The Journal of The Royal Astronomical Society of Canada

Journal

Le Journal de la Société royale d'astronomie du Canada

PROMOTING ASTRONOMY IN CANADA

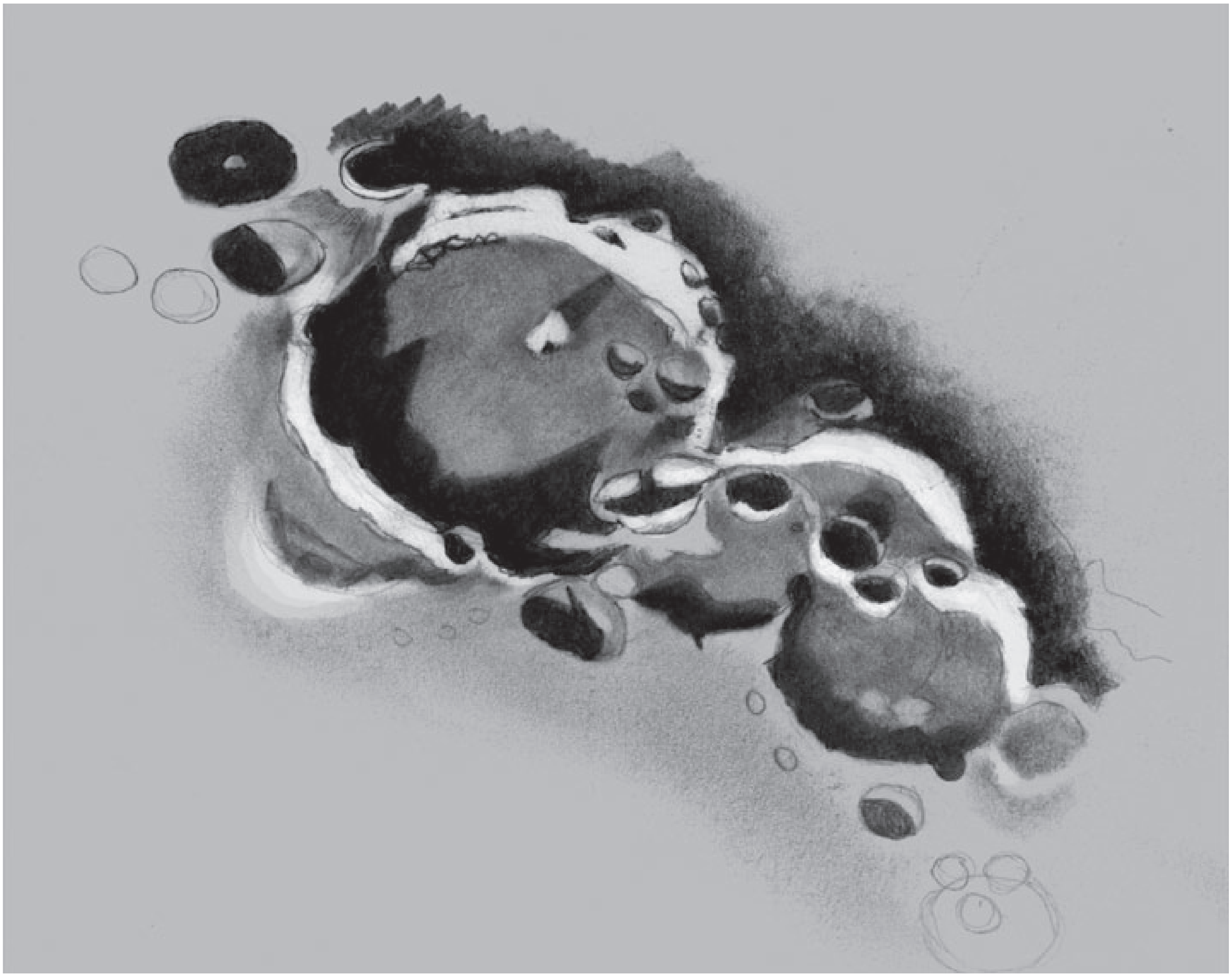
August/août 2018
Volume/volume 112
Number/numéro 4 [791]

Inside this issue:

Trifid & Lagoon

The Best of Monochrome.

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



Michael Gatto spent some time with the Moon on 2018 June 22 to work on his RASC "Observe the Moon" program, with a goal of eventually sketching all the mountains and craters in the list. Here are 2 entries, crater Longomontanus (#61 on the list, top) and crater Wilhelm (#88 on the list, bottom right). This sketch was completed at the eyepiece of a Dob-mounted 8″ ƒ7.5 Newtonian between 10 and 11 p.m., with a 13-mm Baader Hyperion eyepiece, under only average seeing conditions. Scanned and adjusted in Photoshop.

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Royal Astronomical Society of Canada

Société Royale d'Astronomie du Canada

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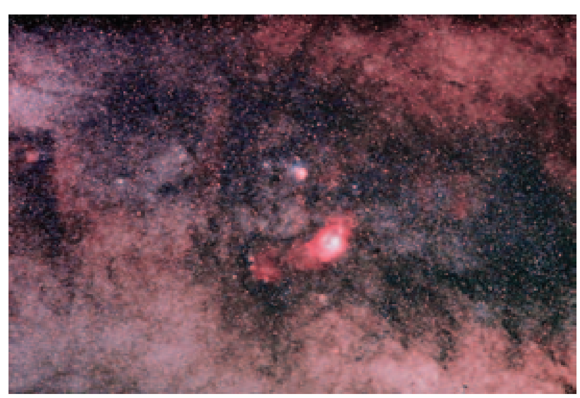

Klaus Brasch obtained this image of the M8 and M20 Milky Way region from his favourite local ultra-dark site, Wupatki National Monument. This is a stack of 3 x 1-, 2-, and 3-minute exposures through his now antique (55-years-old) Olympus Zuiko 200-mm f/4 telephoto lens with his modified Canon 6D and Astronomik CLS insert filter, all mounted on an iOptron Sky-Tracker.

Journal

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

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President's Corner

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Can you predict our Society's next 150 years?

Our Society predates the invention of so many things that have disrupted our lives and have brought immeasurable benefits and challenges. A short list of innovations since 1868 would include Alexander Graham Bell's telephone, Nicolaus Otto's 4-stroke internal combustion engine, George Eastman's photographic film, the Alouette satellite, the Dominion Astrophysical Observatory, David Dunlap Observatory, and many more. Today, the world is more connected, more mobile, and more populated than ever before.

Astronomy is no longer the lone scientist peeking through a long refractor or the amateur grinding a mirror in the basement. We have smartphones that bring us together, electric and hybrid cars that allow easy personal transport, CMOS and CCD cameras that give us stunning images in seconds, and robotic telescopes that can gather data while we sleep comfortably in our memory-foam beds. Science is now an international, collaborative affair, with Canada's participation in the Thirty Metre Telescope (TMT), the Square Kilometre Array, and the *International Space Station*. As I write this, we're all anxiously hoping for a Martian dust storm to pass, so that the Curiosity rover can recharge its batteries and carry on exploring, almost 15 years after its 90-day initial mission (and warranty?) was up. Canada's contribution was the Alpha Particle X-ray Spectrometer (APXS) that is an essential part of this intrepid explorer.

The next 150 years will hopefully bring us stunning discoveries from the TMT, the *James Webb Space Telescope*, and a new generation of radio astronomy powered by "Big Data," the vast computing resources and analytics for processing mind-bogglingly large data set. We will likely see new, more sensitive detectors, new computing capabilities, and new ways of collaborating. The successful *New Horizons* probe will visit Ultima Thule 2014 MU69 in the Kuiper belt and unlock further mysteries as it did during its visit to (dwarf-) planet Pluto. Technology will continue to get cheaper and more capable, and clever people will continue to innovate. I remain optimistic about the future of amateur and professional astronomy in Canada.

As my term as President wraps up at the end of the first 150 years, I look back at the accomplishments we've made together, and look forward with anticipation to the future. Visits to a handful of Centres, various university events, and the recent grand re-opening of the David Dunlap Observatory park helped me realize we are making great strides. More women are pursuing science degrees, more young people are looking up, and a greater focus on STEM (Science, Technology, Engineering and Mathematics) is starting to bear fruit. I am pleased to say there is more family engagement at the Centre level, and the membership is becoming more representative of the Canadian population, with greater diversity.

To prepare for the next 150 years, we will need to rejuvenate our programs, re-commit to the fight to save the night skies, and ensure there are exciting, fun, and compelling activities for people of all ages. Our greatest value is in the sharing of knowledge, the mentoring, coaching, and encouragement that we provide one another. We have great influence, and our efforts in the media, and through publishing, reach more people than we know. Let's use our talent and our reach with care.

I'm proud to see we've made steps to improve our culture, to begin fundraising, and to start the Robotic Telescope project that many of you asked for. You can learn a bit more at www.rasc.ca/telescope.

Thank you for this opportunity to serve you, and I hope to continue to move astronomy in Canada along in the coming years. Please join a committee or a local effort to help set the stage for the next 150 years.

This may be my last column, but not the last time I will say: *"At the RASC, our business is looking up!"* ✶

News Notes / En Manchette

Compiled by Jay Anderson

A real-life counterpart to Star Trek's Andoria?

In the Star Trek anthology, Andoria is an icy Earth-like moon orbiting a ringed, gas-giant planet inhabited by humanoids with blue skin, white hair, and fashionable cranial antennae. Is Andoria imitating real life?

Since its launch in 2009, NASA's *Kepler* spacecraft has detected thousands of exoplanets, the large majority of which were gas giants that offered little or no hope of harbouring life. Attention has focused on a relatively few terrestrial (rocky) planets that lie in their host star's habitable zone, where it is neither too hot nor too cold for liquid water. About a hundred of those have been identified. Terrestrial planets are prime targets in the search for life because some of them might be geologically and atmospherically similar to Earth. But what about the moons that might be orbiting some of the less-terrestrial candidates?

In a paper to be published in *The Astrophysical Journal*, a team of researchers at the University of California, Riverside, and the University of Southern Queensland have identified more than 100 giant planets that potentially host moons capable of supporting life. While not candidates for life themselves, Jupiter-like planets in the habitable zone may harbor rocky exomoons that could sustain life. The *Kepler* mission identified 70 exoplanets with sizes larger than three Earth radii that lie within the "optimistic habitable zone."

"There are currently 175 known moons orbiting the eight planets in our Solar System. While most of these moons orbit Saturn and Jupiter, which are outside the Sun's habitable zone, that may not be the case in other planetary systems," said Stephen Kane, an associate professor of planetary astrophysics and a member of the UCR's Alternative Earths Astrobiology

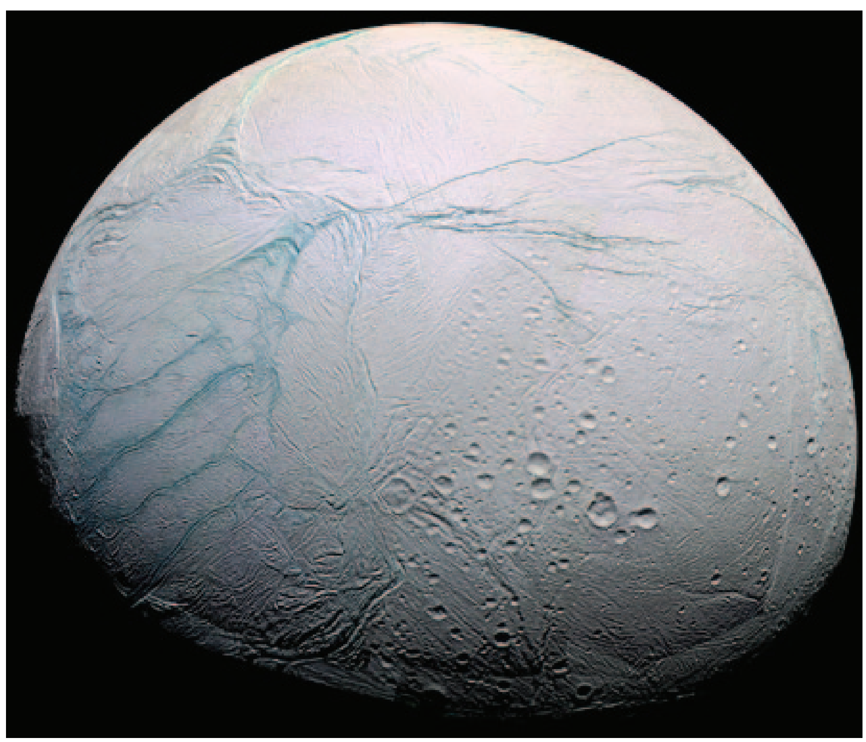

Figure 1 — Saturn's moon Enceladus is rich in water vapour, but a little too far from the Sun to support life on its surface. Were its parent planet as close as the Earth (and Enceladus much larger), life in our Solar System would be considerably more intricate. Image: NASA.

Center. "Including rocky exomoons in our search for life in space will greatly expand the places we can look." Exomoons in a favourable environment for Earth-like life would be more comfortable counterparts of Enceladus around Saturn or Ganymede around Jupiter.

The research team identified 121 giant planets that have orbits within the habitable zones of their stars. At more than three times the radius of the Earth, these gaseous planets are less common than terrestrial planets, but each is expected to accommodate several large moons. Thermal and reflected radiation from the host planet and tidal effects increase the outer range of the habitable zone around these planets, providing an extended environment in which life forms can develop and evolve.

Using a mathematical model, the research team explored possible configurations of host star, exoplanet characteristics, and habitable-zone sizes that could potentially harbour exomoons with life-forming characteristics. They found that if a giant planet sported only one moon, then the occurrence rate of moons in the habitable zone was less than that of terrestrial exoplanets. For giant planets with more than one moon—a likely possibility given the preponderance of moons in our own Solar System—the occurrence rate of habitable planets would likely match or exceed the frequency of life-supporting terrestrial exoplanets.

Not all is sweetness and light, however. Giant planets may have reached their present orbits by migrating inward from more distant reaches of the exoplanet planetary system, and so the moons may have had only a short time in the "Goldilocks" zone to develop life forms. If the giant planet continues to migrate inward, the moons will eventually be stripped from their orbits by the host star. Nevertheless, the idea of a population of life-supporting moons around otherwise unfavourable planets is a tempting one. While the detection of life-supporting exomoons is at or beyond the limit of current telescopes, the Giant Magellan Telescope now under construction should be able to detect at least some exomoons around planets in the habitable zone, principally by observing radial-velocity shifts in the spectrum of the host star. *Kepler* and its successors are able to detect the signature of transiting exomoons, but the signature of an occulting moon as it passes in front of the star may be difficult to disentangle from a number of confounding factors, including other moons that may contribute to the dip in light from the host star.

In fact, one exomoon may already have been detected. In August last year, Columbia astrophysicists Alex Teachey and David Kipping described an observation of Kepler 1625 b, which seems to sport a Neptune-sized moon, if their interpretation of a second dip in brightness of an occulting exoplanet is correct.

Of course, the question could be easily answered by the arrival of a cohort of blue beings.

It's a circus out there

Bumper-car-like interactions at the edges of our Solar System—and not a mysterious ninth planet—may explain the dynamics of strange bodies called "detached objects," according to a new study. Detached objects, such as the dwarf planet Sedna, are outer Solar System bodies that have perihelia (closest approach to the Sun) so distant that they have minimal interaction with Neptune and so appear disconnected from the rest of the Solar System. Sedna, one of nine detached Trans-Neptunian Objects has a highly elliptical orbit that takes it from 86 to 937 AU from the Sun in an 11,400-year period. Scientists have struggled to explain why Sedna and its companions have become separated from the rest of the Solar System.

University of Colorado Boulder, Assistant Professor Ann-Marie Madigan and a team of researchers have offered up a new theory for the existence of planetary oddities like Sedna. But Madigan and her colleagues calculated that the orbits of Sedna and its ilk may result from these bodies jostling against each other and against space debris in the outer Solar System. "There are so many of these bodies out there. What does their collective gravity do?" said Madigan. "We can solve a lot of these problems by just taking into account that question." It's an unusual place, gravitationally speaking. "Once you get further away from Neptune, things don't make any sense, which is really exciting," Madigan said.

Enter the hypothetical Planet Nine. Astronomers have been searching for such a planet, which would be about 10 times the size of Earth, for about two years but have yet to spot it with telescopes.

Madigan's team didn't originally intend to look for another explanation for those orbits. Instead, Jacob Fleisig, an undergraduate studying astrophysics at CU Boulder was developing computer simulations to explore the dynamics of the detached objects. "He came into my office one day and says, 'I'm seeing some really cool stuff here,'" Madigan said.

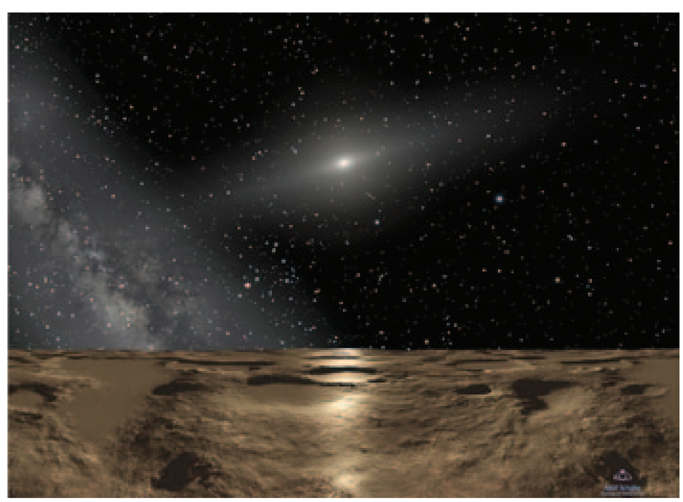

Figure 2 — An artist's impression of noontime on Sedna, with the Sun and Solar System above the horizon. Image: NASA, ESA, and Adolf Schaller.

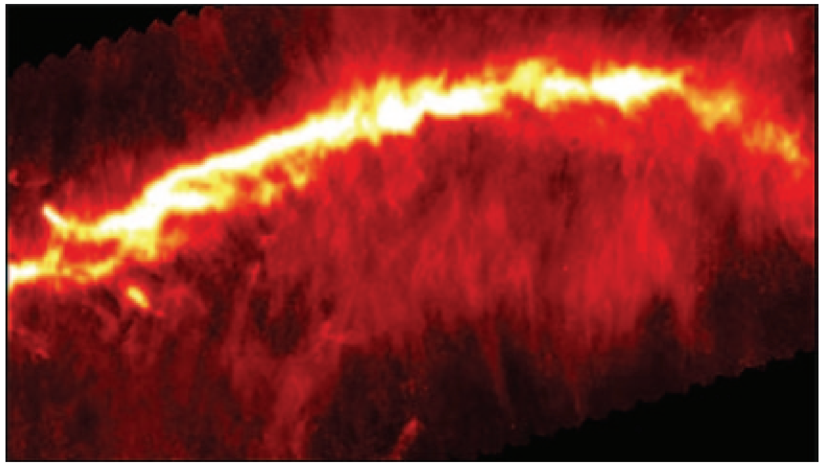

Figure 3 — An image of the Doodad Nebula in infrared from the Herschel Space Observatory. *The filaments used to determine the dimensions of the nebula can be seen below the bright arc of emission. Image: ESA.*

Fleisig had calculated that the orbits of icy objects beyond Neptune circle the Sun like the hands of a clock. Some of those orbits, such as those belonging to asteroids, move like the minute hand, or relatively fast and in tandem. Others, the orbits of bigger objects like Sedna, move more slowly. They're the hour hand. Eventually, those hands meet.

"You see a pileup of the orbits of smaller objects to one side of the Sun," said Fleisig, who is the lead author of the new research. "These orbits crash into the bigger body, and what happens is those interactions will change its orbit from an oval shape to a more circular shape."

In other words, Sedna's orbit goes from normal to detached entirely because of those small-scale interactions. The team's findings also fall in line with recent observations. Research from 2012 noted that the bigger a detached object gets, the farther away its orbit becomes from the Sun—exactly what Fleisig's calculations showed.

The findings may provide clues around another phenomenon: the extinction of the dinosaurs. As space debris interacts in the outer Solar System, the orbits of these objects tighten and widen in a repeating cycle. This cycle could wind up shooting comets toward the inner Solar System—including in the direction of Earth—on a predictable timescale.

"While we're not able to say that this pattern killed the dinosaurs," Fleisig said, "it's tantalizing." "The picture we draw of the outer Solar System in textbooks may have to change," Madigan said. "There's a lot more stuff out there than we once thought, which is really cool."

Composed in part with material provided by the University of Colorado Boulder.

How a filament becomes a pancake

Two astronomers, astrophysicist Konstantinos Tassis **of** the University of Crete and Aris Tritsis, a postdoc at the Australian National University, have determined the three-dimensional structure of a molecular gas cloud in the constellation Musca using information encoded in vibrations in the cloud's magnetic field. The vibrational signature is visible in narrow striations that lie along the periphery of the isolated gas cloud.

Tassis and Tritsis determined that striations visible in 250-μm infrared images from the *Herschel Space Observatory* were molded as the magnetic waves compress the gas, forming regions of brighter emission that trace out the wave structure. The various striations map out a spectrum of harmonic waves whose wavelength depends on the dimensions and composition of the gas cloud. By analyzing the frequencies of the waves, the two astronomers were able to produce a model of the cloud, which showed that it is a large sheet-like structure and not a thin filament, as it appears.

The waves form harmonics because they are trapped, much like a string on a violin or cello is trapped and compelled to resonate at certain frequencies. In a molecular cloud (or anywhere that wave harmonics are present), trapping requires boundaries to reflect the wave. In a gas cloud, resonant magnetic waves may be confined by the external pressure of a warmer, surrounding, more diffuse gas, or as the result of sharp changes in density or magnetic field at some boundary.

In effect, the Musca gas cloud (the Dark Doodad Nebula) is vibrating much like a bell after it has been struck.

Tassis and Tritsis concluded that the Musca nebula is best modelled by a sheet-like, rectangular shape with rounded corners, much like a squared-off pancake with dimensions of 6.2 x 8.2 pc. Their analysis also provided values for the cloud's density. The nature of the striations is not yet fully understood, according to Tassis, but their work proposes how to interpret them as the signature of magnetic waves travelling within the cloud.

Australian National University sets stargazing record

Citizen scientists in every state and territory have helped The Australian National University (ANU) smash its own stargazing Guinness World Records title and to search through thousands of telescope images online to find two supernovae.

More than 40,000 people across hundreds of locations in Australia looked at the Moon at the same time on May 24 to break the world record for the "*Most people stargazing multiple venues*." This was five times greater than the number of people involved in the previous record.

ANU held the previous Guinness World Records title for the category—just shy of 8,000 participants across 37 locations in Australia. Participants looked up to the night-sky at the same time on 2015 August 21.

Dr. Anais Möller from ANU said citizen scientists also searched through images from ANU's SkyMapper telescope to help astronomers identify two new Type Ia supernovae. "SN2018bwq is around 1.1 billion light-years away from Earth, and it is still getting brighter," said Dr. Möller from the ANU Research School of Astronomy and Astrophysics. "SN2018bwp is around 900 million light-years away and it is already fading away."

Dr. Möller and ANU astronomer Dr. Brad Tucker lead the citizen science project, which was part of Australian Broadcasting Corporation's (ABC) *Stargazing Live* broadcast from the ANU Siding Spring Observatory.

"I'm amazed that more than 6,000 volunteers have helped us over 3 days to make more than 1,700,000 classifications in our search for exploding stars in the Universe," Dr. Möller said. "A professional astronomer would need nearly two years to do the same amount of work, so it's an incredible achievement."

Dr. Tucker said the fact that tens of thousands of citizens took part in the citizen science project and the stargazing world-record effort was amazing.

"Events like the world-record attempt and asking for help with searching for new exploding stars just goes to show that science is really for everyone," said Dr. Tucker from the ANU Research School of Astronomy and Astrophysics. He said the partnership with the ABC to engage the public through *Stargazing Live* had been fantastic.

"It has been a great showcase of astronomy and all the great work we are doing in Australia," Dr. Tucker said.

Compiled from material provided by Australian National University.

Yawn. Stretch. *New Horizons* wakes up

NASA's *New Horizons* spacecraft is back "awake" and being prepared for the farthest planetary encounter in history—a New Year's Day 2019 flyby of the Kuiper belt object nicknamed Ultima Thule.

Cruising through the Kuiper belt more than six billion kilometers from Earth, *New Horizons* had been in resource-saving hibernation mode since December 21. Radio signals confirming that *New Horizons* had executed on-board computer commands to exit hibernation reached mission operations at the Johns Hopkins Applied Physics Laboratory (APL) in Laurel, Maryland, via NASA's Deep Space Network on June 5.

Mission Operations Manager Alice Bowman of APL reported that the spacecraft was in good health and operating normally, with all systems coming back online as expected.

After wakeup, the mission team collected navigation tracking data and sent the first of many commands to onboard computers to begin preparations for the Ultima flyby. Those flyby preparations included memory updates, Kuiper belt science data retrieval, and a series of subsystem and science-instrument checkouts. This month, the team will command *New Horizons* to begin making distant observations of Ultima, acquiring images that will help the team refine the spacecraft's course to fly by the object.

"Our team is already deep into planning and simulations of our upcoming flyby of Ultima Thule and excited that *New Horizons* is now back in an active state to ready the bird for flyby operations…," said mission Principal Investigator Alan Stern, of the Southwest Research Institute in Boulder, Colorado.

Since its flypast of Pluto, *New Horizons* has been speeding deeper into space, observing other Kuiper belt objects and measuring the properties of the heliosphere while heading toward the flyby of Ultima Thule, about 1.6 billion kilometres beyond Pluto. The flypast will take place on 2019 January 1.

Figure 4 — Artist's impression of NASA's New Horizons *spacecraft encountering 2014 MU69 (Ultima Thule), a KBO that orbits 1.6 billion kilometres (1 billion miles) beyond Pluto. Image: NASA/Johns Hopkins University Applied Physics Laboratory/Southwest Research Institute/Steve Gribben.*

The 165-day hibernation that ended June 4 was the second of two such "rest" periods for the spacecraft before the Ultima Thule flyby. The spacecraft will now remain active until late 2020, after it has transmitted all data from the Ultima encounter back to Earth and completed other Kuiper belt science observations.

Compiled with material provided by Johns Hopkins Applied Physics Laboratory.

Carbonaceous chondrite in the outer Solar System

An international team of astronomers has used European Southern Observatory (ESO) telescopes to investigate a relic of the primordial Solar System. The team found that the unusual Kuiper Belt Object (KBO) 2004 EW_{95} is a carbon-rich asteroid, the first of its kind to be confirmed in the cold outer reaches of the Solar System. This curious object likely formed in the asteroid belt between Mars and Jupiter and has been flung billions of kilometres from its origin to its current home in the Kuiper belt.

The early days of our Solar System were a tempestuous time. Theoretical models of this period predict that after the gas giants formed, they rampaged through the Solar System, ejecting small rocky bodies from the inner Solar System to far-flung orbits at great distances from the Sun. In particular, these models suggest that the Kuiper belt—a cold region beyond the orbit of Neptune—should contain a small fraction of rocky bodies from the inner Solar System, such as carbon-rich asteroids, referred to as carbonaceous asteroids.

Now, recent observations have presented evidence for the first reliably observed carbonaceous asteroid in the Kuiper belt, providing strong support for these theoretical models of our Solar System's troubled youth. After painstaking measurements from multiple instruments at ESO's Very Large Telescope (VLT), a small team of astronomers led by Tom Seccull of Queen's University Belfast in the UK was able to measure the composition of the anomalous KBO 2004 EW_{95}, and thus determine that it is a carbonaceous asteroid. This suggests that it originally formed in the inner Solar System and must have since migrated outwards.

The peculiar nature of 2004 EW_{95} first came to light during routine observations with the NASA/ESA *Hubble Space Telescope* by Wesley Fraser, an astronomer from Queen's University Belfast, who was also a member of the team behind this discovery. The asteroid's reflectance spectrum was different to that of similar small KBOs, which typically have uninteresting, featureless spectra that reveal little information about their composition. "The reflectance spectrum of 2004 EW95 was clearly distinct from the other observed outer Solar System objects," explains lead author Seccull. "It looked enough of a weirdo for us to take a closer look."

However, even with the impressive light-collecting power of the VLT, 2004 EW_{95} was still difficult to observe. Though the object is 300 kilometres across, it is currently a colossal four billion kilometres from Earth, making gathering data from its dark, carbon-rich surface a demanding scientific challenge.

"Not only is 2004 EW95 moving, it's also very faint," adds Seccull. "We had to use a pretty advanced data-processing technique to get as much out of the data as possible."

Two features of the object's spectra were particularly eye-catching and corresponded to the presence of ferric oxides and phyllosilicates. The presence of these materials had never before been confirmed in a KBO, and they strongly suggest that 2004 EW_{95} formed in the inner Solar System.

Seccull concludes: "Given 2004 EW95's present-day abode in the icy outer reaches of the Solar System, this implies that it has been flung out into its present orbit by a migratory planet in the early days of the Solar System."

"While there have been previous reports of other atypical KBO spectra, none were confirmed to this level of quality," comments Olivier Hainaut, an ESO astronomer who was not part of the team. "The discovery of a carbonaceous asteroid in the Kuiper belt is a key verification of one of the fundamental predictions of dynamical models of the early Solar System."

Compiled with material provided by the European Southern Observatory. ✶

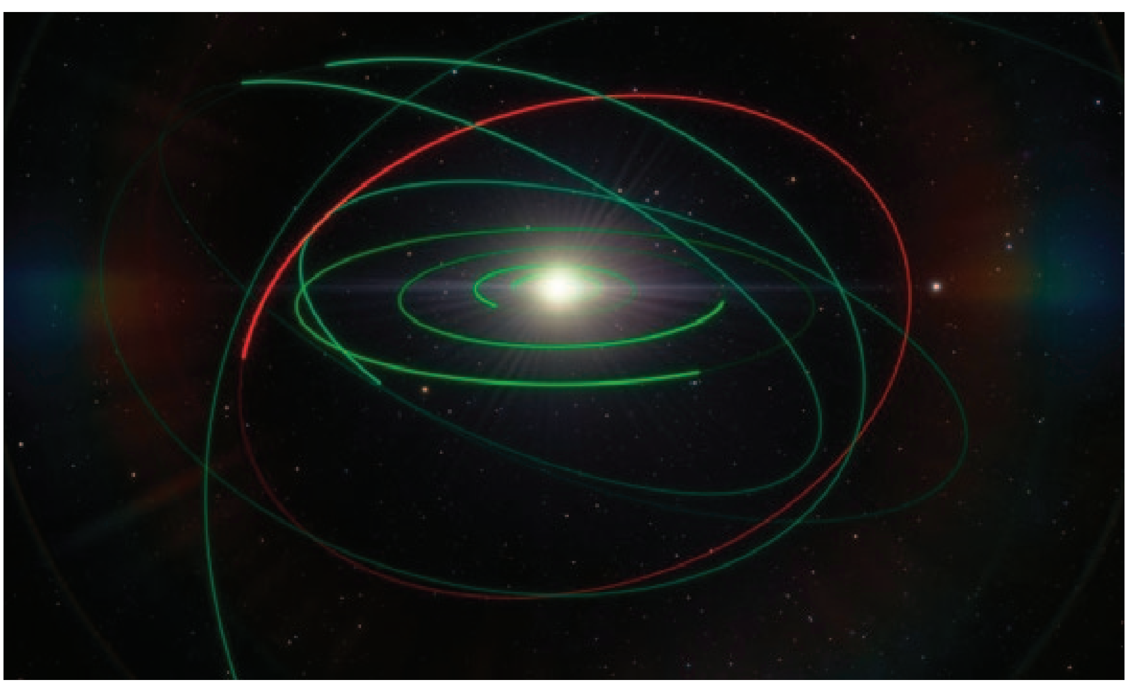

Figure 5 — The red line in this image shows the orbit of 2004 EW_{95}, with the orbits of other Solar System bodies shown in green for comparison. Image: ESO/L. Calçada.

Fran Bagenal's Visit

by James Edgar, Regina Centre
(james@jamesedgar.ca)

In early November 2017, I had just finished reading a *Sky&Telescope* article about the *Juno* spacecraft orbiting Jupiter, and the plasma experiment onboard the satellite. Then, the author's name leapt off the page—Fran Bagenal. I knew that name! I quickly looked her up on the University of Colorado Boulder website, got her email address and wrote this:

> Hi Fran, I just finished your S&T article on Jupiter. Fascinating stuff!
>
> I'm writing to ask if you might have a connection to Northern Ireland. A couple centuries back Lord Bagenal had a castle in Newry, Co. Down, near where my family came from, Kilkeel.
>
> Are you part of that Bagenal family?
>
> James

Her quick response was positive:

> Hi James
>
> Well spotted!
>
> Indeed, I am related to the Bagenal family of Bagenalstown in Ireland.
>
> I actually visited there with my brother last summer. I had been doing some digging through the family history. It turns out that there are only 25 people with last name Bagenal, and none of them live in Ireland. The last was in the early 1900s. My great grandfather moved over to England about the time of the First World War. We met some lovely people including a couple of elder gentlemen who knew lots of the local history.

Figure 1 — Fran Bagenal's asteroid in wood 10020 Bagenal.

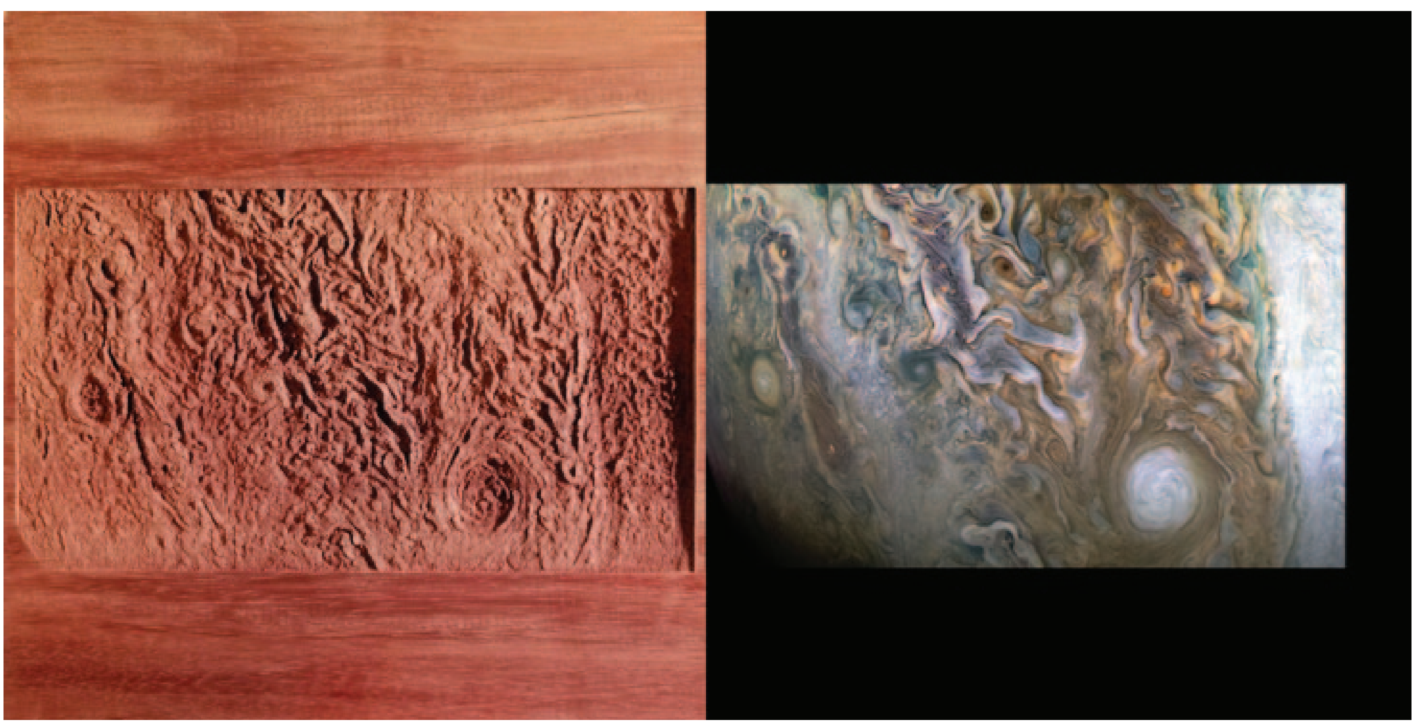

Figure 2 — The carving of the image from Perijove 9, in African rosewood.

I came over to the US in 1976 for graduate school (at MIT) and got involved in the *Voyager* mission (check out the PBS program The Farthest).

Since 1989 I have been at the University of Colorado, and lucky enough to work on a bunch of planetary missions.

What brought you to the US? I'm guess that if you read S&T then you may also be in a technical field.

Best regards, Fran Bagenal

From there, the conversation went on to an offer to speak to an astronomy group near to where I live. After a few back and forth emails, we settled upon a time in early May when Fran would fly to Regina to give a talk to the Regina Centre, then go on to Saskatoon to address the Centre there. She signed above her name *p.s. Asteroid 10020 Bagenal*. I couldn't let that slide by without a carving on my CNC milling machine. I quickly popped it into the mail.

A little later, I created a 3-D carving of Jupiter's cloudtops from an image taken during Perijove 9 (the 9th orbit of the *Juno* spacecraft), and I thought who better to have it than Fran.

She responded in a most positive way:

Dear James - Wow. Wow. Wow.

Thank you so much. I am really impressed.

Not just my asteroid - but Jupiter's clouds!

Many thanks indeed. You've gotten me thinking about what I should take up as a hobby on retirement…..

Very best wishes for 2018!

When my wife and I received Christmas gifts in 2017 from our son and daughter-in-law, one of them was a DVD entitled *The Farthest Voyager in Space*. Who should we see on the DVD but a very young Fran Bagenal, speaking about the plasma experiment on board *Voyager*. Through the experiment, Fran discovered that Uranus has a magnetic field almost 60 degrees away from the uptilted rotation axis—very strange! Apart from *Juno*, Fran has participated in the plasma and magnetosphere experiments on *Galileo*, *Deep Space 1*, and *New Horizons*.

Fast forward to May 11, that long-awaited date for Fran's visit to Regina. I was flat on my back in a hospital ward having just had open-heart surgery (six bypasses!). I was in no shape to get to her talk. I was sore and sorely disappointed! That was Friday. But, on Saturday, I got a short email from Fran asking if I could receive visitors. And I quickly responded "YES!"

A short while later, Vance Petriew, President of the Regina Centre, and Fran showed up at my hospital room. We had the loveliest of visits, and we're sure to see her again in a couple of years. Vance intends to have Fran as a guest speaker at the Saskatchewan Summer Star Party 2020.

She was so thoughtful to bring me a poster and a *Juno* sticker to keep.

As planned, Fran drove up to Saskatoon, got to tour the Canadian Light Source at the university, had a tour of SED (Systems Engineering Division) arranged through Rick Huziak of Saskatoon Centre (he works there), and presented her talk to an enthusiastic crowd on May 14.

I may not have heard Fran's talk, but I will treasure forever the visit we had on May 12, and the numerous emails back and forth over the six months from November 2017 to May 2018. I'm still "Over the Moon!" [Note: Regina Centre distributed a YouTube video of Fran's talk, recorded for posterity. So, I got to see and hear it after all.] ✶

James Edgar is the production manager of the Journal, *a past president of the Society and the editor of the* Observer's Handbook.

Figure 3 — James, Fran Bagenal, and Vance Petriew in Regina General Hospital.

Viewing the Moon Across Time: RASC Sesquicentennial Observing Program

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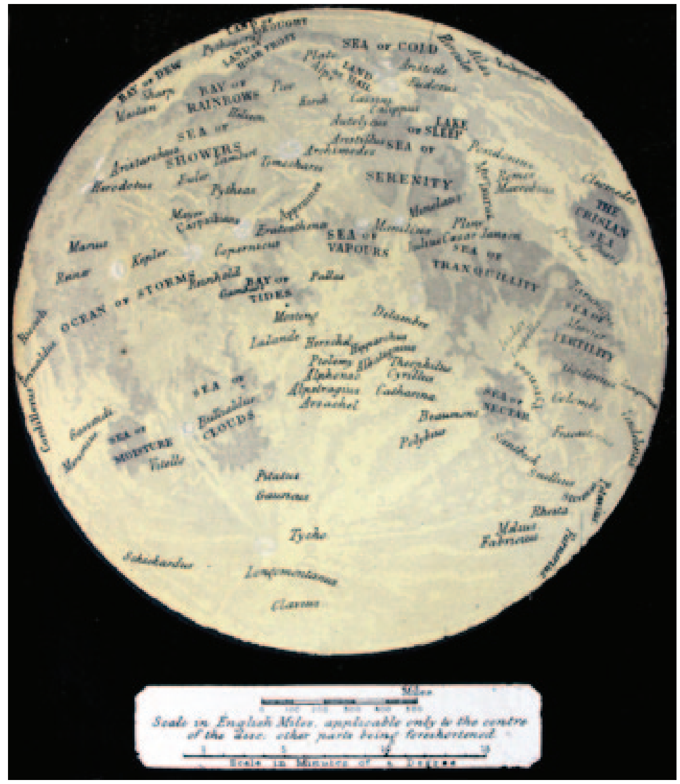

Figure 1 — Moon map (1859) by Mary Ward. A guide suitable for a mid-Victorian beginner engaged in low-magnification, whole-disk observations. A window onto a past perception of the Moon, it presents a face both familiar, and unfamiliar. In observing with Mrs. Ward's map, what can we discover about differences between how we and our predecessors viewed the Moon? Mary Ward, Telescope Teachings *(London: Groombridge and Sons, 1859), frontispiece. The map was reissued in 1869, and 1879. Reproduced courtesy of the Specula astronomica minima.*

Abstract

This paper presents the Society's sesquicentennial observing program, inviting participants to enter experientially into the world of observing of 150 years ago (www.rasc.ca/viewing-moon-across-time). Observers are given guidance in developing their own experimental archaeology of observing. Recommendations for balancing the realities of the cognitive archaeology of observing are also provided.

Is observing with Andrew Elvins still possible?[1]

Observing, the experience of seeing astronomical phenomena for oneself, of encountering alien worlds through direct observation, was established as a core activity of the RASC (and its predecessor organizations) from the very start (TAS Minutes 1868, 30-46). That spirit continues to animate much of what the RASC does—visible across the spectrum of its observational and educational programs, and reflected in the title and purpose of the Society's renowned *Observer's Handbook* (Bishop 2008).

Change is characteristic of many aspects of the act of observing, as it is of the formation of observers. Observing is not a static activity, however much it may strike an onlooker as a type of concentrated stillness. Observers develop individually as they pursue their craft. The broader astronomical culture in which amateurs participate changes as fashions for targets come and go, new techniques are introduced (or *re*introduced) and popularized, and new instruments enter the field (or are revived). Becoming part of an astronomical community in the real world or online is a process of enculturation, as one learns the jargon, concepts, and techniques, all the while absorbing opinions on equipment, and the identity of the community's current heroes. The content of the elements of enculturation are not invariable over time. So much for the observers; what about the observed? Some of the most important amateur observing consists of the careful detection and recording of change.

Continuity also plays a significant role in amateur astronomical culture. Changes in how amateurs observe don't tend to happen suddenly and sweepingly, but occur variably over time. Many of the objects in the present observational repertoire are those which were also viewed by amateurs in the second half of the nineteenth century; the Sun, the Moon, planets, meteors, comets, multiple star systems, variable stars, and the brighter nebulae (*e.g.* Chambers 1867; Webb 1868). Many amateurs continue to make graphic records of their observations with pencil and paper, as amateurs did a century or more ago (indeed, some outstanding astrophotographers of the present day also practice astrosketching).[2]

It is the cumulative weight of the changes in observing between 1868 and 2018 that create the sense of distance between then and now. Walking that distance is a route to potential discovery (see at Goals pp. 155–156).

It's not hard to imagine most current members of the RASC believing they would have been among those to answer the call in 1868 to form what in time became Canada's longest-lived national astronomical organization. There is, of course, no way of knowing if our self-imagined status as post-Confederation astronomical pioneers would survive any test of temporal relocation, given that casual "consumer" time travel remains the stuff of science fiction, fantasy beyond reach, and optimistic futurists. That aside, how many of us have ever wondered what it was like to observe in the period of the Society's formation? Is there some way even now to partially experience observing alongside Andrew Elvins one of the RASC's founding members, and colleagues? There is a creative and disciplined way to come as close as possible to observing with our astronomical forerunners of 150 years ago. And it is what this project is about.

An approach through experimental archaeology

The most useful, and usefully engaging way to observe with Andrew Elvins is to:

A.

i. research the observing equipment, and techniques which would have been generally available to him and his colleagues for viewing the Moon in 1868;

ii. identify the materials and techniques of the time for representing the Moon;

iii. procure original equipment (i), guides (i), and drawing materials (ii), or modern close substitutes and analogues;

iv. gain familiarity and competence in the use of the relevant equipment (i), and techniques (i) of the 1860s;

and B.

i. find representative examples of "good" 1860's depictions of the Moon;

ii. recover the most generally accepted contemporary theories put forth to explain the observed lunar features; and

iii. cultivate an 1860's view of the Moon through repeated exposure to 1860's modes of lunar depiction, and 1860's explanations of the nature and origins of lunar features, which can be at hand in the mind's eye when observing.

Fortunately, two well-established subdisciplines of archaeology are available with their literatures to provide guidance, examples, and case studies which can be adapted to an active archaeology of observing. One is experimental archaeology, and the other is cognitive archaeology. Neither is a royal road to an unmediated and full recovery of the past (an impossibility fully the equal of time travel), but both can offer routes as good as any to recovering the limited experiences of the past which are presently available to us. Surprising as it may seem, neither experimental nor cognitive archaeology have been much used in researching the history and heritage of astronomical observing.

What is experimental archaeology?

> "Experimental archaeology is the reconstruction of the processes, man-made and natural, which culminate in the artifact in one of several states: a pristine original state, a present decayed state, or some intermediate state. An experiment may be focused not on the total artifact but on only one aspect of it—for instance, marks of wear on a single surface, or the performance of a part under a particular condition. An experiment may be concerned with how an artifact may have been produced, [or concentrate on how it was used,] and an experiment may be part of an array of such experiments" (adapted from Rosenfeld 2003, 73).[3]

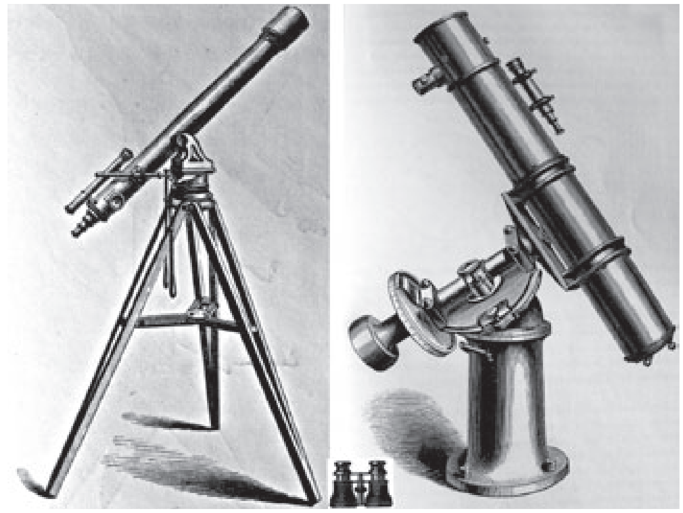

Figure 2 — Astronomical instruments from George F. Chambers, Descriptive Astronomy *(Oxford: Clarendon Press, 1867), pp. 617, 631, & plate XXXVI, fig. 186. The instruments potentially available to Society members in 1868–1869 were essentially similar to those available to their astronomical descendants. Anyone opting to* View the Moon Across Time *with the naked-eye is equipped with virtually the identical instrumentation as Victorian astronomers. Reproduced courtesy of the Specula astronomica minima.*

Traditionally, experimental archaeology has involved replicating things such as stone tools, ceramics, buildings, and ships, and the processes of using the things replicated or reconstructed.[4] It has chiefly been applied to questions about prehistoric cultures. For purposes of "TViewing the Moon Across Time," the artifacts are lunar observations of 1868, and the ("man-made") processes to be reconstructed comprise the techniques of lunar observation and record in 1868, or some component thereof.

Rosenfeld & Beckett *et al*. (2013, 30) in the pages of this *Journal* have provided a general protocol for an experimental archaeology of astronomical observing. It is worth reproducing here, but before doing so, it is important to contextualize it for present purposes. The degree to which the Rosenfeld & Beckett protocol is followed is purely a matter of choice; it is up to the discretion, taste, and available resources of the individual participant how strictly to adhere to it. Following it to the letter would be suitable for a well-controlled experiment destined for peer-reviewed publication. Any of a wide range of user-defined casual approaches are equally valid—provided they are documented.

1. The equipment used should be that available to the original observers, or its equivalent;
2. Techniques should be those of the time, place, and activity under investigation;

3. Modern technicians should not be incompetent, inexperienced, or inexpert in their handling of 1 and 2 above;
4. Modern technicians must be fully informed of the goals of the experiment, and be sympathetic to its aims, unless the experimental design requires them to be uninformed;
5. In regard to 1 and 2 above, modern materials and technologies should play as little a role as possible in the crucial elements of the experiment, unless they form part of the experimental design. Where they are necessary, their use should be controlled, and recorded;
6. Parameters, qualifications, and limits to an experiment should be clearly formulated and stated;
7. Experiments in sequence should be consistent, unless the experimental design dictates otherwise;
8. Experiments should be developed and run with reference to previous trials (if any);
9. All possible ways documented from historical sources that something may have been done should be considered for investigation where practicable;
10. The experiment should be reproducible if at all possible, should the opportunity for similar experiments present themselves;
11. Results must be stated as accurately as possible, with all necessary qualifications, chief among which is that ***a successful experiment provides only one possible way something may have been done***;
12. The experiment should be scrupulously recorded (including any failures of technique, equipment, or observers), using the most appropriate modern technology;
13. The experiment must be published as fully, transparently, and rigorously as possible.

Rosenfeld & Beckett *et al.* (2013) themselves provide a case study where only a selection of the points of the protocol was followed. Other case studies are Alan Binder's experiments using reconstructions of a medium focal length 17th-century singlet O.G. refractor for replicating aspects of the experience of 17th-century planetary, double-star, and nebulae observers, and the performance of the instruments, and Klaus Staubermann's and Christiaan Sterken's experiments using a reconstructed Zöllner photometer to determine the accuracy of the data harvested in the 19th century, and the experience of using the 19th-century apparatus today (Binder 2010a-b; Sterken & Staubermann 2000; Staubermann 2007). Various levels of rigour are applied to the design and conduct of the experiments reported.

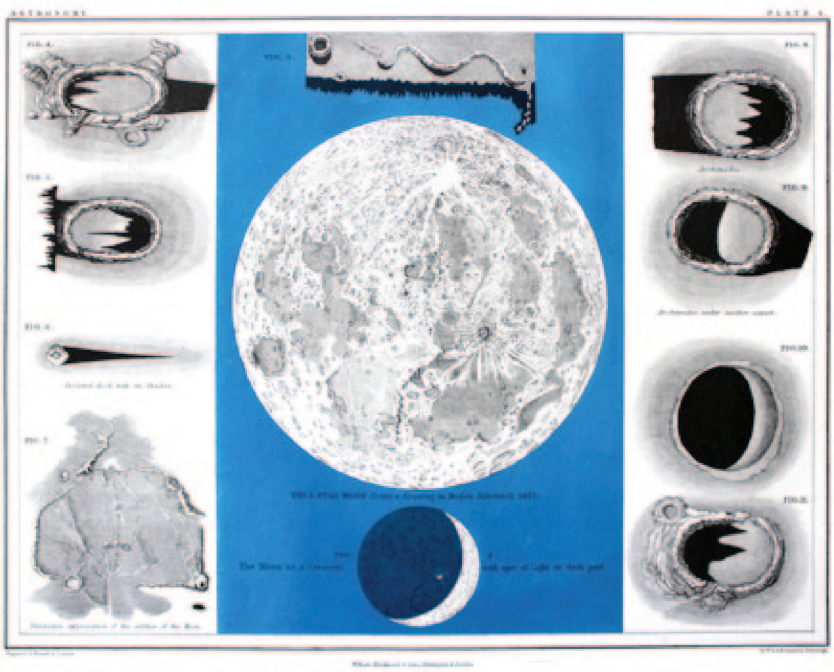

Figure 3 — Full Moon image and details of features from Alexander Keith Johnston, A School Atlas of Astronomy *(Edinburgh and London: William Blackwood and Sons, 1856), pl. 4. Johnston's atlases enjoyed a high contemporary reputation for reliability. This image of the full Moon is broadly familiar (note he has reproduced an image from 1825!), but what about the detailed views of craters and ridges? The style of representation is not that of today. Johann Friedrich Julius Schmidt's images of lunar features in* Der Mond *(Leipzig: Verlag Johannes Ambrosius Barth, 1856), are in a style that seems much more modern (Figure 4). Both sets of images were published in the same year, yet the Johnston ones may have been more typical of what was found in most Victorian books. What were the factors allowing observers to see the Moon that way? Is it possible to reach some understanding of their lunar perception through trying to see as they did? Reproduced courtesy of the Specula astronomica minima.*

Adapting the approach to available resources is sane. To illustrate this further, not everyone has access to a 3- to 5-inch O.G. astronomical refractor dating to the 1860s, but many of us have access to 20th- or 21st-century 3- to 5-inch O.G. achromats. And, while buying a fully-functional 19th-century refractor from Bonhams or the Dorotheum can be an expensive proposition, purchasing a pair of 19th-century opera glasses from eBay or a weekend yard sale is a much more reasonable one. And it is always useful to remind ourselves that no extra expense to procure equipment is necessary if we set out to replicate naked-eye observations from the past. Some 19th-century observing guidebooks can be extremely rare and prohibitively expensive, yet their digital facsimiles are freely available (see below). You may want to try the experience of observing like a casual observer of the late 19th century using a pair of 1890's opera glasses guided by Serviss's *Astronomy with an Opera Glass* (1890), and feel that a formal approach of planned experimentation, recording, and analysis would be contrary to the spirit of casual observing then and now. These are all legitimate choices. How you choose to participate is up to you.

Archaeological experiment and cognitive archaeology

In attempting to observe with Andrew Elvins on his terms, it is certainly sufficient for the construction of an interesting and memorable observing project to limit efforts to finding reasonable analogues for the historic observing apparatus, and discovering and mastering the period observing techniques for that equipment. What this may not accomplish is to enable the modern observer to enter a perceptual space different from the one she or he normally inhabits when observing. Much may be gained through the experience of trying to see astronomical phenomena through the visual context of the past. It may provide valuable insights into explaining the textual and graphic record of some 19th-century observations. And here the techniques of cognitive archaeology may help.

Figure 4 — Moonscape around Tycho at sunset, from Edmond Weiss, Bilder-Atlas der Sternenwelt...Eine Astronomie für jedermann*, 2nd ed. (Stuttgart: J.F. Schreiber, 1892), plate VIII, after Julius Schmidt, Der Mond (Leipzig: Verlag Johann Ambrosius Barth, 1856). Reproduced courtesy of the Specula astronomica minima.*

Cognitive archaeology is more recent (*ca*. 1990-) than its sometimes complement experimental archaeology, yet both grew out of the same general matrix. Like experimental archaeology, it has chiefly been deployed on prehistoric remains. Renfrew & Zubrow (1994) is often taken to be the foundational text in English, and its very opening provides a succinct definition of what the subdiscipline is about:

"One of the most taxing problems in archaeology is to determine about what and in what manner did prehistoric people think. Is it possible to make the 'mute stones speak', and will they tell us how (if not what) our predecessors were thinking?" (Renfrew & Zubrow 1994, xiii).

Fortunately, those working on historical period materials have an easier time of it. For *Viewing the Moon Across Time*, those endeavouring to observe with Andrew Elvins and colleagues would like "to determine in what manner Elvins and Co. thought about what they observed."

For orientation, Renfrew & Zubrow is still worth perusing; Preucel (2006) attempts to provide some critical (perhaps overly critical) context for those new to cognitive archaeology; and Malafouris (2013) offers a well-thought-out recent approach. More specifically astronomical (but still largely dealing with prehistoric material) is Clive Ruggles's (2005, 108-109) balanced entry in his encyclopedia; Magli's (2016) interesting reflections on various issues when recovering cognitive archaeological aspects of early historic Archaeoastronomical sites; and Frake's (1994) paper in Renfrew & Zubrow dealing with the cognitive archaeology of some practical astronomy largely in the historic period.

For *Viewing the Moon Across Time*, probably the best way to try to enter into the perceptual and conceptual space of the lunar observers of 1868 before putting one's eye to the telescope, is to:

a. work from contemporary lunar maps;
b. look at a sufficient number of contemporary renditions of the lunar landscape, till you can draw on those visual images at will from memory;
c. read the 1860's recommendations for programs of lunar work;
d. and become familiar with 1860's written descriptions of lunar landscapes, identifications and interpretations of features, and explanations for the appearance of the formations.

Limitations of method

It is crucial to note that much of the past is destined to remain unknown and unrecoverable. Materials often only survive imperfectly and partially, and once common procedures, precisely because they were common, may never have been carefully described at the time. And, as noted above in the protocol for an experimental archaeology of astronomical observing, ***a successful experiment provides only one possible way something may have been done*** (point 11).

As with the equipment and techniques for observation, so it is with past perceptions and conceptions of the universe. It is impossible for a modern observer to forget everything of modern astronomy she has read and seen. The observer of 2018 performing an archaeological replication of a historic observation of the Moon from 1868 cannot forget everything we've learned about impact cratering since the 1960s, and post-Apollo lunar geology; nor can she forget the imagery from the SELENE probe any more than she can forget the decades of *Hubble Space Telescope* imagery. Even if she could, it would be an unreasonable request. It is not as an empty slate to be filled with 1868 images and theories of the Moon that the experimenter is to fulfil the cognitive part of *Viewing the Moon Across Time*. Yes, as much of the graphic tradition of 1860's selenography with its contemporary theoretical underpinnings should be taken in as possible. Once acquired, it will be used as the mental setting of the observer replicating the observations, where it will coexist with the observer's modern knowledge of the Moon. To the extent that the incomplete 1860's mental framework can be used when performing the replicated observation, it will be a success. Any contrasts which arise between the two coexisting mental contexts of lunar observation, that of 1868 and that of 2018, will be worth noting and exploring.

Materials and techniques for experimental archaeology

A. Equipment and Techniques: see descriptions in Webb (1868: tinyurl.com/yd9zh33k); Chambers (1868: archive.org/details/descriptiveastr00chamgoog); or Proctor (1873a—originally published 1868: gutenberg.org/files/16767/16767-h/16767-h.htm). It is important to note that the attitude frequently encountered in amateur circles today, which equates mediocre telescopes of the present with good telescopes of the past, has little basis in empirical reality. The majority of those who slight the performance of the best 18th-century catadioptrics and archromats, or 19th-century achromats and silver-on-glass reflectors have no experience using the older equipment. A corrective can be found in works by those with actual experience of the older technologies, such as Alan Binder, Roger Ceragioli, and Alan Agrawal (Binder 2010a-b; Smith, Ceragioli, & Berry 2012, 88-118). If you encounter modern statements that the non-detection of an object is attributable to instrumental deficiencies, or that an observational feat exceeds the capabilities of a past technology, examine the statements carefully. If the people making them have not performed actual observational experiments with either originals or replications of historically relevant instruments, then their statements are of little value.

B. Materials of record, and their manipulation: some are described in Rosenfeld (2008: adsbit.harvard.edu/full/seri/JRASC/0102//0000200.000.html); Finlay (1990); Hambly (1988); and Rowbotham (1853: archive.org/details/artofsketchingnatu00rowb). Even if he doesn't directly address the art of lunar depiction, Green (*ca*. 1880: books.google.ca/books?id=8-UHAAAAQAAJ&printsec=frontcover#v=onepage&q&f=false; 1892–1893: articles.adsabs.harvard.edu/full/1893JBAA....3..367G) offers valuable advice from an experienced professional artist who was also a prodigiously talented observational artist.

C. Visual and theoretical context: Madler (1837: planetarymapping.files.wordpress.com/2015/11/beer_madler_1837.jpg); Ward (1859: tinyurl.com/yby7xxt3); and Proctor (1873b: https://archive.org/details/moonhermotionsa00procuoft).

The sources in A-C can all be supplemented by numerous others (www.rasc.ca/resources-0).

Goals

Taking part in *Viewing the Moon Across Time* offers scope through self-designed programs of experimental and cognitive archaeology of observing to answer questions such as:

1. are there skills practiced by observers of 1868 that have fallen out of use, which if reintroduced could benefit modern observing?
2. when astronomers viewed the Moon in 1868, what did they see at the eyepiece that was qualitatively different from what we see now (based on published representations)?
3. how can we account for those differences? Can any of them be attributable to differences in selenographical conceptions and perceptions between 1868 and 2018? Are any of them arguably due to differences in observing technique?
4. what can we learn from the familiar and unfamiliar in our predecessors' approach to the night sky?
5. how would you adapt the lessons from trying to observe with the tools and eyes of 1868 to enrich modern education and public outreach efforts?

There are even greater possibilities. Dr. Hasok Chang, the Hans Rausing Professor at the Department of History and Philosophy of Science at the University of Cambridge, has discovered that restaging historical experiments with care can lead to the recovery of significant —and fascinating—results in the physical sciences (Hasok Chang, The Myth of the Boiling Point; Chang 2017; Hasok Chang, Who cares about the history of science?). This possibility is present for anyone who participates in *Viewing the Moon Across Time*.

Participation offers a path to observational growth, and the best possibility of observing "alongside" the Society's founders. Why not take up the challenge in our sesquicentennial year? ✶

If any reader would like further advice in designing a program, or wishes to share their experience and results, please don't hesitate to contact the author.

Endnotes

1 For those who don't know, Andrew Elvins (1823–1918) was a founding member, active observer, and an enduring source of Societal continuity between 1868 and the period of revival in the 1880s; Chant et al. 1919; Broughton 1994, 20; R.A. Rosenfeld, The 2018 Podcast: Episode

2 Damian Peach, Jupiter in 2010, Damian Peach's Views of the Solar System; Klaus Brasch, Jupiter 196008190100. Admittedly, their astrosketching seems to have been mostly practiced early in their respective careers.

3 I will not venture into the history (1970s–) or present state of disputes between processualists and post-processualists on the theoretical status of the techniques described here. For those with a burning interest to know, I lean somewhat toward the former, while acknowledging virtue in the positions of the moderate representatives of both camps. Contrasts in approaches seem at their starkest in the prehistoric field; in a period with many varieties of historic sources to draw on such as the nineteenth century, reconstructions of technical processes through experiment benefit from the greater controls afforded by greater and more informative sources, as do attempts to reconstruct mental processes.

4 Representative bibliography for a range of projects to ca. 2003 can be found in Rosenfeld 2003. Foundational texts in the Anglo-American tradition are Coles 1973, Coles 1979, and Ascher 1961. These are still worth looking at, although they are not unproblematic.

Acknowledgements

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

This paper is dedicated to the memory of Richard Baum, FRAS (1930–2017).

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(consulted 2018 June 5)

Early Theoretical and Digital Research at the Dominion Astrophysical Observatory

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Figure 1 — Jean Petrie (left) and Anne Underhill (right) in the telescope dome at the 75th anniversary of the Dominion Astrophysical Observatory.

Abstract

Following post-graduate study in the United States, two Canadian women, Jean McDonald Petrie and Anne Underhill brought theoretical astrophysics to the Dominion Astrophysical Observatory in the early 1950s. They also were the first staff members there to apply digital computers to astrophysical problems.

Introduction

As expected for an observatory with one of the world's largest telescopes during its first 30 years, observational astrophysics would be the research priority. Consequently, the staff astronomers at the Dominion Astrophysical Observatory (DAO) near Victoria, B.C., concentrated on photographing stellar spectra to determine radial velocities. Thus John Plaskett (1922) found that HD 47129 is an exceptionally massive pair of stars and Plaskett with Joseph Pearce (1934) confirmed the pattern of a double sine-wave with galactic longitude as predicted by the Lindblad-Oort theory of galactic rotation and estimated a distance of 10 kpc to the centre. In other observational projects Carlyle Beals investigated peculiar hot stars, Helen Hogg variable stars in globular clusters, Robert M. Petrie the properties of B stars and spectroscopic binaries and Andrew McKellar molecules in stars and the interstellar gas.

However, in this essay I want to describe two other Canadian astronomers, Jean McDonald, later Jean Petrie, and Anne Underhill (Fig. 1), who studied in the United States and then developed their research careers at the DAO. Both women made notable contributions to observational astrophysics, but here I shall emphasize their theoretical and computational initiatives.

Jean Knox McDonald

Jean McDonald (1913–2010) was born in Paradise Valley, Alberta, and earned a B.A. in mathematics at the University of Alberta in 1937. During the early war years, she worked at the National Research Council in Ottawa and then joined the DAO staff. Her first astronomical publication was an article with R.M. Petrie dated Victoria, B.C., November 1943, describing the January 1944 lunar occultation of Jupiter (Petrie and McDonald 1943) (Fig. 2). Later she completed papers on the Wolf-Rayet star HD 193793 and the binary HD 193611 (McDonald 1947, 1949).

In July 1948 the DAO granted Jean leave to follow graduate study at the University of Michigan. She returned during the summers of 1949 and 1950 to photograph and reduce stellar spectra for her research and permanently in June 1951 to complete the work. The university awarded her a Ph.D. in 1952 for her thesis titled "Hydrogen absorption lines in the spectra of B stars"(McDonald 1952, Tenn 2016) in which she acknowledges the guidance of both Dr. L.H. Aller and Dr. R.M. Petrie. Jean first computed a model stellar atmosphere starting with a surface gravity log g = 3.80 (with g in units of cm s^{-2}) and an assumed effective temperature* T_{eff} = 20 700 K, which increased to 22 700 K when the calculations were complete. Then she computed profiles of hydrogen Balmer lines, compared them with observations of four stars and concluded that her model best represented a B2.5 IV star. This she later revised to B2 V.

Jean used the predicted spectral distribution of this model to prepare a short note on bolometric corrections for hot stars with Anne Underhill, who contributed results from two O-type models (McDonald and Underhill 1952). Jean reported the details of her model at a meeting of the American Astronomical Society (AAS) in Victoria and in the Observatory Publications (McDonald 1952, 1953a).

During 1953–54, Jean visited the Computation Centre at the University of Toronto to learn how to program Canada's first digital computer, *Ferut*, so named because it was built by Ferranti in England and located at the University of Toronto. In an abstract for an AAS meeting (McDonald 1953b) she reports using a variational method to solve the integral equation for the source function. In Toronto she also produced some tables relevant to model-atmosphere calculations that she published on her return to DAO (McDonald 1955a, 1955b). In a more popular article (McDonald 1954) she

* The integral of the emergent flux πF_ν over all frequencies ν and Stefan's constant σ define the effective temperature T_{eff} according to $\pi F = \pi \int F_\nu d\nu = \sigma F_{eff}^4$.

Figure 2 — The staff of the Dominion Astrophysical Observatory in 1945 or 1946. Left to right around the table are Sidney. S. Girling, the instrument maker, Robert M. Petrie, Joseph A. Pearce, Carlyle S. Beals, Andrew McKellar, Kenneth O. Wright, Jean K. McDonald, and Jo-Anne? Cooke, the secretary.

described the wonderful capabilities of *Ferut*—a fast memory depending on electric charges on eight cathode-ray tubes, each holding 1280 binary bits, and a 256-track magnetic drum holding 655 360 binary bits. In this vacuum-tube machine, transfer of one track from the drum to the fast memory took about 0.05 sec; addition of two 40-bit numbers required about a millisecond and multiplication twice that time. I was a student assistant at the David Dunlap Observatory while Jean was visiting and I remember meeting her.

She spent the academic year 1956–57 at the University of California, Berkeley, and then she concentrated on observational projects at DAO (Petrie, Andrews and McDonald 1958, McDonald 1959, Wright and McDonald 1959).

In 1960, Jean married the Director, Robert (Bert) Petrie following the death of his first wife. Afterwards, presumably to avoid director-staff complications, Jean (Fig. 3) taught astronomy at Victoria College, which became the University of Victoria in 1963. On Monday evenings, Bert joined her as the lab assistant for the practical part of the course. After Bert's untimely passing in 1966, she became a part-time lecturer at the University of British Columbia from 1966 to 1971 and a member of the Board Governors of the University of Victoria for the four academic years from 1967 to 1971. She also spent some time at the Canadian High Commission in London, England as an assistant to the Science Attaché, who happened to be William Petrie, Bert's younger brother.

Jean also completed and published three of Bert's astronomy projects involving spectroscopic binaries and stellar motions (Petrie and Petrie 1967a, 1967b, 1968). At the opening of the R.M. Petrie Science Building at York University in November 1969, she received an honorary D.Sc. from that university and spoke on "R.M. Petrie and the B-star program of the Dominion Astrophysical Observatory" at an associated symposium (Petrie 1970).

Figure 3 — Jean McDonald Petrie from the University of Victoria Archives Historical Photo Collection, ref.#051.1001.

While still in Alberta, Jean joined the Alpine Club of Canada and then became Secretary of the Edmonton Section in 1938. According to the *Canadian Alpine Journal* for 1938 and 1939 and records from the Whyte Museum in Banff, she attended six of the summer climbing camps from 1937 to 1946 and the spring ski camps in 1939 and 1940. At the Columbia Icefields Camp during the summer of 1938, Jean trekked to an advanced camp far up the Athabaska Glacier. From there, on July 18, Jean and three other women made the first ladies' ascent of 3747-m Mt. Columbia, the second highest peak in the Canadian Rocky Mountains (Gibson 1938). Other ascents included McDonnell Peak (3277 m), Thunderbolt Peak (2665 m), and Mt. President (3139 m) on skis and Mt. Forbes (3020 m) one summer.

In 1967, a party of mountain-climbing astronomers, George and Marcia Wallerstein, Lyman Spitzer, Bob O'Dell, Tom Grenfell, and myself, made some first ascents in what is now Kakwa Provincial Park in the Northern Rockies of British Columbia (Morton 1968, 2011). We proposed naming two peaks after past Directors of the Dominion Astrophysical Observatory, so now the official government map shows a rock tower labelled Mt. Plaskett (2940 m) above a broad glacier, and an attractive snow and rock peak designated Mt. Petrie (2900 m) above Dimsdale Lake (Fig. 4). At the time we were unaware of Jean's climbs in the Rocky Mountains, but now the designation of Mt. Petrie seems doubly appropriate.

Anne Barbara Underhill

Anne Underhill (1920–2003) was born in Vancouver. She was active as a Girl Guide and excelled at high school, winning the Lieutenant Governor's medal as one of the province's best students. Her mother died when Anne was 18 so, along with her twin brother, she had to assist in raising their three younger brothers while she attended the University of British Columbia (UBC). There she obtained an honours B.A. in chemistry in 1942 and an M.A. in physics and mathematics in 1944. That year with William Petrie, the younger brother of Bert, she published her first astronomical research paper (Underhill and Petrie 1944) based on spectra available at the DAO.

With a scholarship from the Canadian Federation of University Women, Anne began doctoral studies at the Univer-

Figure 4 — Dimsdale Lake and Mt. Petrie, the highest snow dome at the upper right.

sity of Toronto and moved to the Yerkes Observatory of the University of Chicago for two years from 1946 to 1948 (Tenn 2016). There she presented three papers for her Ph.D. thesis, a theoretical one on "The Schuster problem for an extended atmosphere" under the guidance of Chandrasekhar (Underhill 1948a), an observational one on the spectrum of γ Peg (Underhill 1948b) with an acknowledgement to Jesse Greenstein, and a combination one on B-Star line profiles involving both theory and observations (Underhill 1948c) with acknowledgements to Otto Struve as well as Greenstein. The goal of the extended atmosphere paper was to predict how the profile of an absorption line in a spherically symmetric atmosphere appropriate for a supergiant would compare with a line calculated with the usual assumption of a plane-parallel atmosphere of a main-sequence star. During her two years at Yerkes she published an additional four papers and two notes in the Astrophysical Journal (Underhill 1946a, b, 1947a, b, 1948d, e). The 1946 photo in Fig. 5 shows an outstanding array of colleagues and mentors for Yerkes students at that time.

Anne continued this combination of theoretical and observational research during a post-doctoral year 1948-49 at the Copenhagen Observatory with Bengt Strömgren with support by the U.S. National Research Council (Underhill 1949a, b, c, d). There Anne developed a model for an O9.5V star with T^{eff} = 36 800K and log g = 4.20 (Underhill 1950a). With this experience, she joined the scientific staff of the DAO in 1949 and soon after published a model for an O5V star (Underhill 1950b). In this model with Teff = 44 600K and log g = 4.2, radiation pressure almost dominates over gravity.

Anne also was an early user of digital computers. In 1960, Strömgren, who then was the resident astronomer at the Princeton Institute for Advanced Study, invited her to visit and write code for model stellar atmospheres. Back in Victoria there was no digital computer at the DAO so Anne used one at the Pacific Naval Laboratory in Esquimalt or travelled across the Strait of Georgia to the University of British Columbia in Vancouver.

In the fall of 1957, my second-year project as a graduate student at Princeton University required a comparison of theoretical and observational Hertzsprung-Russell diagrams. Consequently, I wrote to both Jean McDonald and Anne Underhill and obtained the calculated bolometric corrections* and colour indices I needed from their model stellar atmospheres to complete my paper (Morton 1959).

Figure 5 — Staff and students at the Yerkes Observatory in 1946. Yerkes Observatory photo.

Back Row: Paul Ledoux, Arne Slettebak, Margaret Phillips, Fred Pearson, John Phillips, Armin Deutsch, Roy Wickham, Merle Tuberg, William Bidelman, Marshall Wrubel, Irene Hansen, Francis Breen, Arthur Code, Alice Johnson, Gertrude Peterson, Marguerite Van Biesbroeck, Carlos Cesco, Edith M. Janssen, Victor Blanco, John Vosatka, Harold Bernstein.

Middle Row: Polydore Swings, Gerhard Herzberg, Luise Herzberg, William Morgan, Otto Struve, Jesse Greenstein, Gerard Kuiper, Subrahmanyan Chandrasekhar, George Van Biesbroeck, Louis Henyey.

Front Row: Dorothy Deutsch, Martha Carlson, ***Anne Underhill****, Guido Munch, Doris Blakely, Margaret Krogdahl, Nancy Roman, Carleton Pearson.*

* The bolometric correction permits the conversion of a stellar magnitude in the visible band to an absolute magnitude that accounts for the total emission over all wavelengths.

Figure 6 — Anne B. Underhill.

Four years later, following two post-doctoral years at the U.S. Naval Research Laboratory, I returned to Princeton University to join Lyman Spitzer's space ultraviolet project. Along with preparing rocket payloads, I wanted to extend the calculations of Gaustad and Spitzer (1961) on the blanketing of strong absorption lines in hot stars. Anne generously provided the code to calculate the emergent fluxes from two main-sequence stars with T_{eff} = 25 673 and 31 023 K (Morton 1964, 1965). These results further demonstrated the importance of ultraviolet line blanketing in the types of stars we hoped to observe from space and led to a collaboration with Dimitri Mihalas. He wrote the code for a new model atmosphere with the profiles of 98 of the strongest lines included in the frequency variation of the opacity with optical depth. (Mihalas and Morton 1965). Later, on two occasions, I welcomed Anne's proposals to prepare joint papers on our common interest in the ultraviolet spectra of stars (Underhill and Morton 1967, Morton and Underhill 1977).

In 1962, Anne moved to the Netherlands as a full professor at the University of Utrecht, where she also wrote her first monograph on hot stars (Underhill 1966). According to Henny Lamers (2003), who was one of her students, "She was a great teacher who taught us to be critical and trust observations more than theories. She was always very helpful. She felt that we were in some way her children, so she was interested in our lives and organized parties in her house for her students and their girlfriends."

Anne became Chief of the Laboratory of Optical Astronomy at the NASA Goddard Space Flight Center in Maryland in 1970. There she contributed much as Project Scientist for the International Ultraviolet Explorer during the early development of this very successful space mission. From 1977 to 1985, as a senior scientist at Goddard, she continued her research and book writing (Underhill and Doazan 1982). She retired to Vancouver (Fig. 6) with an honorary professorship at UBC, where she mentored students and often brought them to the DAO for observing.

York University gave Anne an honorary degree in 1969 at the same time as Jean Petrie, and the University of British Columbia similarly recognized Anne in 1992. The Royal Society of Canada elected her a fellow in 1985. That same year the Canadian Astronomical Society gave her the C.S. Beals Award in recognition of her outstanding achievements in research. The SAO/NASA Astrophysical Data System has 345 entries for Anne's publications.

Anne had many interests outside of astronomy including hiking, bird watching, singing in church choirs, and Girl Guides. During her Victoria years she did not observe Monday nights because that was the night she led a Guide troop at St. John's Anglican Church. There she also sang in the choir and at the Anglican Church in Utrecht.

Final Comment

So, as we celebrate the centenary of the Dominion Astrophysical Observatory in 2018, it is appropriate that we recognize how these two exceptional astronomers at that institution pioneered the development of model stellar atmospheres and the use of digital computers. The radio archives of the Canadian Broadcasting Corporation www.cbc.ca/archives/entry/astronomy-the-stargazers include a 1955 visit to the DAO with contributions from both Jean and Anne. ✶

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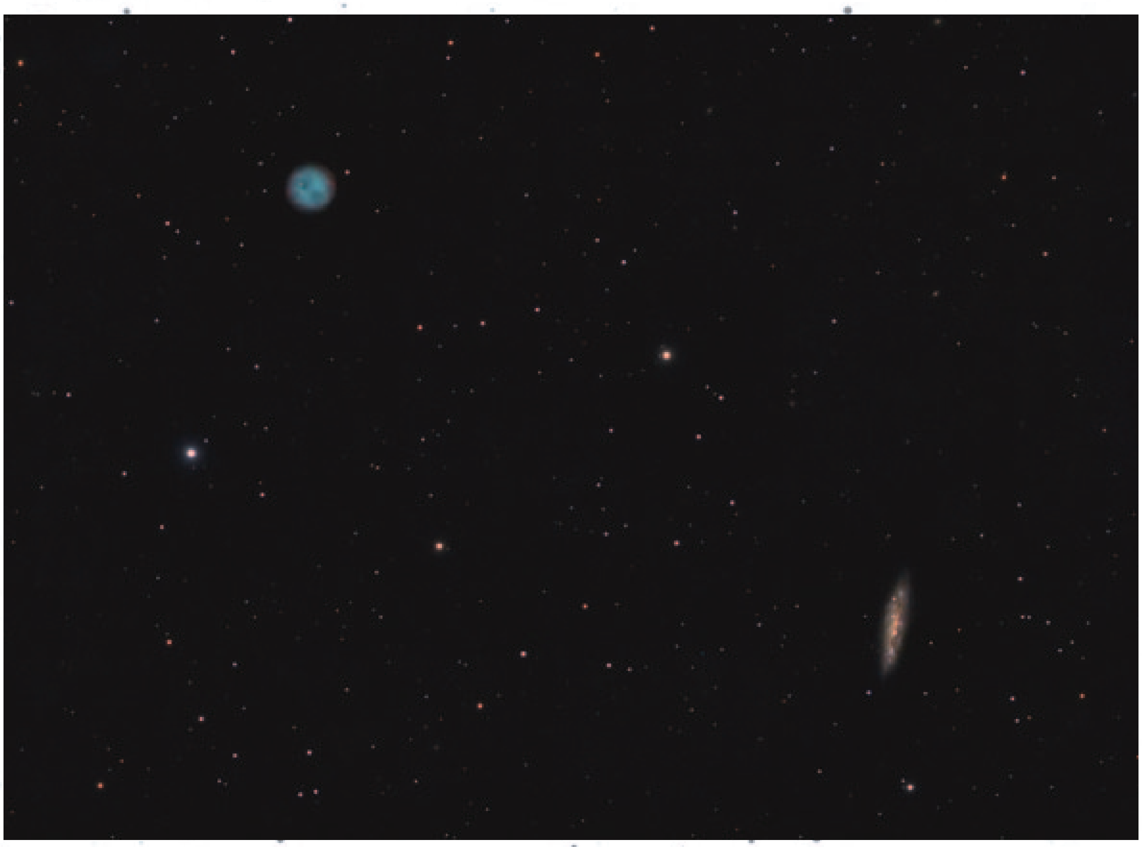
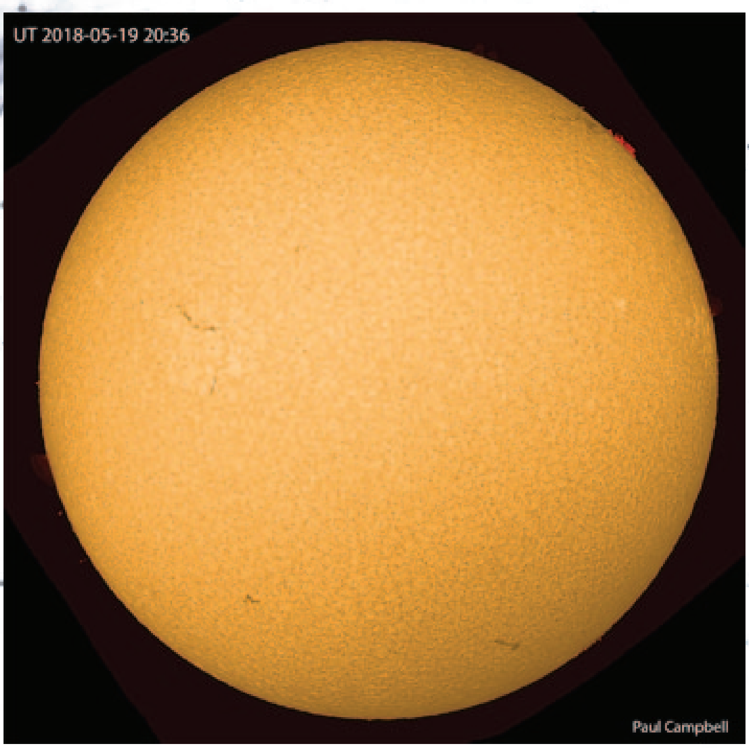


Blair MacDonald says this image "is an urban effort on M108 and the Owl taken from my driveway under light-polluted urban conditions. There is even an LED street light directly across the street blazing away. As long as you stick to brighter targets and are careful in your image capture and processing, such conditions should not deter the intrepid astrophotographer."

The Southern Cross and the Coal Sack, taken by Michael Watson outside Uluṟu-Kata Tjuṯa National Park, Northern Territory, Australia. Michael used a Nikkor AF-S 70–200-mm ƒ/2.8 G ED VRII lens on a Nikon D850 camera body, mounted on Sky-Watcher HEQ5 equatorial mount with Kirk Enterprises ball head. He took 1-minute exposures at ƒ/4.5 unguided at ISO 3200 and stacked seven images in Registar. Processing was done in Photoshop CS6.



This image of the Jellyfish Nebula (IC 443) was taken by Dan Meek. It is a 4.5-hour narrowband image taken with a 5-inch refractor and a CCD camera from Calgary.

Paul Campbell created this false-image of the Sun in May using a DMK-style video camera at 1/76th sec with a gain of 260. He stacked the videos in Registax, then stitched together as well as processed the images in Photoshop.

CFHT Chronicles

SPIRou Comes to Life

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

Spring at CFHT brought the first light of SPIRou and an interesting science result from SITELLE. For both topics, I have added additional information into news releases issued by CFHT and others.

After four months of hard work by engineers and scientists from France, Canada, and CFHT, and over a decade in the making, an important milestone has been reached for SPIRou, CFHT's new planet hunting spectropolarimeter. On April 24 around 7:50 p.m. Hawaii time, the instrument recorded, for the first time, light coming from a star through the telescope and the various fibre-linked SPIRou components. During the following few nights, SPIRou gathered an impressive collection of about 440 spectra of 24 stars, while demonstrating a few of its unique capabilities in the process.

As we have discussed in the previous few columns, SPIRou (SpectroPolarimètre InfraRouge) is a high-resolution spectro-polarimeter and a high-precision velocimeter optimized for discovering Earth twins orbiting in the habitable zone of nearby red-dwarf stars and exploring fledgling stars and their planetary systems in the making.

During this first on-sky run, SPIRou observed stars cooler than the Sun known as red dwarfs, a stellar population comprising most of the stars in the neighbourhood of our Solar System. The first star observed with SPIRou was AD Leonis, a very active red dwarf located 16 light-years from Earth in the constellation Leo. AD Leonis is known for its strong magnetic fields and hugely energetic flares.

"AD Leonis is very famous for being an active star with large radial-velocity variations and a known magnetic field. That makes it a perfect target for the first SPIRou observations. We're observing AD Leonis to determine if the data we observe with SPIRou matches the known results on the star," explains Claire Moutou, resident French astronomer and SPIRou instrument scientist at CFHT. SPIRou demonstrated its ability at detecting the magnetic field of AD Leonis.

During its first run, SPIRou also observed hot stars known as "telluric standards," stars whose spectra contain mostly telluric lines from the Earth's atmosphere. When a star's light passes through the Earth's atmosphere, molecules within the Earth's atmosphere contaminate the star's spectrum with their own emitting and absorbing. These telluric or "Earth originating" molecules are dominated by water vapour, oxygen, and OH. As an infrared instrument, telluric lines particularly affect SPIRou. Identifying the telluric spectrum is essential to determine which features of SPIRou's spectra are from the observed stars and which come from the Earth's atmosphere. The distinction is critical in revealing the presence of orbiting planets.

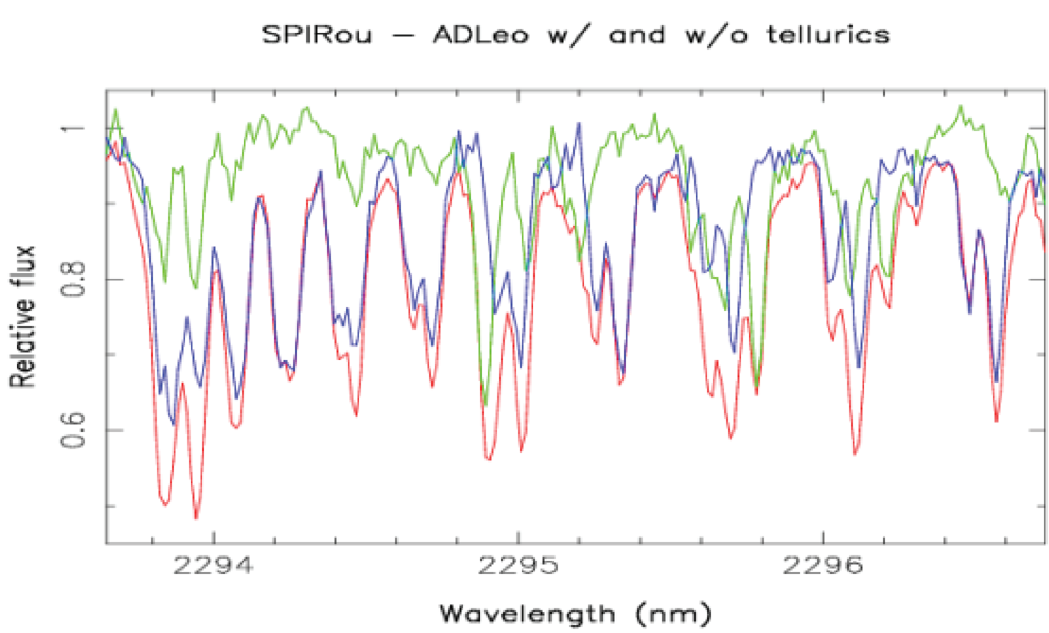


Figure 1 — Small portion of the SPIRou spectrum of the active red dwarf AD Leo as observed (with telluric lines, red) and once the telluric spectrum (green) is removed (blue). This illustrates how critical telluric subtraction is to properly identify which lines can tell us some information about the observed star, and the planets potentially orbiting it (©J.-F. Donati).

SPIRou uses a technique known as "velocimetry," radial-velocity measurements coupled with polarimetry in the infrared, to detect the tiny wiggle in a star indicating the presence of planets to very precise levels.

"We anticipate the astronomy community will use SPIRou extensively in the following decade," says Jean-Francois Donati (CNRS), the principal investigator of SPIRou and leader of the SPIRou science team. "SPIRou will play a key role in the coordinated exoplanet surveys to come involving multiple space-based missions like the recently launched TESS, and the upcoming *James Webb Space Telescope* and the future PLATO.

After being delivered at CFHT in January, SPIRou was installed at its new home location on the third floor of CFHT and reassembled by engineers and specialists from SPIRou partners, namely IRAP (CNRS/UPS), Institut de planétologie et d'astrophysique de Grenoble (CNRS/Université Grenoble Alpes), Laboratoire d'astrophysique de Marseille (CNRS/CNES/AIx-Marseille Université), Institut d'Astrophysique de Paris (CNRS/Sorbonne Université), National Research Council Herzberg (Victoria, Canada), Observatoire du Mont-Mégantic (OMM), Université de Montréal (Montréal, Canada), with invaluable support from the whole CFHT team. The instrument was then cooled down for the first time at CFHT to verify alignment of the optical components and conduct engineering tests. Cryocooled to a temperature of -200 °C, SPIRou is thermally stabilized to a within a thousandth of a degree to be able to detect the tiny signatures that planet encode in the light from their host stars.

The team also installed the 35-m fluoride fibre that feeds SPIRou from its Cassegrain unit, mounted on the bottom of the telescope and located at the fifth floor of CFHT. The fibre transmits the light from the telescope to SPIRou, located two floors below inside of CFHT's inner coudé room. In parallel, they successfully tested this Cassegrain unit, providing image stabilization and guiding facilities at the telescope focus. The crucial test came on the first night of the commissioning run. Twenty-four stars were observed during the first commissioning run, which ran from April 24 to 30, starting the SPIRou collection with hundreds of exquisite spectra.

"SPIRou is a unique and very powerful instrument. At the Institute for Research on Exoplanets, we are all very excited about the fact that it will find the closest habitable worlds from the Earth, the ones we will be able to study in more detail with the James Webb Space Telescope," says René Doyon, SPIRou co-PI at Université de Montréal, director of iREx and OMM.

"A lot of work is still ahead for SPIRou, but we are encouraged by the results of the first commissioning run," says CFHT's director of science, Daniel Devost. "A sincere congratulations to the entire SPIRou team for the work they have put into this outstanding instrument."

A second SPIRou engineering run occurred May 23 to 29. The SPIRou team took more observations of telluric standards plus objects with well-known spectra to measure SPIRou's spectral resolution and polarization sensitivity. Our software group and remote observers tested the queue observing software for SPIRou.

Like all of CFHT's instruments, SPIRou will be operated in "queued service observing" or QSO mode. In queue, another name for QSO, the PIs never set foot at CFHT. They do not go to the summit and operate the instruments themselves. In fact, they do not get assigned specific nights. Instead the Time

Figure 2 — Part of the team of engineers from France, Canada, and CFHT, after closing up the SPIRou cryostat (behind) for the first time in the CFHT coudé room.

Allocation Committees (TAC) allocates them a ranking and a set number of hours. Each of CFHT's constituent countries has a separate TAC: Canada, France, Hawaii, Taiwan, China, and Brazil. For example, Canada A1 ranking with 36 hours means your program is the top-ranked program on CFHT from Canada and 36 hours of telescope time will be devoted to completing your observations.

Once a PI receives their ranking and time allocation, they use PH2, a detailed online form designed and managed by CFHT, to detail their observations. Within PH2, the PI creates observing groups (OGs) and selects all the necessary information to complete their program effectively; the image quality range (IQ), sky background, photometric versus non-photometric conditions, etc.... They can also schedule time sensitive observations and leave comments for the QSO team to consider when observing or scheduling. All information for all programs is stored within a custom database.

QSO is ideal for SPIRou because of instrument's science goals. The SPIRou Legacy Survey, which will likely start sometime in 2018B is feasible because of QSO. The survey has two primary goals: 1) to search for and characterize Earth-like planets orbiting low mass stars, and 2) investigate the impact of magnetic fields on star and planet formation. Both of these goals require monitoring of selected stars at specific cadences for weeks, months, or even years. QSO facilitates these observations without the astronomer needing to spend months at CFHT.

The next SPIRou run is not scheduled yet as the CFHT schedule runs on a semester basis. The current semester concludes at the end of July. I will continue to provide updates on its progress.

Moving from tiny planets to clusters of galaxies, we have some exciting new science news from SPIRou. Ph.D. student Marie-Lou Gendron-Marsolais and professor Julie Hlavacek-Larrondo, from Université de Montréal, as well as professor

Laurent Drissen and Thomas Martin from Université Laval, used SITELLE to reveal the intricate dynamic around the galaxy NGC 1275. The four are all part of the Centre for Research in Astrophysics of Québec (CRAQ).

Located 250 million light-years from Earth, NGC 1275 is a galaxy like no other. It sits in the middle of the Perseus galaxy cluster, a gigantic cluster harbouring thousands of galaxies in the constellation of the same name. NGC 1275 is immersed in a hot, diffuse intracluster gas with an average temperature of tens of millions of degrees.

Intracluster gas forms most of the luminous mass of galaxy clusters. The galaxy cluster environment is very complex: the hot gas tends to cool and fall toward the galaxy but at the same time the central supermassive black hole releases powerful jets of very energetic particles visible by radio telescopes and blowing gigantic bubbles into the hot gas, preventing it from cooling completely.

NGC 1275 is different. At specific optical rather than radio wavelengths, a spectacular network of thin intricate filaments surrounds the galaxy.

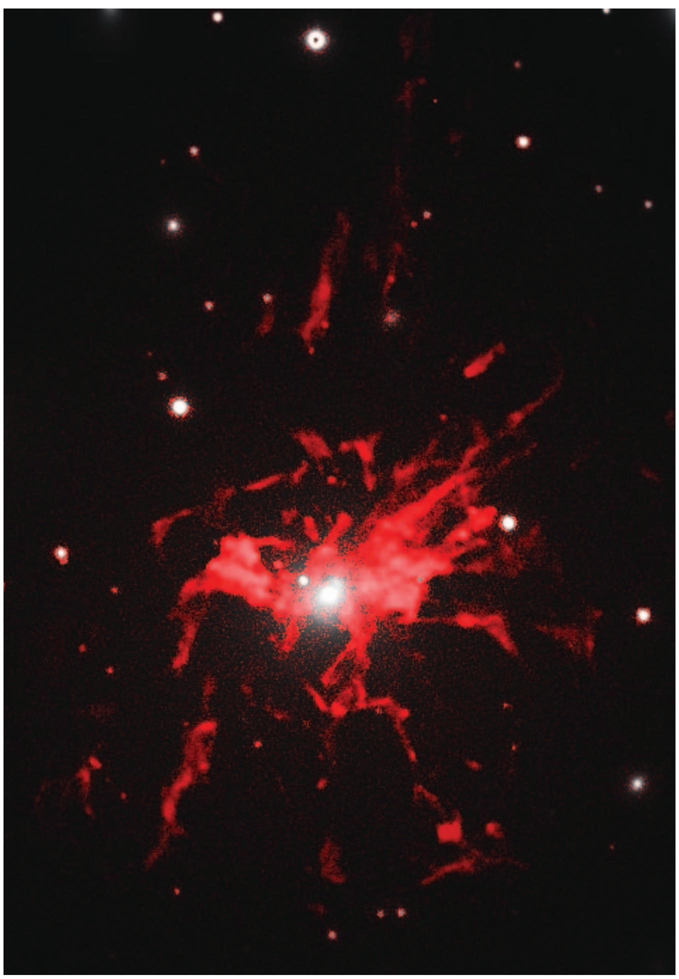


Figure 3 — Hα filamentary structure around NGC 1275. (SDSS/CFHT, Marie-Lou Gendron-Marsolais, Julie Hlavacek-Larrondo, Laurent Drissen and Maxime Pivin-Lapointe)

"These types of filaments are often visible around galaxies that lie in similar environments...but their origin is a real mystery," says Marie-Lou Gendron-Marsolais, lead author on the paper.

Extending over 250,000 light-years, two and a half times the size of our own galaxy, the link connecting this large nebula to its environment is still very poorly understood. Two hypotheses clash: it could be filaments condensing from the hot intracluster gas and sinking toward the centre of the galaxy or rather gas lifted by the bubbles created by the central supermassive black-hole jets and driven out of the galaxy.

To unravel the mystery of these filaments, researchers decided to use SITELLE, to map the galaxy at several different wavelengths simultaneously. SITELLE is an imaging Fourier Transform Spectrograph that takes both images and spectra of everything in its field of view. The observations consist of a sequence of images of the target acquired using a Michelson interferometer. Each of the over four million pixels of the detector have an associated interferogram, which gives a spectrum once the data is reduced.

"You get a spectrum for each pixel in the image," said professor Julie Hlavacek-Larrondo. "But what is unique about SITELLE is its vast field of view, covering NGC 1275 in its entirety for the first time since the discovery of the nebula, 60 years ago."

Because of SITELLE's unique capabilities, the team of researchers could measure the radial velocity, namely the speed along the line of sight, of each of the filaments, thus revealing their dynamics with an unequaled level of detail.

"It seems that the movement of this network of filaments is very complex; there does not seem to be any uniform movement, it is extremely chaotic," says Gendron-Marsolais.

The researchers are convinced that such observations can help to unravel the mystery of these structures. Overall, the understanding of the dynamics of these filaments is directly related to the processes of heating and cooling of the gas that feeds the central black hole. It therefore constitutes a key element in the study of galaxy evolution and, on a larger scale, environments such as clusters of galaxies.

The results of the research conducted by Marie-Lou Gendron-Marsolais, Hlavacek-Larrondo Julie, Laurent Drissen, Thomas Martin, as well as international collaborators, appeared in a letter of the May issue of the *Monthly Notices of the Royal Astronomical Society*. ✶

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.

Skyward

An Observing Man for all Seasons and Sharing the Sky

by David Levy, Montreal and Kingston Centres

On Friday evening, 2018 May 4, the Tucson Amateur Astronomy Association (also known as the TAAA) bestowed its highest honour, the Bart and Priscilla Bok award, to Dr. Tim Hunter, a retired radiologist at the University of Arizona. The award honours a lifetime of service to astronomy, and a dedication and passion for the night sky.

The TAAA's Bok award was started around 1984 in honour of the husband-and-wife team of astronomers whose lives were devoted to studying our galaxy, the Milky Way. Bart and Priscilla Bok's enthusiasm led to four editions of a popular science book called *The Milky Way*. After Priscilla's death in 1975, Bart produced a legendary fifth edition, which he dedicated in his wife's memory. "This is the first time I've revised the book without her," he wrote.

At that time, Tim Hunter was beginning his career in radiology and rapidly expanding his work in astronomy. He has approached the night sky with an energy that can hardly be compared to anyone's. He has taken thousands of photographs, ranging from five planets in a single exposure back in 1984 to in-depth images of remote galaxies from his Grasslands Observatory in the hills around Sonoita, in southeastern Arizona.

Besides observing, Tim has maintained a close relationship with the TAAA. He served as its president during the early 1990s, the time when the association was just beginning its search for a dark-sky observing site that has evolved today as the Chiricahua Astronomy Complex. Tim has written an astronomy column for the *Arizona Daily Star*, Tucson's newspaper, for years and years. Through this writing Tim uses his considerable talent to inspire his readers to enjoy the night sky. Just as he operates one of his remote telescopes in Sonoita from his Tucson home, he hopes that his readers will enjoy the sky from their homes, either just by looking up or by using their small telescopes.

Of all the many different lectures Tim has given over decades, by far my favourite is his autobiographical "My Life and Hard Times as an Amateur Astronomer." I first heard him give this lecture in 1990. I sat in the front row. I smiled. I laughed. I cried. I was taken by the depth and perception of Tim's words and insights. Here is a man who loves the night sky. It is with this spirit and pleasure that, with much happiness, we present Tim Hunter with his Bart and Priscilla Bok award.

Figure 1 — Tim Hunter, dressed for observing, stands with the original 24-inch telescope at the Grasslands observatory.

The National Sharing the Sky Foundation

Back in 2006, Wendee and I founded an organization designed to spread our enthusiasm and passion for the night sky. We called it the National Sharing the Sky Foundation. Its basic purpose was to bring the magic of the night sky to as many people as we possibly could.

Over the years, we have encouraged thousands of people to enjoy the night sky. Whether this happened in small groups, at public schools or even smaller groups at our home, at big "star parties" on university campuses, or at dark-sky sites at remote locations, our goal has always been to share the sky in the simplest way we could.

Do I have a favourite memory from Sharing the Sky? Indeed, I do. Of all the nights I have spent under the stars, the greatest moment was at our Adirondack Astronomy Retreat in upstate New York. One night there I gazed at the giant globular star cluster in the constellation of Pegasus. It is called Messier 15. I was looking through Fritz, a giant 25-inch diameter reflector telescope belonging to long-time retreater David Rossetter. As I peered through the eyepiece, I was not looking at the cluster. I was strolling down an avenue of myriad stars. Stars to my left, stars to my right, and stars surrounding me like a field of golden flowers.

In fact, of all the events Sharing the Sky has put on, the retreat was my favourite. Each summer, we would join some 35 to 45 people, most of them with telescopes, notebooks, and often cameras. The people attending this retreat are the smartest I've ever met. Their attitudes, their hopes to see that faint galaxy, or even catch a comet roaming among the stars, were wonders to behold. The enthusiasm of the group was contagious.

On most nights I also tried to follow whatever conversations were taking place across the field of telescopes. Whatever I took away from these tidbits of wisdom, whether they had anything to do with the night sky or not, I have never forgotten them. Sometimes the topics to be discussed would be political, sometimes literary, or at other times just nonsensical fun.

Most important, I felt a part of the joy that the other people were feeling.

Sharing the sky is not just sharing knowledge about the Universe. It is sharing a feeling of peace and fun that comes when the sky begins to darken at the start of a perfect night.

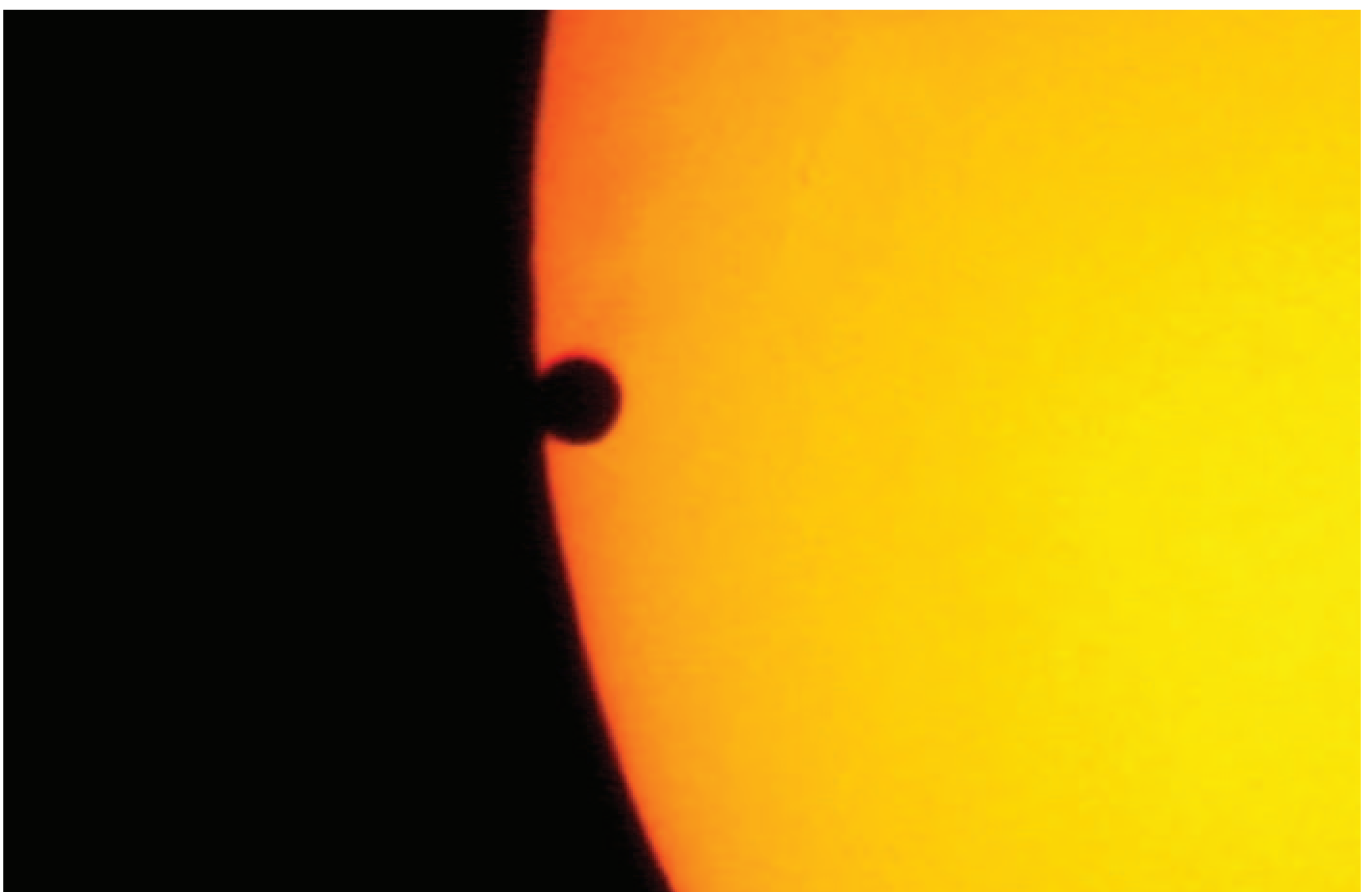


Figure 2 — The Transit of Venus, photographed by Tim hunter on 2004 June 8.

Figure 3 — In 2006, David lectured about astronomy to young students at Roslyn School, the school that once taught singer Leonard Cohen. David attended Roslyn from 1955 to 1960.

Passing on the effort

Last May, however, I reached my 70th birthday. I hope I have many good years left, and to help ensure that I do, Wendee and I decided that the time has come to hand our foundation over to younger people. Accordingly, on May 22 (my 70th birthday) Joe and Rita Wright, good friends who live in Kansas City, took over the Sharing the Sky Foundation.

We are not bowing out completely. Our monthly star evenings at the Corona Foothills Middle School will continue. There we will go on inspiring the bright young minds of tomorrow's adults. They may be in middle school or high school now, but who knows what they will accomplish with a little help from a friendly night sky? I will also continue this Skyward column. It is important to motivate readers any way I can.

It is not enough to learn the night sky. One must experience it. And just looking up is insufficient. When you get your first look at the Moon through a high-powered eyepiece, or the exquisite rings of Saturn, or a galaxy whose light has travelled across a billion years of space and time, your life can change in ways you cannot begin to imagine. Put away your cellphone, open your eyes, and gaze toward heaven. You will become a part of a cacophony of people who have looked up in earlier times. And that is what Sharing the Sky is all about. ✶

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

The October *Journal* deadline for submissions is 2018 August 1.
See the published schedule at
www.rasc.ca/sites/default/files/jrascschedule2018.pdf

Observing Tips

Surviving Aperture Fever

by Bill Weir, RASC Victoria Centre
(metchosinskies@hotmail.com)

[*Note from Dave Chapman, RASC Observing Committee Chair: This is the fifth in a series of articles contributed by RASC members on observing, edited by me. It is said that "bigger is better" when it comes to telescopes, but I believe there is always something to observe, regardless of the conditions or the size of the instrument—veteran observer Bill Weir explains why. For future columns I am looking for practical content contributed by active observers—please email me at observing@rasc.ca with your ideas.*]

For those of us who like deep-sky observing, aperture fever can be a problem. In the past, this malady was often precluded by high cost and poor availability. However, in today's market, what used to be considered a large-aperture telescope is now commonplace. Often, entry-level reflecting telescopes have mirror diameters of 10–12 inches (250–300 mm). Even larger (up to 20-inch) reflectors can now be obtained at relatively low cost from Asian manufacturers. No longer do those seeking large aperture need to suffer the often-exceedingly long wait times of custom telescope builders, unless they want to. There is always the build-it-yourself route, but that doesn't apply to most of us and really is a different topic altogether.

In my opinion, the downside of easily available, large-aperture telescopes is that the development of individual observing skill has suffered. If you pay any attention to online astronomy forums, you might have noticed that when someone asks the question, "What scope should I buy for deep-sky observing?" the majority of responses are often the same: "Buy the biggest 'scope you can afford."

I'm not convinced this is the best decision. If you immediately start with a large-aperture telescope, you don't need to struggle (so to speak) to see many objects. I believe that the challenge of observing with small telescopes helps one hone observing skill. Learning those tricks of the trade: averted vision, cloaking your head to avoid stray light, using various filters—not to mention that biggie of putting some gas in the car to drive to a darker location—all contribute to observing skill. Like with any faculty, observing skill doesn't just happen, it needs to be trained and developed. Spending time night after night on the same object trying each successive time to tease out more detail also improves observational skills. Start a sketch of an object and see if each time you observe it you can add a little more detail to that same sketch. It's surprising how this can give the perception of increasing aperture without doing anything. I believe spending time pushing the limit of what you can see with any telescope better prepares you to deal with the benefits provided by increasing aperture later on, or with being given the opportunity to view through a larger 'scope.

When I first got into astronomy about 20 years ago, I bought a 6-inch Dobsonian-style reflector that came with two simple eyepieces, Terry Dickinson's book *NightWatch*, and that was it. I didn't belong to a club and I had no mentor, and now that I look back, it was probably the best thing that could have happened to me. I had no one there to tell me what I shouldn't be able to see.

Until recently, I've worked as a Registered Nurse in a preoperative admission clinic, where I'd teach patients how to be best prepared for major surgery and recovery afterwards. My constant refrain to those who might lose a function that they would then need to regain was, "You will only know you have failed for sure if you give up, because you gave up." This has been the philosophy that has guided my observing program also. I had no one to tell me what I shouldn't have been able to do with my modest telescope. Consequently, I gave it a try on many objects that would never be considered possible and, while the objects could only be deemed "detected" at best, they were possible.

In the first few years I had that scope, I probably spent hundreds of hours out alone with it under my semi-rural sky. Night after night, I would work my way through the star atlases that I had. If it was on the page of *The Cambridge Star Atlas* or *Uranometria*, I gave it a go. While *Uranometria* handed me many unobservable objects, it was surprising the number that were observable. Everything in *The Cambridge Star Atlas* was observable in a 6-inch 'scope under a reasonable sky.

I now own a very fine 20-inch reflector that is capable of showing me more than I could possibly observe in my lifetime. However, it never ceases to amaze me at star parties how often the view through it can disappoint an inexperienced observer. Then the next person in line (who I know has an experienced eye) will observe the very same object and go on and on about how they have never before seen it in such detail.

This thought takes me back to one time I was at the Mt. Kobau Star Party: it was late one night, most of the early evening frivolities and socializing was over, and people had started settling in with their own 'scopes to start working on their personal observing programs. I was busy working on some Abell and Hickson galaxy clusters in the western Hercules–Serpens region of the sky with my 12.5-inch scope, when a couple came wandering up the road heading toward the top of the mountain.

"What are you looking at?" was what I heard over my shoulder.

"Galaxy clusters. Got a nice one right now with about a dozen in the field of view, with a couple being kind of bright," I responded. I recognized one of the couple as someone who worked at a telescope shop and who owned a 16-inch reflector, so I quickly offered up my 'scope. The first guest looked and said she could see nothing, then stepped aside. I quickly looked

Figure 1 — The author at his favourite observing site with his 150-mm f/8 Orion Dob and his 500-mm f/3.3 Starmaster.

in the eyepiece to check, and everything appeared as it should. Her companion looked, taking a bit more time, then stepped back with a "Huh" and a shrug. The couple then looked at each other and silently continued their trek to the top of the mountain. I often think back to this encounter and reflect on how and why our views and appreciation were so different.

This past year, I was reintroduced to the wonders of small-telescope observing. The solar eclipse of 2017 found me at the Sandy Beach Campground in Glendo State Park in eastern Wyoming. All I was able to bring with me on this trip was my little 80-mm semi-apochromatic refractor. I ran into a fellow amateur from Holland who had brought with him a 6-inch (150-mm) Schmidt-Cassegrain. Later that night, we met up on the beach to do some observing together with our respective little 'scopes. Both of us currently are accustomed to using telescopes of much larger aperture. He has a 12.5-inch (building a 20-inch) and I have a 20-inch. Our conversation showed that we had very similar early observing histories of working our way up to our current 'scopes having spent a great deal of observing time with smaller apertures. Over the course of the evening, we were consistently thrilled with the number of objects we were able to log with our little 'scopes. Soon it became a game of "I wonder if this object is possible?" and more often than not it was. While many of the objects were barely detectable, the observation was made.

Now, I am in no way saying that all objects can be seen with small 'scopes, as that would be a lie. With most objects, aperture is king. On the other hand, I fondly remember an RASC General Assembly I was at and having a conversation with Alan Dyer. I was thanking him for creating the Finest NGC List (in the annual *Observer's Handbook*) and how it really helped me improve my observing skills as someone newish to the hobby. I then casually mentioned how some of the objects had been a real challenge with my 6-inch Dob. He then looked me straight in the eye and said, "Wait, you saw IC 289 with a 6-inch 'scope?" That moment felt great, as that object in particular had taken over a year to log twice after dozens of tries.

The point I'm trying to make is to push the limit of what you can see with the aperture that you have. Not all of your observing challenges are solved by increasing the aperture of your 'scope right away. Time spent with whatever 'scope you have will give you experience, and that experience will improve your ability to see more. Push the envelope. If you do this, when you eventually succumb—and you will succumb—to that age-old aperture fever, you will be better prepared to accept what that bigger telescope can provide, because it might not be obvious right away. Oh, and don't be so quick to get rid of that smaller 'scope—hold on to it. Big 'scopes have their own built-in hassle factor. They are big, and that usually means more effort to transport and set up. On nights when you just don't feel like that hassle, your smaller 'scope will always be there for you. Then you can get out easily and continue to hone those observing skills, trying to tease out details that aren't quite as easy as they would be with a bigger scope. ✶

Bill Weir is an on-again, off-again, and now on-again member of the RASC Victoria Centre who is willing to visually observe anything astronomical. He has been awarded RASC observing certificates for the Messier Catalogue, Finest NGC Objects, and Deep-Sky Challenge observing programs. His main interest is deep sky, and he is well into the 2100s of the Herschel 2500 list. Most of his observing is done at the Godin/Newton Observatory at Lester B. Pearson College of the Pacific in Metchosin on the rural southern tip of Vancouver Island.

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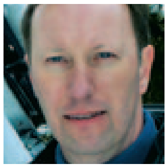
Imager's Corner

Noise Reduction and Masks



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

Now that the "Great Canadian Eclipse" is over, it's time to return to masks and their uses. In this edition we will look at how to control noise reduction using a mask to keep detail in the bright areas while smoothing the background and removing that pesky fine-grain noise.

All noise reduction blurs your image to some extent and the noise is most visible in the dimmer areas as seen in the crop from a M51 shot shown in Figure 1 — Noisy image of M51.

Figure 1 — Noisy image of M51

If we apply a straight-forward noise reduction, we get the following result.

Here you can see that the noise in the dim areas is greatly reduced in the image on the right, but at the expense of detail in the core of the satellite galaxy. Adding a simple inverted luminance mask helps to solve the problem (see Figure 3 on the next page). The mask prevents the blurring action of the noise reduction in the bright areas, preserving more detail than the same noise reduction alone.

The image on the right has the mask applied and shows more detail but retains the excellent noise reduction. Usually a simple inverted luminance mask allows some blurring in the bright areas. Most often a levels adjustment, increasing the black point, is required to make the dark areas of the mask a little darker and lowering the white point to make the light areas of the mask a little lighter as shown in Figure 4.With the application of a very simple inverse luminance mask you can noise reduce your images while retaining all that detail you have worked hard to get in the first place. For tough transition areas, don't be afraid to paint on the mask. Remember to use a blurring brush on the edges of any area that you paint to blend the effect into the rest of the mask.

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

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

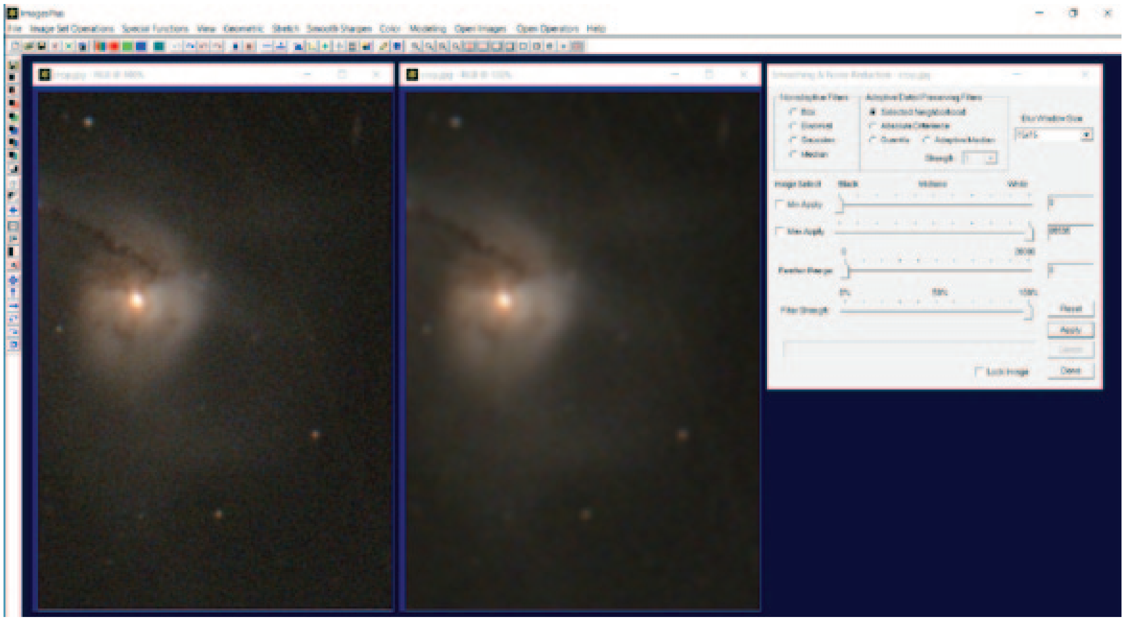


Figure 2 — Simple noise reduction

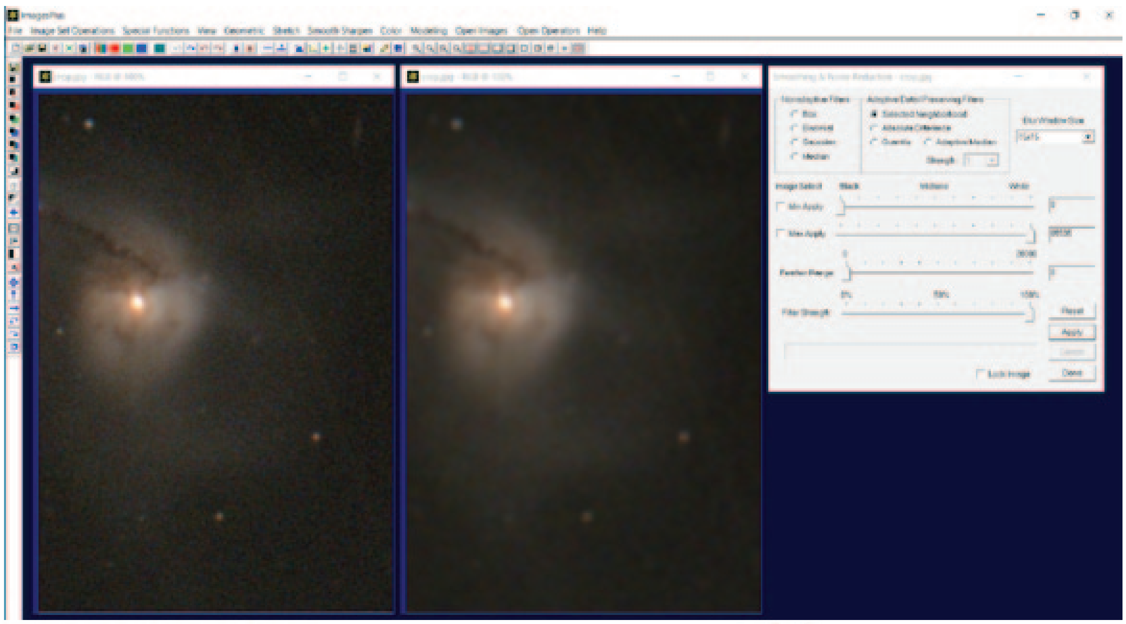


Figure 3 — Image on the right has had the mask applied

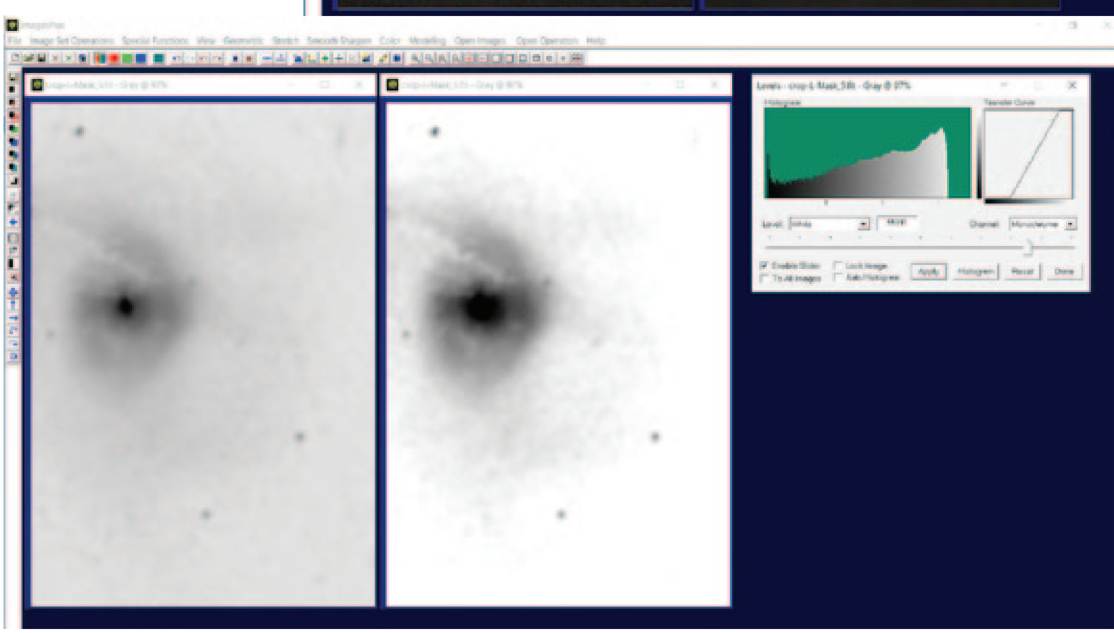
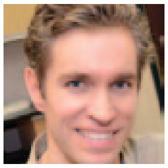


Figure 4 — Mask levels adjustment

Mysterious Magnetism



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

The easiest way to derail a meeting of astrophysicists is to pipe up and ask "What about the magnetic field?" While gravitation is the dominant force that shapes so many astrophysical processes, magnetism is thought to be the other critical force needed to explain the phenomena we observe. From the formation of stars and planets to how black holes influence the evolution of galaxies, the magnetic field is thought to play a central role. However, it is difficult to observe magnetic fields directly, so they are often left as mysterious agents that can be used to explain away measurements that just don't quite make sense. When pressed on how these fields are actually shaping the physics, astronomers will often resort to waving their hands. This disturbing gap in our understanding comes from two main reasons: observing magnetism can be quite difficult and the actual physics of magnetism is more complex than that of gravity (at least the physics of the relatively weak gravitational fields that dominate the Universe). While the physics will remain relatively difficult, radio telescopes are providing one of the key methods to reveal the presence of magnetic fields in space.

One of the main ways that gravitation differs from magnetism is by the directions in which it acts. Gravity is a "round force," meaning that it doesn't have a preferred direction for action. The gravitational influence between two objects always acts in the direction along the imaginary line connecting those two objects. In contrast, magnetism arises from moving electric charges that create a magnetic field. When another charged particle moves into that field, it feels a force that acts at right angles to both the direction of its motion and the magnetic field. You may be experiencing traumatic flashbacks to the "right hand rule" in physics at this point, but that strange directional behaviour of magnetism is fundamentally what makes the physics of magnetism so complex. Magnetic fields cannot exert forces in the same direction that they are oriented, so there are preferred directions for magnetic fields. Gravity has no such preferences. Just like compass needles will line up to run parallel with Earth's magnetic fields, so too do objects in space line up with cosmic magnetic fields. When we look carefully at how those objects give off light, we can start to see the signs of cosmic magnetism.

Magnetic fields are observed through the effects of polarization on light. Light is made of an electromagnetic wave, where the electric component of the wave is oscillating up and down along a line. The direction of that oscillation defines the polarization of a single wave. Most celestial sources produce light that has no preferred polarization direction. However, because magnetic fields will align matter, that matter will give off light with a specific polarization. By measuring how strongly the light is polarized and the direction of that polarization, both the strength and the direction of the magnetic field can be determined.

Many detectors of astronomical light cannot detect the polarization of the light waves that arrive at them. For example, the cameras used in optical astronomy only measure how much light lands on them and cannot determine if it is polarized. It becomes possible to use a polaroid material (a filter that only transmits light polarized in one direction) to turn cameras into polarimeters. For reasons only loosely related to magnetic fields, light reflected off surfaces is also polarized, so fancy sunglasses will use a polaroid material to block the polarized light from reflective glare. This same material can, in principle, be used to detect polarization by taking an image with the polaroid oriented in one direction and then a second image with the polaroid turned 90°. Objects emitting polarized light will have different brightnesses in the two images, while unpolarized objects will be the same brightness.

Radio telescopes have a slightly different issue. At the heart of every radio telescope is an antenna that only detects a single polarization of light. Many telescopes put two of these antennae into the same part of the receiver to detect light from

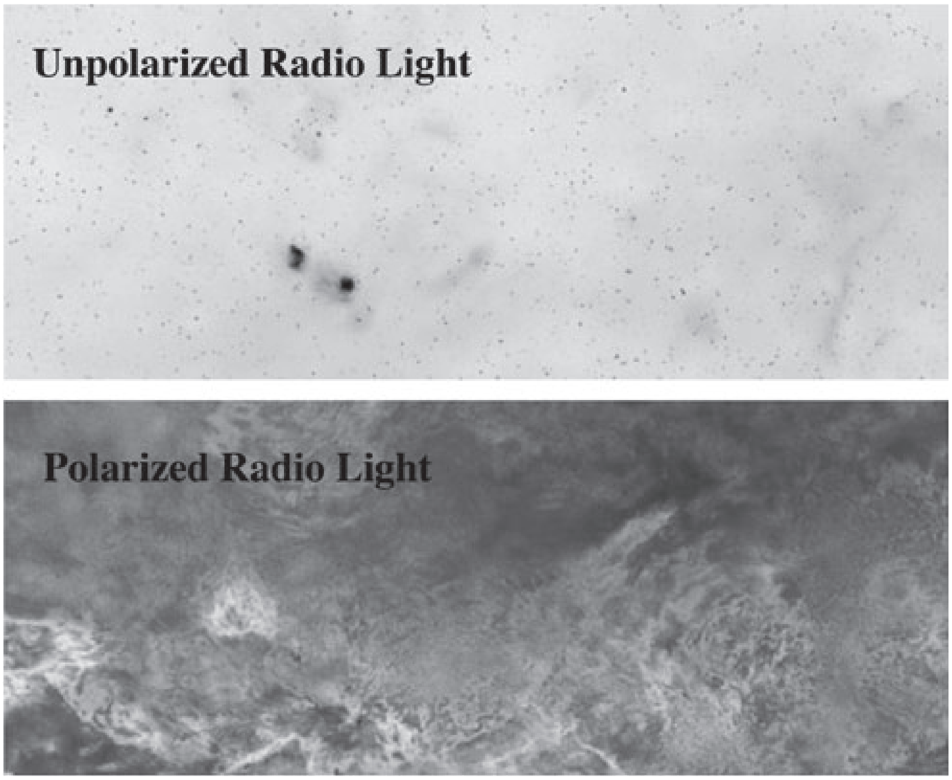


Figure 1 — Two views of radio emission from the Milky Way galactic plane in the constellation of Perseus. The top panel shows the total emission in radio waves with a frequency of 1.4 GHz (darker greys correspond to brighter emission). The prominent sources are two emission nebulae (Sh2-209 N and S). The bottom panel shows the same region of the sky but only showing the polarized emission. The dappled pattern is a sign of the tangled magnetic fields in this part of the galaxy.

the possible polarizations, but this doesn't change that every radio telescope only detects polarized light. The technique for detecting the polarization of light is similar to the sunglasses-polarimeter in the optical: does the radio telescope receive more power in one polarization versus the other?

Radio telescopes see the influence of magnetic fields from two main sources. First, high-energy electrons, accelerated from supernovae, fly around the galaxy and get caught in magnetic fields. As they whip around the field lines, they give off radiation perpendicular to the orientation of the field. Second, elongated grains of interstellar dust will preferentially align to the magnetic field. These grains will also emit light perpendicular to the field. In both cases, only a few percent of the total radiation will be polarized, meaning that these measurements must be made carefully with a good deal of attention to the properties of the telescope that might lead to false signals.

The view of the polarized Universe is markedly different from what we see in unpolarized light. Figure 1 shows two views of the same part of the Milky Way's galactic plane seen in radio emission toward the constellation of Perseus. The top view shows the total power in radio light with darker greys meaning more power. In the image, the two notable features are ionized hydrogen nebulae (specifically the pair Sh2-209 N and S). There are many faint sources, which are background galaxies, but otherwise, the image is relatively smooth. In the polarized light, however, the picture changes dramatically with rippled emission across the field. This dappled pattern is the sign of the small-scale tangling of magnetic fields stretching throughout the galaxy.

This radio imaging provides a rare glimpse into the hidden influence of magnetic fields on the Milky Way Galaxy. The key influence of these fields comes because of their tight connection with the rest of the matter in the galaxy. Gas flows in the galaxy are shaped and steered by the magnetic fields. Stars generate their own fields that connect to the larger fields spanning the galaxy, providing channels for the stellar winds to push out from the stars. Magnetic fields control how stars and stellar systems form, slowing the collapse of protostellar gas cores. Even the jets around black holes are thought to be launched to near to the speed of light by twisted magnetic fields.

But where do these fields come from? There are no metal magnets in space. These fields must be generated by electromagnets, namely through the flow of electrical current. Where are these currents generated? Are the fields getting stronger in galaxies over time? These are questions that next-generation telescopes are poised to answer. Understanding the origins of cosmic magnetism is one of the key goals of the Square Kilometre Array. Over the next decade, we hope to build a clearer picture of these subtle effects to establish where and how they control the evolution of galaxies.

Read more: www.skatelescope.org/magnetism ✶

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

Commemorative coin and stamps are issued for the Society's 150th anniversary

by Randy Attwood, Executive Director

The 150th anniversary of the Society has been recognized by two major Canadian institutions.

On June 26, the Royal Canadian Mint unveiled a unique collectible silver coin at a special ceremony in Toronto. The coin's design is based on the Society's 150th anniversary logo. On the coin is mounted a fragment of an actual meteorite.

"One hundred and fifty years of research, education, and discovery by the Royal Astronomical Society of Canada is an engaging story to tell on a coin," said Sandra Hanington, President and CEO of the Royal Canadian Mint. "It is only fitting that RASC's many scientific achievements be recognized on a vividly coloured coin, which breaks barriers of its own by featuring a shard of a real meteorite."

Designed by Canadian artist Alexandra Lefort, the reverse design of this coin features a deep-space vista enhanced by engraved textural details and full colour. Prominent design elements include the Eagle Nebula and its pillars of interstellar gas and dust, which are known as the Pillars of Creation. Also featured are the Moon, the Andromeda Galaxy, and a blazing meteorite, enhanced by a genuine iron meteor fragment from the Campo del Cielo meteorite field.

On June 29 at the General Assembly in Calgary, Canada Post unveiled two astronomy stamps. The stamps showcase the majestic splendour of two spectacular phenomena: the Milky Way and the Northern Lights.

The stamps depict astrophotos taken by two RASC members. Matt Quinn's stunning photo of the Milky Way was taken at Bruce Peninsula National Park in Ontario. Alan Dyer captured a magnificent image of the Northern Lights in Churchill, Manitoba. Both photographs were taken in 2016.

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The cover of the booklet of 10 and the Official First Day Cover include decorative astronomy-themed illustrations—a satellite, a celestial body, and an observatory, a subtle tribute to the National Research Council of Canada's Dominion Astrophysical Observatory in Victoria, B.C., which celebrates its 100th anniversary this year.

Designed by Parcel Design of Toronto, the stamp includes metadata—the date and time the photograph was taken, coordinates and type of camera lens used for the photo—in special ink in the borders, making it visible only under a black light. Lines and names overlaid on the images highlight constellations.

The stamps, first day covers, and souvenir sheets can be ordered from the Canada Post website www.canadapost.ca.

The 2018 $20 Fine Silver Coin—150th Anniversary of the Royal Astronomical Society of Canada has a limited mintage of 5,500 and retails for $149.95. ✶

John Percy's Universe

What Does a Giant Star Look Like?

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

What does a star look like? As someone who has done research on stars and stellar evolution for over half a century, I have always wished that I could see what "my" stars looked like, close-up. Most of us have seen the Sun, either "live" or in superb images such as those in this *Journal*, but stars come in many varieties, most of them quite unlike our star. So I was very excited to see a remarkable new image of π^1 Gruis (Paladini et al. 2018): it's just the kind of star that I and my students are now working on—a pulsating red giant (Percy, 2015).

But first some background. Naked-eye observers, viewing the Sun through clouds or near the horizon, can and did see that it was round, and occasionally had spots on the disk. Telescopes such as Galileo's revealed smaller spots and, from the apparent spot motion, also revealed that the Sun was rotating. The Sun also appears fainter and redder near the limb or edge—limb-darkening. Increasingly sophisticated telescopes, on Earth and in space, have revealed a wealth of other features and phenomena, granular convection cells, concentrated magnetic fields, a two-million-degree outer atmosphere, coronal mass ejections, and more. These features can be inferred on other Sun-like stars, using observations at many wavelengths. But they cannot be seen directly.

Indirect Imaging

But we can still infer the appearance of stars indirectly. A very simple approach is to observe a star repeatedly with precise multicolour photometry, using a photometer or CCD camera. If the star has a large starspot, like a sunspot, then the star will appear slightly fainter if the spot is on the side of the star facing us. As the star rotates, and if the rotation axis is not pointed toward us, then the brightness will vary with time. The timescale of the variation is the rotation period of the star. The amplitude of the variation is a measure of the area and darkness of the spot. There is a wide variety of spotted stars, including the red dwarfs that make up the bulk of the stars in our galaxy (1).

Even more information can be obtained by combining the photometry with high-dispersion, high-resolution, time-series spectroscopy. As rotation carries the spot on and off the visible disk, there are tiny changes in the shape of the stellar absorption lines. These are caused by the Doppler effect, which results from the motions of the spotted and unspotted regions as they rotate toward and away from us. See Percy and Rice (1) for a detailed account of how spots can be "Doppler-imaged" on Sun-like stars, and what this tells us about how the Sun compares to others of its kind. There is even a video showing a Sun-like star as it rotates. This account is based on many years of research by John Rice, of Brandon University, who was a leader in the field of Doppler imaging.

There is another group of stars whose surfaces can be Doppler imaged—the "peculiar A stars," much hotter than the Sun. Like Sun-like stars, the Ap stars have strong magnetic fields; these fields are not concentrated in spots, but are global like the Earth's. These fields are strong—up to 20,000 Gauss (the Earth's is about 1 Gauss). These global magnetic fields allow radiation pressure to "levitate" some rare chemical elements to the star's surface, producing a star whose spectrum is dominated by rare elements such as europium, strontium, mercury, and manganese. Furthermore, the magnetic field causes these rare elements to concentrate in patches on the surface, so the spectrum of the star varies as the star rotates. These stars are also called "spectrum variables." No wonder these A-type stars are called "peculiar"! Time-series photometry and spectroscopy can be used to Doppler image the patches, and create a "picture" of the star. The magnetic field can be mapped by time-series polarimetry, because the magnetic field causes some stellar absorption lines to be polarized. See Percy and Rice (1) for other information, images, and videos of a rotating Ap star.

Direct Imaging

But you might ask: why not just look at a star and see what its surface looks like? The problem is that the stars are very far away. The Sun, even at the distance of the nearest other star, would look like a point of light. The apparent or angular size of a star is directly proportional to its diameter, and inversely proportional to its distance. The apparent size of the Sun is about 0.5 degree. The apparent sizes of other stars are measured in milliarcseconds (mas) where 1 mas = 0.001 arcsecond, and 1 arcsecond = 1/3600 of a degree! The angular sizes of most of the naked-eye stars are a few mas. They will be greatest for large and/or nearby stars.

Betelgeuse is a relatively nearby red supergiant. Its apparent size is about 55 mas. Images with both ground-based interferometers and with the *Hubble Space Telescope* (HST) show a bright, hot patch that may be an upwelling convective cell—called a granule in the case of the Sun. Such large convective cells were proposed by Martin Schwarzschild in 1975, on theoretical grounds. Despite the importance of convection in astronomy, it is still poorly understood because of the wide range of sizes of the convection cells, their randomness, and the near-impossibility of duplicating stellar conditions in a terrestrial laboratory setting. If convection was better understood, astrophysicists could simulate the appearance of the star. See (2) for an example of a "state of the art" simulation of Betelgeuse, by Bernd Freytag and his colleagues.

The angular size of Mira, the prototype pulsating red-giant star, is about 35 mas. Ground-based and HST observations of this star also show evidence of one or more bright spots, which seem to change on time scales of months.

The new and exciting observations that provoked this column are of π^1 Gruis, a pulsating red-giant star. It's a member of an attractive, 6th-magnitude southern visual binary, 530 light-years away, in the constellation of the Crane. According to my analysis of visual and photoelectric observations in the AAVSO International Database, it has a mean pulsation period of 195 days, and a mean visual amplitude of 0.10 magnitude. But like most pulsating red giants, its period "wanders" by several percent, and its amplitude varies by a factor of ten—from 0.05 to 0.50!

Paladini et al. (2018) used the four-telescope system of the Very Large Telescope Interferometer at Cerro Paranal, Chile, to image π^1 Gruis. It utilizes four 1.8-m telescopes. Interferometric observations require a reconstruction algorithm to convert them to an image. Paladini et al. (2018) used two different algorithms, each producing very similar results. Figure 1 shows one image. The size of the convective cells is about 120 million km, or about a quarter of the diameter of the star, which is 350 times the diameter of the Sun. Thankfully, the observed size of the cells is roughly consistent with theoretical expectations.

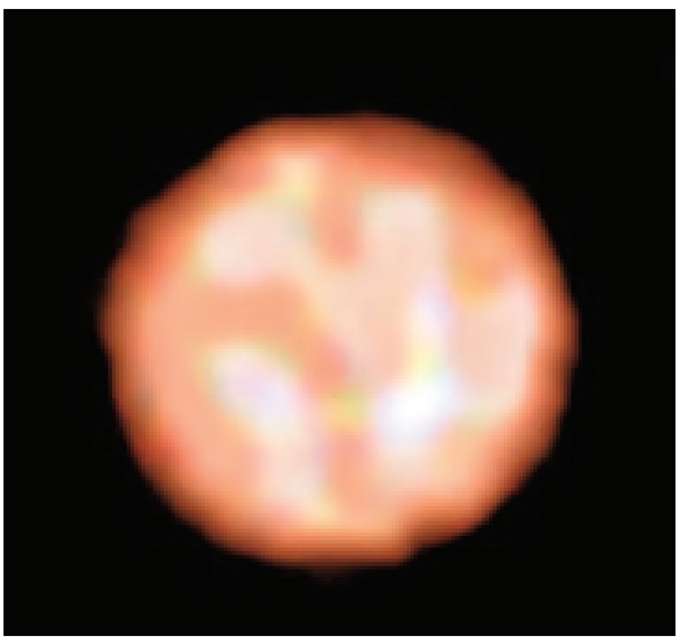

Figure 1 — An interferometric image of the red giant star π^1 Gruis, obtained at a wavelength of about 1.7 micrometres with the Very Large Telescope Interferometer in Chile (Paladini et al. 2018). The bright regions are believed to be large convection cells.

I am happy to see these giant granulation cells, in part because such cells may help to explain some of the unsolved long-term variations in red-giant pulsation (Percy and Deibert 2016), either through their random occurrence, or the time scale of their turnover, or through rotational variability as they rotate on and off the visible disc of the star. ✶

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

References

Paladini, C. et al. (2018), "Large granulation cells on the surface of the giant star π^1 Gruis," *Nature, 553*, 310.

Percy, J.R. (2015), "What my students and I have learned about pulsating red giants," *JRASC 109*, 39.

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Notes

1. Percy, J.R. and Rice, J.B. (2017): www.aavso.org/rotating-variables-mapping-surfaces-stars
2. www.astro.uu.se/~bf

Binary Universe

A New Weather Forecasting Resource

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

In early May, via a Facebook post by Alan Dyer, I learned of a new weather forecasting tool for astronomers called Astrospheric. I briefly surfed into the website and had a quick look around. My first impression was that it looked good. The evocative site appeared to be another useful tool for analyzing our crazy weather and whether I should pack my 'scope for a trip to the dark-sky site or ready a robotic telescope for imaging. Later, as I dove deeper, I started to feel that the Astrospheric tools will prove most useful, consolidating a number of different data sources.

The Website

When I first visited the www.astrospheric.com website to learn about and quickly explore the weather resource, I found a wealth of information "above the fold." Also, a quick 4-step tutorial helped me get up and running rapidly.

You will be presented with a multi-faceted dashboard (see Figure 1) with a map, controls for the map, indicator bars and rows, and a list of your favourite viewing or imaging sites (once configured).

The map marks your detected or selected location with a red bullseye. The map is overlaid with clouds showing you the coverage at the moment.

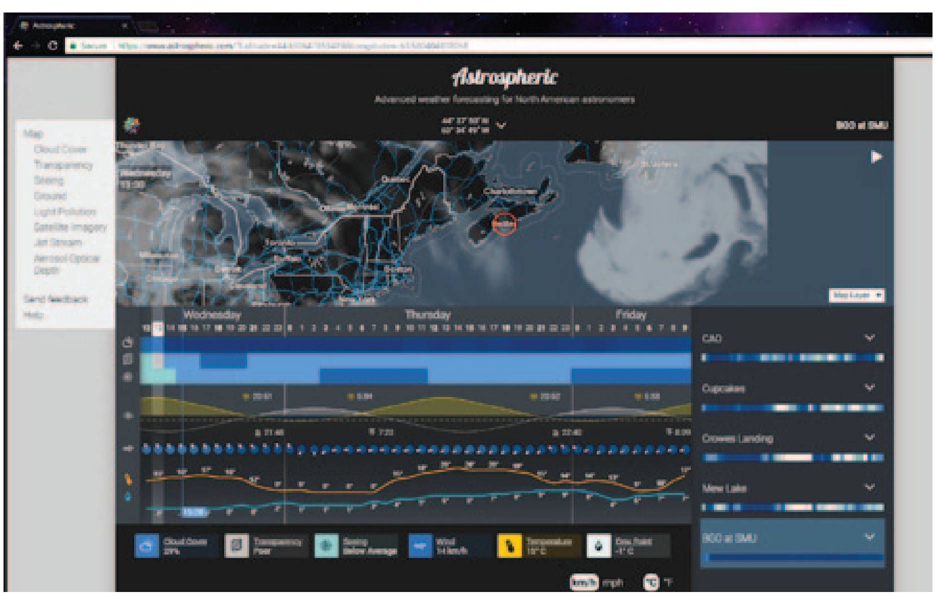


Figure 1 — The upper portion of the Astrospheric web page with favourites.

Below the map is a familiar style of table. Like the Clear Sky Chart display by Attilla Danko, the 48-hour forecast panel in hourly columns shows cloud cover, air transparency, and atmospheric seeing, along with midnight divisions. Navy and dark blue is good; grey or white is bad.

While CSC graphics show the Sun and Moon brightness with coloured blocks, here Astrospheric uses an intriguing method with sinusoidal waves. The solar diurnal cycle is marked by the yellow wavy line; the lighting effect of the Moon is accomplished with a grey rhythmic line. As the curves cross the dark grey background, you can glean when the Sun and Moon are rising and setting. The to-the-minute times are shown nearby. The dashes below the horizon mark the "night" line signalling astronomical twilight! Very clever. Those hunting for deep-sky objects in the ocular or wishing to avoid unwanted photons in their photos will want to look for synced yellow and grey waves or grey troughs in the evening.

Next is the wind indicator. Once again, the colour alludes to the condition, i.e. dark blue means no wind or a light breeze. The direction the wind is coming from is indicated.

Finally, another line graph shows on the screen, this time with air temperature and the dew point calculation. This reminds me of the Weather Underground webpage when used in 10-day mode. Now you know if you'll need your woollies and/or dew heaters.

This entire set of graphic elements reminds me a bit of the Clear Outside prediction resource, from First Light Optics, with its multiple "channels" of information. Astrospheric also triggered an old memory in me of the 7Timer! tool (which I believe now is defunct).

Below the various rows showing the expected conditions for the next two days are icons with values. The values are for current or selected time slot. When you click on any time period in the table, the immediate or predicted cloud, transparency, seeing, wind, temperature, and dew point numbers are shown. The icon colours will change. You will also notice the map changes, showing the cloud cover for that hourly period. This is not unlike when you click a chip in a Clear Sky Chart.

Arguably, this is the same information that you may obtain from our time-tested resource, with a spin on presentation. CSC shows humidity, does not show wind direction, and uses pop-up windows. A neat little feature of Clear Outside is the *International Space Station* icon indicating upcoming flyovers.

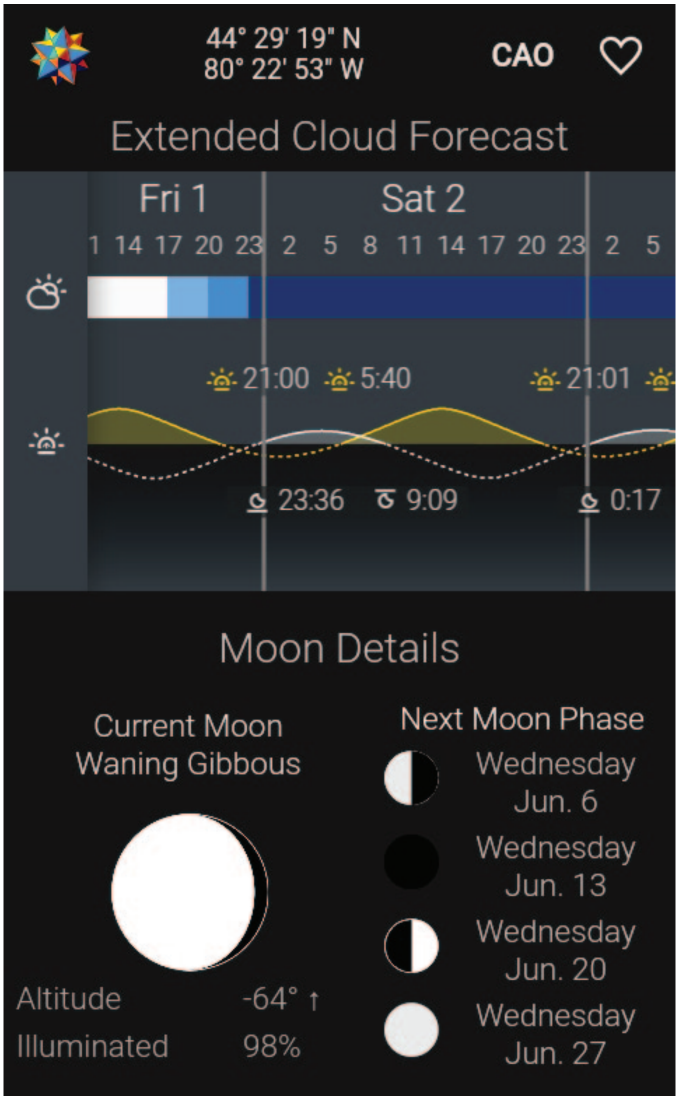


Figure 2 — The main screen with Extended forecast and Moon info (on an Android device).ready.

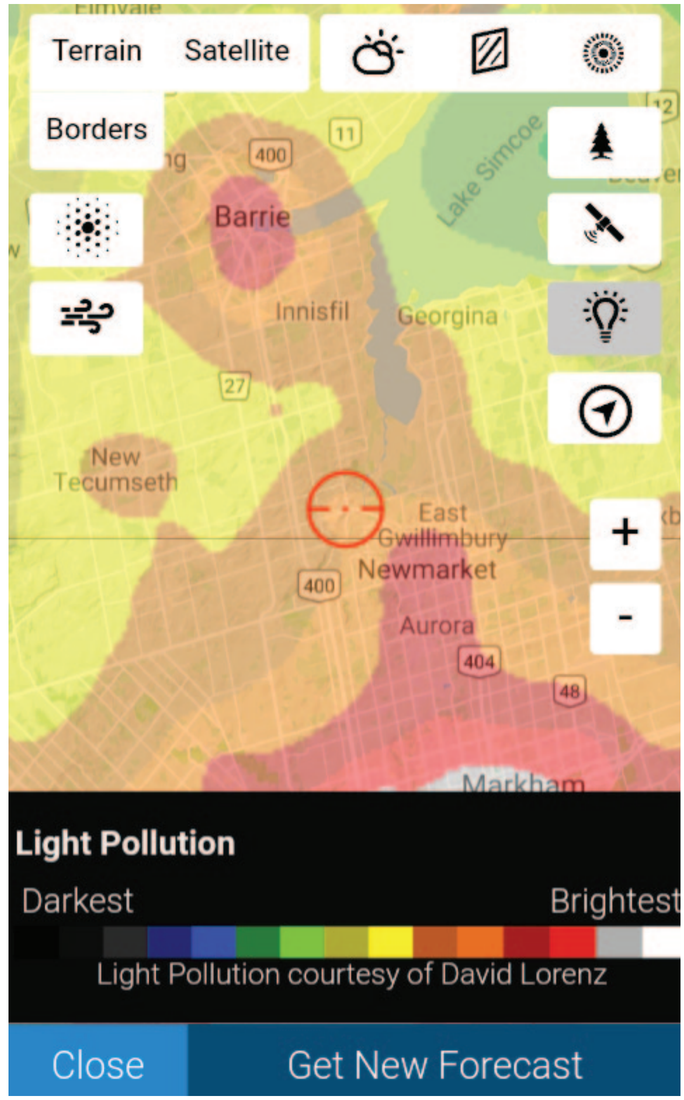


Figure 3 — Map with light pollution overlay for selecting a location (Android).

Things get more interesting as you scroll down on the Astrospheric webpage.

You will encounter the Extended Cloud Forecast section (Figure 2), which shows another 5 days, for a total of 8. This handy element lets you quickly gauge future sky conditions along with the Moon phase.

Speaking of our natural satellite, the Moon Details sections follows the long-range forecast with the current phase visually represented. The instantaneous altitude is noted and whether the orb is rising or falling. The upcoming main quarterly phase dates show to the right.

The last section shows a zoomed map to verify your location. There are notes about how stale the data is and when it will be updated next. Like CSC, the cloud, transparency, and seeing data is updated every 12 hours.

At the bottom of the webpage, we can see that forecast data comes from the Canadian Meteorological Centre (the same source that Danko uses) with long-range data being injected from the NCEP Global Forecast System and satellite imagery and light-pollution data from the University of Wisconsin. The author, Daniel Fiordalis, has carefully collated all data sources into a concise and powerful package.

All this is rather impressive the more I think about it and this page presents information that I could only find in the past by using several websites. And it's all free.

It is easy to see weather predictions for effectively any place in North America (Figure 3). First you click the map and then you choose your location by dragging the map. In other words, drag the map under the fixed bullseye until it is positioned over your destination.

If you want to create a listing of regularly used locations, you can employ the Favourite feature. First you submit an email address to which Astrospheric will send an alphanumeric code. Enter the code and now your favourites will be kept. Use the

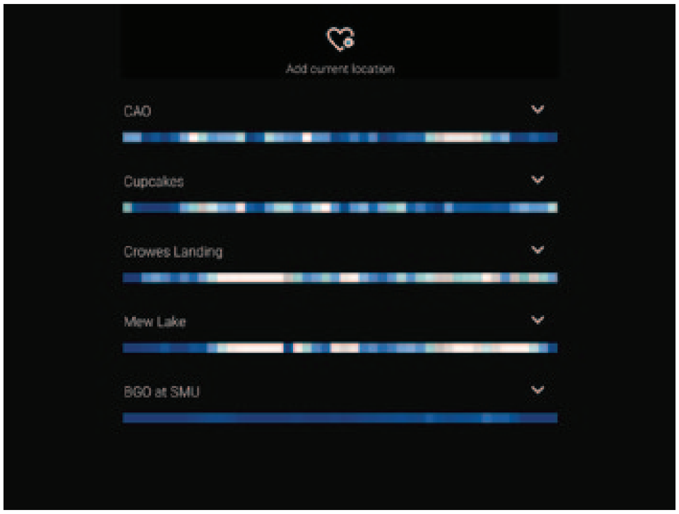


Figure 4 — The Favourite screen (on an iOS device) for selecting and adding observing sites.

same email address to generate more codes for "transferring" your favourite spots to your mobile devices or browsers on other computers. Single-row miniature versions of the cloud-cover bar show for each of your locations (not unlike the "thumbnail" offered by CSC). When you have multiple viewing or imaging locations loaded, you can tag one as the default.

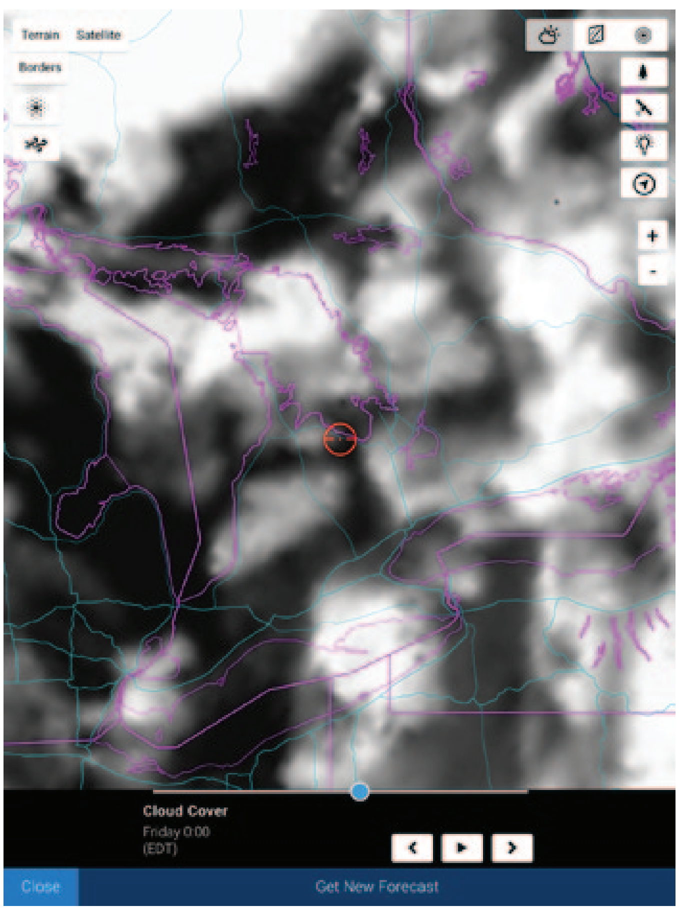


Figure 5 — The full map screen with borders mode and cloud cover overlay (on iOS).

Accessing the map can be easily accomplished by using the menu on the left edge of the webpage. Initially, I never saw this; actually, I thought there was something wrong with the site, that an artifact was rendering oddly in my Chrome browser. But it turned about to be an issue with the screen size! When I moved the maximized browser window from my small screen (1280 pixels wide) to my wide monitor (1920px), the menu magically appeared. This shows that the website wants a lot of screen real estate! Whether you see the menu or not, you can access the map by simply clicking on it.

The modes and overlays available in the full map are helpful. Like any mapping software, you can show terrain or satellite. As well, you can switch to the simplified land and water borders (Figure 5). You can show cloud cover, transparency, seeing, ground temperature, light pollution, satellite infrared imagery, the jet stream, and the aerosol optical depth (for haze).

The map feature deserves some additional discussion for it can be used as a location selection tool. Say you're keen to capture

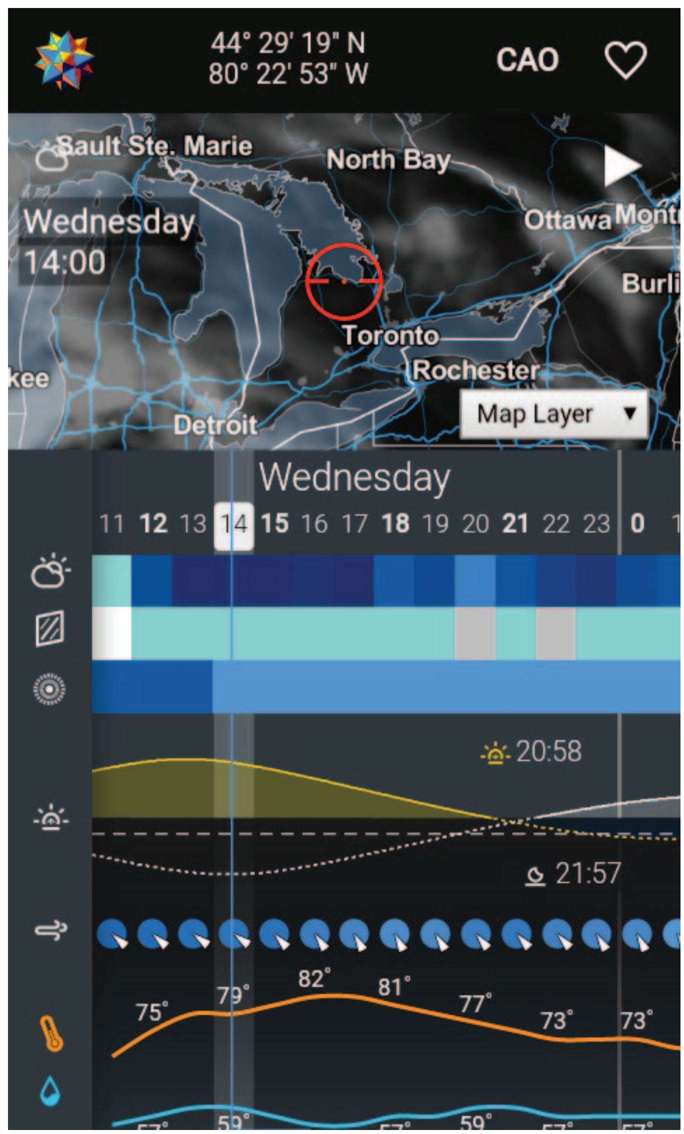


Figure 6 — The upper portion of the Astrospheric screen on Android.

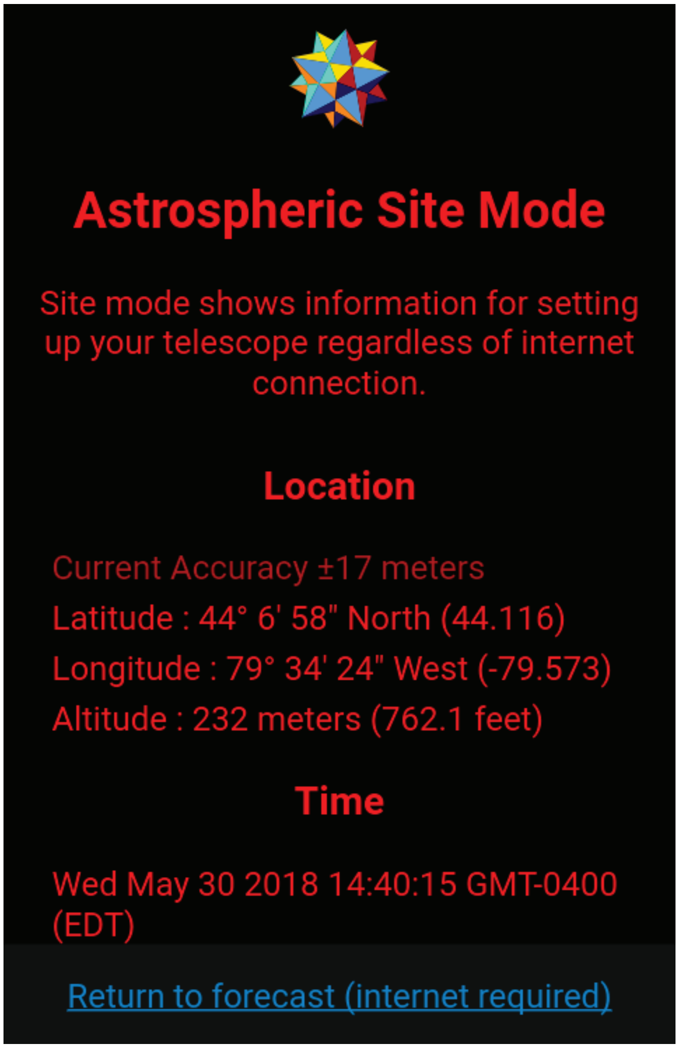


Figure 7 — The Site Mode screen for precise latitude, longitude, altitude, and time (Android).

an asteroid occultation or image a shadow transit on Jupiter but you're clouded out at your current location. In map mode, with the cloud cover and seeing and light pollution overlays, to name a couple, you can find a spot with clear and good skies, hopefully nearby. This gives Astrospheric a unique capability in terms of session planning when you are able to roam. This might be rather handy for any upcoming solar eclipses traversing North America…

The Android app

https://play.google.com/store/apps/details?id=com.astrospheric.dfior.astrospheric

When I installed the Astrospheric Android app to my tiny Alcatel smartphone, I wondered how well it would work. I was concerned about the rather small display (four inches), whether it would show all the information correctly. Some of this concern was from the minor aforementioned display issue on my Windows computer.

Happily, the Android app looks good on my mobile device (Figure 6). It works fine in portrait or landscape mode. Swiping reveals data in the future and the additional sections below.

Switching to my pre-programmed locations was easy using the heart icon at the top.

While in the map, I could easily access any of the overlays and easily pan. Pulling up the full map was trivial from the main screen by tapping the small map (no menu needed).

The mobile app offers the "site" mode feature not available on the webpage (Figure 7). Using GPS and network location data from the device, the app tries to display accurate geomatics data including elevation above sea level. This may be helpful information when precisely configuring your telescope mount for a new location.

The iOS app

https://itunes.apple.com/us/app/astrospheric/id1166046863

Downloading and installing the iOS version of Astrospheric was straightforward. After configuring it to allow location detection I was up and running. The app looked good on the iPad 9½-inch screen (Figure 8).

Once again, I requested a code for the Favourite Locations and saw my previously configured viewing sites present themselves.

Adding a location on one device seamlessly makes it show on the others. Slick.

I have experienced issues with the cloud animation in various ways. You should be able to click or tap the play button at the top-right of the map. On my Windows computer, it didn't work on many occasions—simply nothing happened. It seems the iOS app crashes when I try to use it. It has dynamically shown cloud movement every time I've tried it on Android. When it works, it's great.

An Excellent Resource

I communicated with the author. A red light or night mode is in the works. I raised a few other questions but have yet to hear back.

There are extensive notes and help pages for Astrospheric. While you may not be normally inclined to read help documentation, it is intriguing to learn how the system works, what the author has considered useful for astronomers and astrophotographers, and how other weather sites you use may actually turn out to be not as helpful as you think.

I am already enjoying using Astrospheric. I have configured my favourite locations. I'm going to add it to my personal

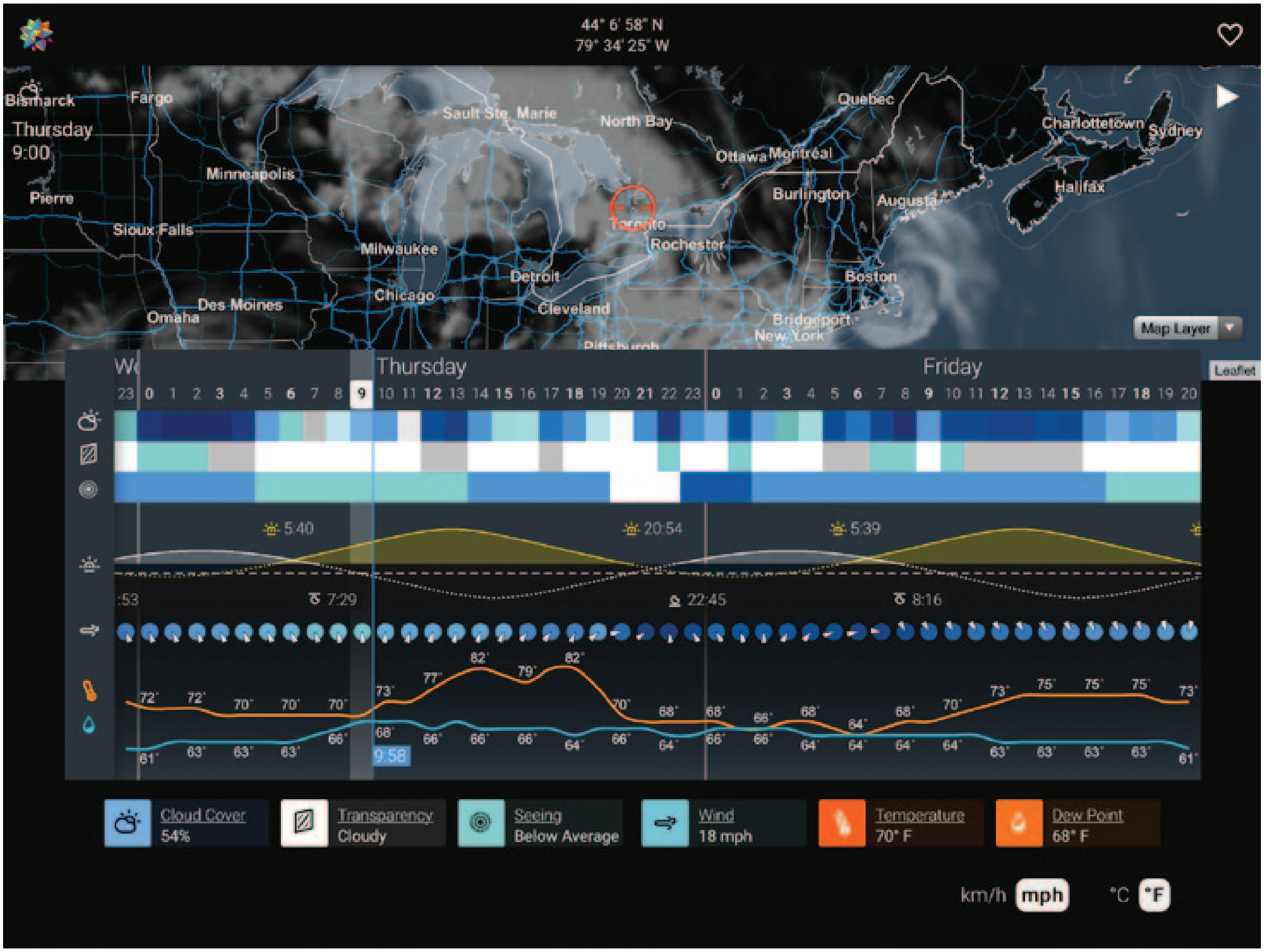


Figure 8 — The upper portion of the Astrospheric screen on an iOS device.

weather portal webpages. I'm really looking forward to using it on my smartphone.

I don't think it will eliminate my use of other weather resources. I still like using animated satellite visuals from NOAA that show clouds marching. And if I'm keen to spot, photograph, or video record the ISS, I'll need another tool. Still, I believe Astrospheric will bring a lot of disparate data together into one spot saving me time. And as my high school buddy Cam says, "Time is a non-renewable resource."

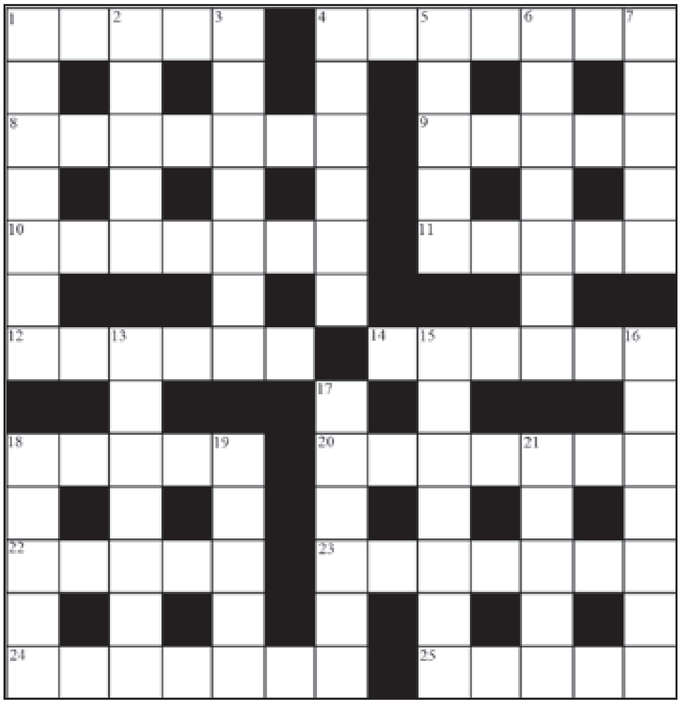
Bits and Bytes

An issue with the Sky Events app was brought to my attention by the eminent astronomer Jean Meeus. He noticed that the Daily Data screen with the Sun and Moon times shows all seconds values as 00. I believe this is due to essentially a formatting issue in the app and that times are not actually calculated to the second. In other words, you must ignore the seconds display in this screen. ✶

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

Astrocryptic

by Curt Nason



ACROSS

1. Land on Mars and stop back in Québec City (5)
4. Great comet bent around northeast Taurus (7)
8. Prominent zone gas has a mom in a dither (7)
9. Atlas maker or Moon howler (5)
10. Opposition period computed for Don's icy wanderer (7)
11. Board member landed in Edinburgh, perhaps (5)
12. Crooked spears point to a distinction of open clusters (6)
14. Some ID required to orbit Mars (5)
18. See 19 Down (5,5)
20. Caltech observatory was a friend to a tentmaker (7)
22. Astronomer's tool on the catwalk (5)
23. Drive back about Lepus in disarray (7)
24. It rants wildly when Mars is highest (7)
25. Piscivorous eagles spin Astronomer Royal around a pole (5)

DOWN

1. Argon and sulphur detected in this volcanic ridge (7)
2. Battler who looked up to Mars or man in distress (5)
3. Have no ideas about the Muses (7)
4. Leaves attached to giant stream from the main sequence (6)
5. Bonestell lets loose and scrambles to get a prestigious prize (5)
6. Plain on Mars but heavenly to the Greeks (7)
7. How a Messier marathoner feels. Like Curiosity? (5)
13. Bishop's university with royal beginning in plain site on Mars (7)
15. Orbital figure makes the Spanish kisser excited at first (7)
16. Spenser was upset over a broken constellation (7)
17. It rips around on Mars, or not (6)
18. Fifty-one went to prestigious school, the minimum distance predicted by Roche (5)
19. (With 18 Across) A scull is so useless on a sunny lake (5,5)
21. Renowned astrophotographer made a name in animal instinct behaviour (5)

Answers to June's puzzle

ACROSS

1 TRIPLET (2 def); **5** CHANT (hidden); **8** CUPID (2 def); **9** IMBRIUM (anagram); **10** ONTARIO (anag); **11** LASSO (hid); **12** COSMOS C(os)MOS); **14** ASLEEP (anag); **17** T-RING (T+ring); **19** LAPLACE (anag); **22** EYE LENS (an(Y)ag); **23** LEO II (Ole (anag)+II); **24** ABELL (anag); **25** LARISSA (an(R)ag+a)

DOWN

1 TYCHO (2 def); **2** IAPETUS (anag); **3** LIDAR (l(Ida)r); **4** TRIPOD (anag); **5** CYBELES (Cy+be+les); **6** ARIES (varies-v); **7** TOM BOPP (tombo+pp); **12** CYTHERA (an(the)ag); **13** ORGUEIL (o(anag)il); **15** ETALONS (E+talons); **16** PLOSSL (PL+anag); **18** IRENE (2 def); **20** POLAR (Polaris-is); **21** ERIKA (anag)

It's Not All Sirius

by Ted Dunphy

Great Images

by James Edgar

Journal *Production Manager James Edgar obtained this image of the Moon and Venus on the evening of 2012 April 24 using his Canon 50D with a Canon 17–55-mm lens at 17 mm, ƒ/2.8, and ISO 100 for 1/2 sec.*

Journal

Great Images

Switching back to his 12.5-inch Planewave, Andre Paquette targeted M106 for its "first" light. He used a CGE Pro mount, with an Apogee U16M camera and a Celestron Skyris 274M guider.