1 PULSATE (anag-h); **2** ORBIT (orb+it); **3** IMAGERS (I+ma(GE)rs); **4** ARIES (Ar(I)es); **5** GINGA (anag); **6** URANIAN (Urania+N); **7** SOLAR (so(L)ar); **13** IAPETUS (anag); **14** LARISSA (a(AR)nag); **15** STEPHAN (step+Han); **16** BRAGG (bra(g)g); **17** OORTS (anag); **18** ZOSMA (hid); **22** AMICI (am+ici)

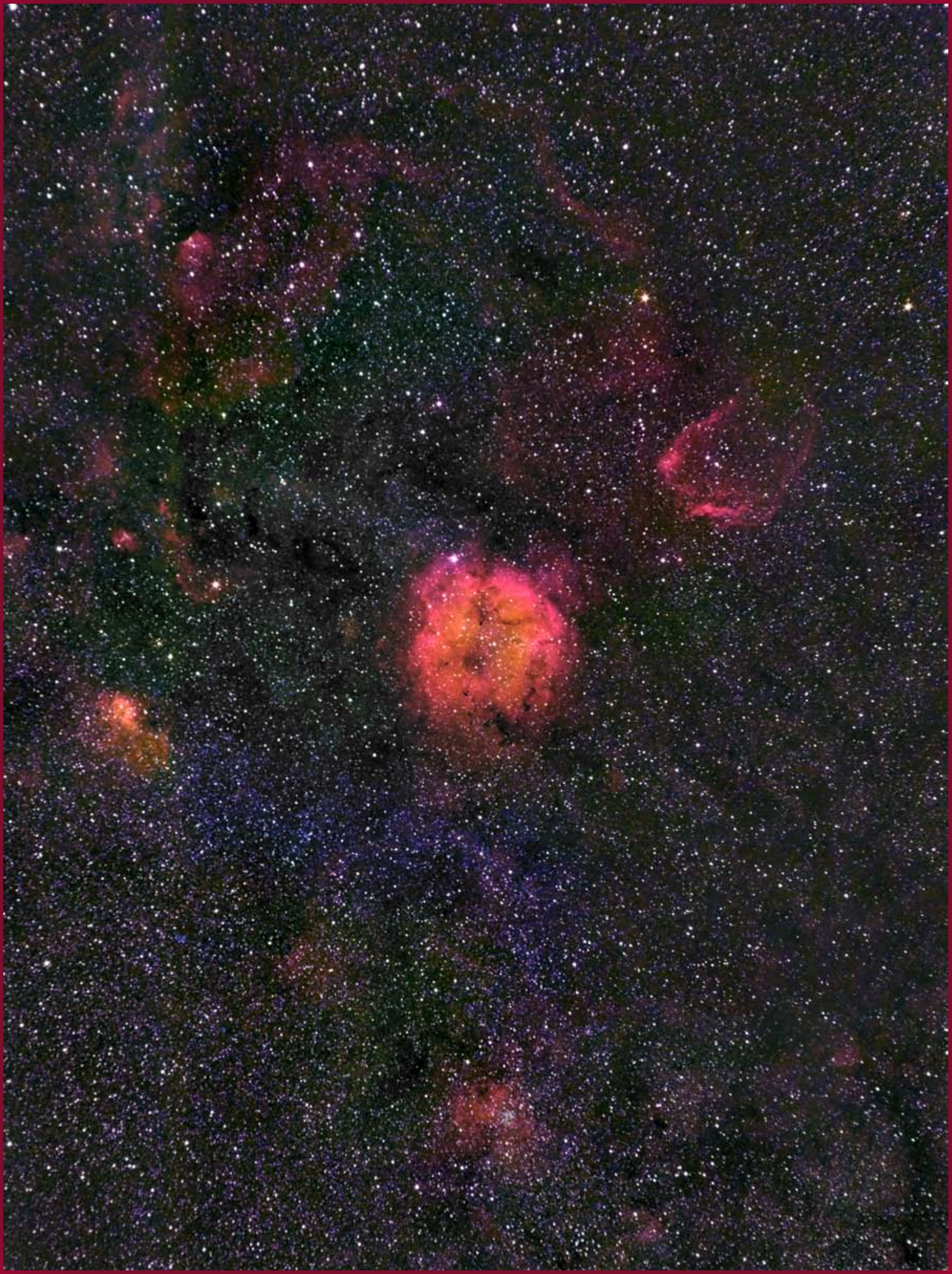
It's Not All Sirius

by Ted Dunphy

Great Images

by Nicole Mortillaro

The beautiful craters and maria of the Moon are seen here in this photograph taken by Journal *Editor-in-Chief Nicole Mortillaro. The image was taken through a Celestron Edge HD with a 0.7-mm focal reducer.*



Journal

Great Images

Francois Theriault imaged IC 1396 in narrowband using a Nikon 50-mm Nikon Nikkor lens at ƒ/1.4 through an SBIG STF8300M mounted on a CGEM. The image was processed using Photoshop, Sequence Generator Pro, and PixInsight.