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Journal

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PROMOTING ASTRONOMY IN CANADA

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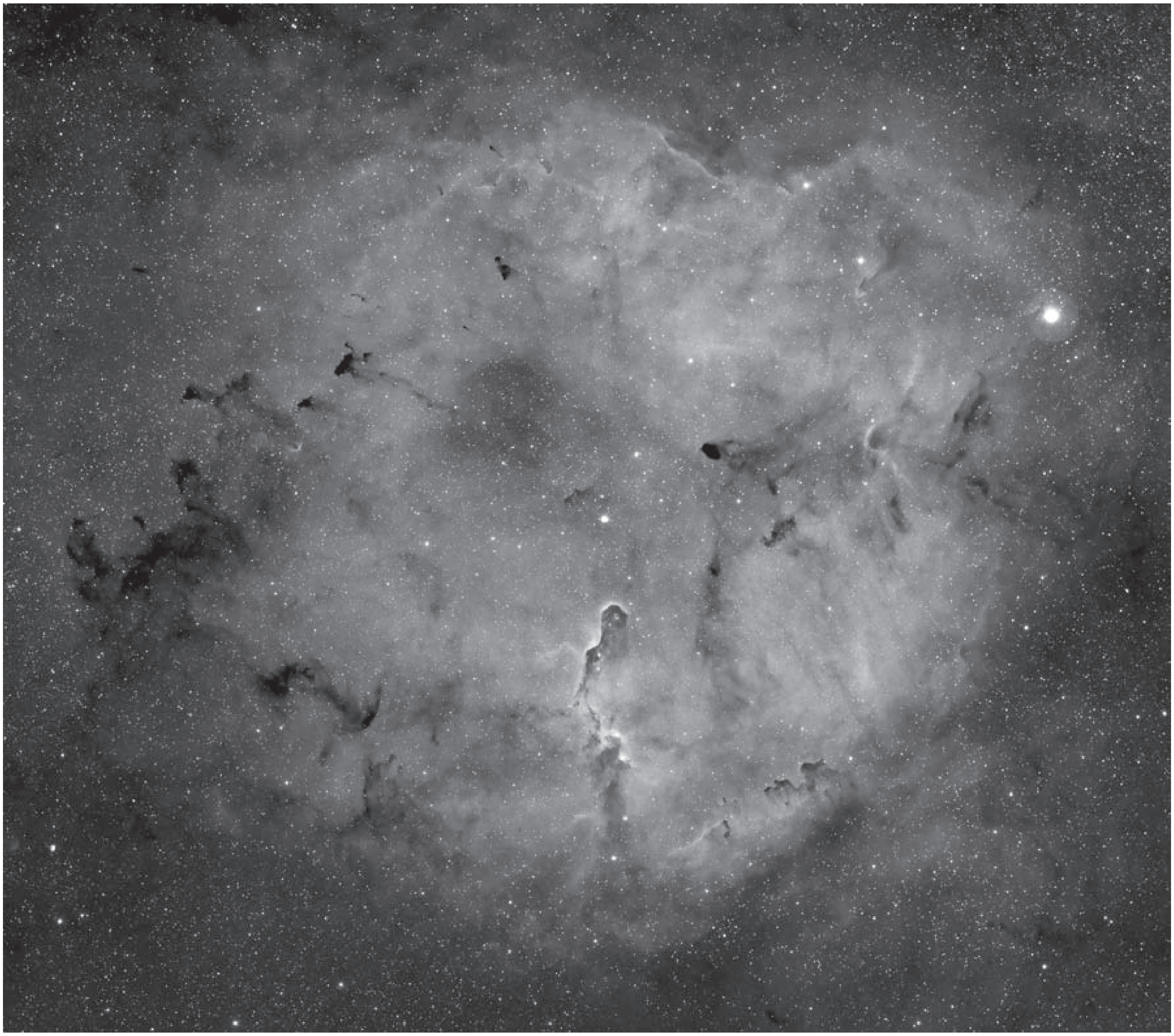
Inside this issue:

A Colour Canvas in Scorpius

The Best of Monochrome.

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



James Black specializes in narrowband imagery such as this Hα rendition of the Elephant Trunk Nebula (van den Bergh 142) and surrounding nebulosity in Cygnus. James used a Takahashi FSQ 106ED at ƒ/3.6 and a Starlight Express SXVR-H36 camera for this 3-hour exposure (6×30 min).

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

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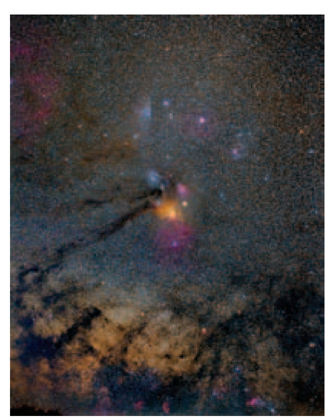
Front Cover — A Colour Canvas in Scorpius. Lynn Hilborn took advantage of a holiday in Aruba to obtain this photograph of one of the most colourful regions of the sky. Centred on Antares, the image covers central Scorpius and includes two globular clusters (M4 and NGC 6144), both reflection and emission nebulae, acollection of several dark nebulae, all part of the Rho Ophiuchi cloud complex. Lynn used a modified Canon 6D with a 50-mm f/1.4 lens at f/2.8. Exposure was 6×1 minute using an iOptron ZEQ25 mount.



Journal

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

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President's Corner

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

Looking at the list of past presidents (thanks to Peter Jedicke for the list!), I see a host of highly capable, dedicated, and energetic men and women—people who guided the RASC through some good times and some challenging times. I'm pleased and honoured to share in that hallowed tradition of wielding the gavel, to be chosen as the 62nd President of our venerable Society, and I will do my utmost to fulfil the presidential role, right alongside our hardworking team on the Board of Directors.

That said, we have some interesting times over the horizon, with the International Year of Light coming up fast in 2015, the prospect of joint outreach efforts with the Canadian Astronomical Society (CASCA), preparing for the 2017 total solar eclipse, and some exciting ideas and opportunities for new publications.

On a different note, we realized, in retrospect, that some of the wording of our By-Law #1 and Policy Manual created last year needed polishing up. We have done some of that housekeeping at the Board meeting in June for the Policy Manual, and and the By-Law changes will have to wait another year for the next Annual General Meeting. Since we no longer use proxies, part of the Policy Manual cleanup was to word the election process to reflect electronic voting. A show of hands at a meeting is a lot less appealing than having the entire membership capable of voting via a software package online.

Separating the Board and Council meetings was probably not the best idea, and we have made great strides in getting the two groups back together for joint face-to-face meetings at the General Assembly and teleconferences in spring and fall. We'll probably find some other wrinkles that need smoothing as we go forward, so stay posted.

This isn't all hard work and no play, though. I urge you to get out under the night sky and share the sights with your friends, family, and townsfolk. Talk to the tourism office in your area and fit your astronomy into their schedule. See if a national or provincial park has room for you in their summer programs to show the Sun or nighttime sky to campers. In the fall, contact a local school (or two) and offer to show a classroom of kids some views of the Sun through a solar telescope. That's our mandate, after all: to share our knowledge and to educate through outreach.

Until next time—clear skies and have fun! ✶

News Notes / En manchettes

Compiled by Andrew I. Oakes

Space telescope reveals Milky Way's magnetic fingerprint

Data from the *Planck Space Telescope* have permitted astrophysicists to tease out an exceptional map that charts the Milky Way Galaxy's magnetic field.

According to a recent Web site posting by the Canadian Institute for Theoretical Astrophysics (CITA) at the University of Toronto, the map reveals magnetic field lines running parallel to the plane of the galaxy, as well as great loops and whorls associated with nearby clouds of gas and dust.

The analytical work on the data was done by an international team of astrophysicists including researchers from CITA and the University of British Columbia (UBC). The Canadian partners are part of larger grouping of participants known as the Planck Collaboration.

The *Planck* telescope has been charting the Cosmic Microwave Background (CMB)—the light from the Universe some 380,000 years after the Big Bang—since 2009, while also observing light emitted from much closer than the edge of the visible Universe. An onboard apparatus called the High Frequency Instrument (HFI) allows *Planck* to detect the light from microscopic dust particles within our galaxy.

Astrophysicists have calculated that the density of dust is extremely low, equivalent to just one grain in a volume of space equal to a large sports stadium or arena. CITA notes that *Planck*'s HFI identifies the non-random direction in which the light waves vibrate, known as polarization. It is this polarized light that indicates the orientation of the field lines.

"Just as the Earth has a magnetic field, our galaxy has a large-scale magnetic field—albeit 100,000 times weaker than the magnetic field at the Earth's surface," said team member Professor Douglas Scott of UBC. "And, just as the Earth's magnetic field generates phenomena such as the aurorae, our galaxy's magnetic field is important for many phenomena within it."

The magnetic field governs the coupling of the motions of gas and dust between stars, and so plays a role in star formation and the dynamics of cosmic rays. The "fingerprint" and other results are described in four papers released in May 2014 for publication in the journal *Astronomy & Astrophysics*. The four are available online at www.sciops.esa.int/index.php?project=PLANCK&page=Planck_Published_Papers.

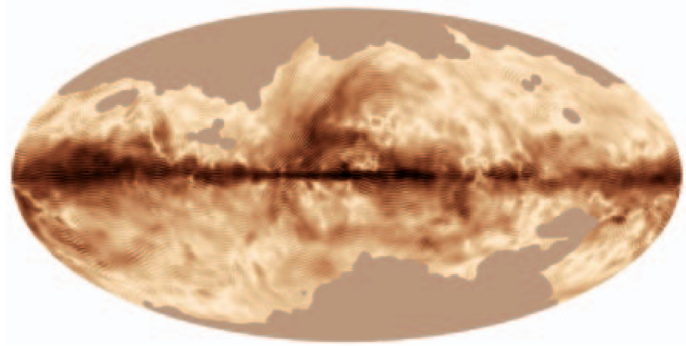

Figure 1 — The magnetic field of our Milky Way Galaxy as seen by ESA's Planck *satellite. This image was compiled from the first all-sky observations of polarized light emitted by interstellar dust in the Milky Way. Image: ESA.*

Professor Peter Martin of CITA uses *Planck* data to study the dust found throughout our galaxy. "Dust is often overlooked, but it contains the stuff from which terrestrial planets and life form. So by probing the dust, *Planck* helps us understand the complex history of the galaxy as well as the life within it," said Martin.

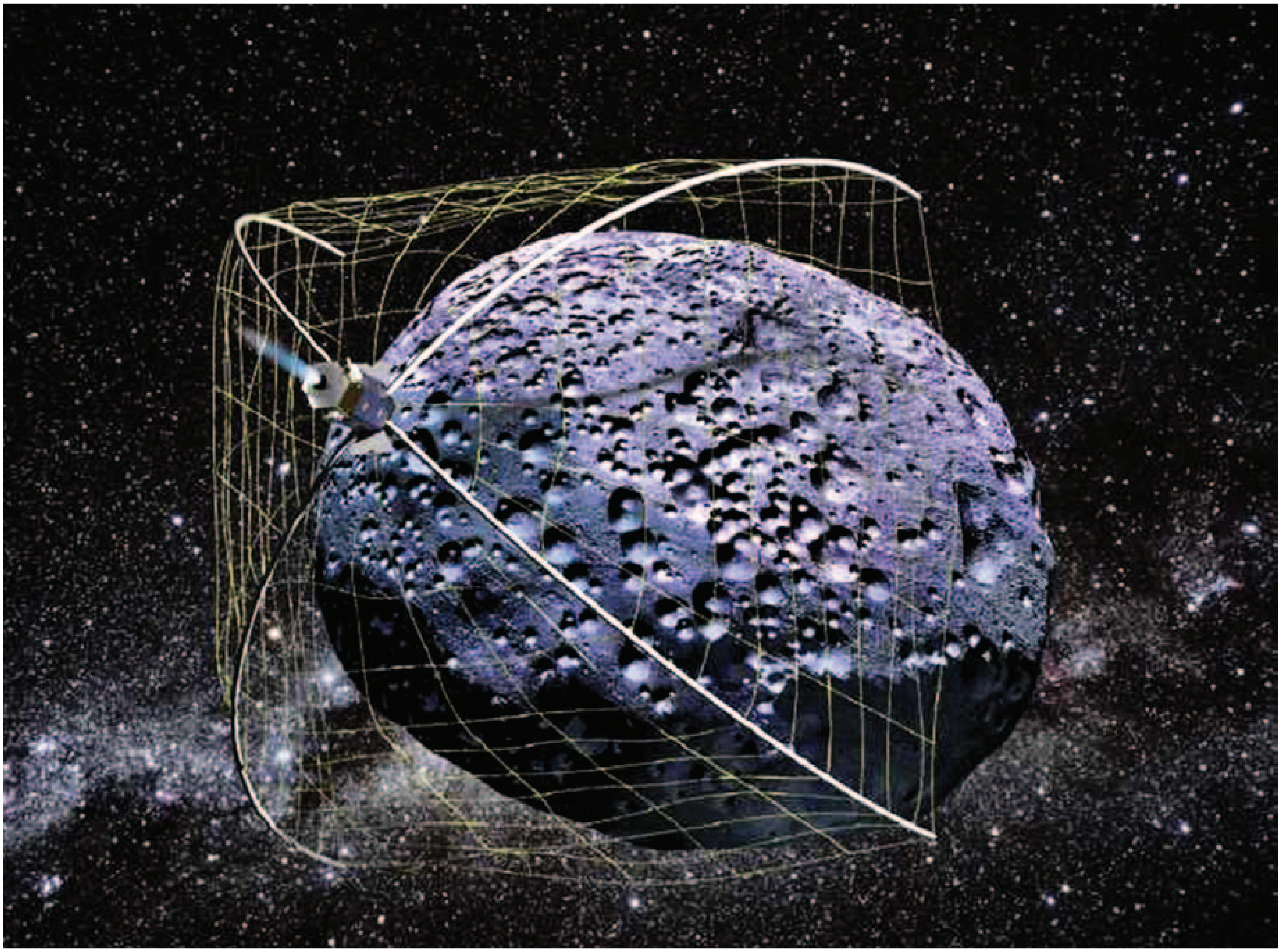

Figure 2 — An artist's concept of the Weightless Rendezvous And Net Grapple to Limit Excess Rotation (WRANGLER) *system. Image: Tethers Unlimited*

Also, for cosmologists studying the origin and evolution of the Universe, data to be released later this year by scientists from the *Planck* Collaboration should allow astronomers to separate with great confidence any possible foreground signal within our galaxy from the tenuous, primordial, polarized signal from the CMB. The *Planck* data enable a much more detailed investigation of the early history of the cosmos, from the accelerated expansion when the Universe was much less than one second old to the period when the first stars were born, several hundred million years later.

And according to Professor J. Richard Bond of CITA, "These results help us lift the veil of emissions from these tiny but pervasive galactic dust grains that obscure a *Planck* goal of peering into the earliest moments of the Big Bang to find evidence for gravitational waves created in that epoch."

Planck includes contributions from the Canadian Space Agency (CSA). The CSA funds two Canadian research teams that are part of the *Planck* science collaboration and who helped develop both of *Planck*'s complementary science instruments, the High Frequency Instrument (HFI) and the Low Frequency Instrument (LFI). Bond of the University of Toronto, Director of Cosmology and Gravity at the Canadian Institute for Advanced Research, and Scott of the University of British Columbia lead the Canadian *Planck* team, which includes members from the University of Alberta, Université Laval, and McGill University.

Breakthrough technologies sought for space explorations

NASA continues to make annual "seedling investments" with the aim of nurturing breakthrough technologies in support of its plans to explore beyond low-Earth orbit, into deep space and to neighbouring Mars.

In step with its Evolvable Mars Campaign, the American space agency in June 2014 selected 12 proposals—including 3 from the Jet Propulsion Laboratory, Pasadena, California—for study under Phase I of the NASA Innovative Advanced Concepts (NIAC) Program. The objective of the NASA program is to develop pioneering technology.

Proposals funded cover a wide range of concepts, including:

- A submarine to explore the methane lakes of Titan;
- Using neutrinos to perform measurements for the icy moons of the outer planets; and
- A concept to safely capture a tumbling asteroid, space debris, and other applications.

According to NASA's Space Technology Mission Directorate (STMD), it selected this year's Phase I proposals based on their potential to transform future aerospace missions. It is hoped that the proposals will be able to enable either entirely new missions or breakthroughs in future aerospace capabilities that could accelerate progress toward NASA's goals.

Each NIAC Phase I award is worth approximately $100,000. The funding supports a nine-month initial definition and analysis study of each concept. Any feasibility studies deemed successful will lead to the next stage—an application for a Phase II award of up to $500,000 for two more years of concept development.

The awards represent multiple technology areas such as space propulsion, human habitation, science instruments, materials for use in space, and exploration of other diverse technology paths needed to meet NASA's strategic goals.

The 12 chosen Phase I projects were selected through a peer-review process that evaluated each project's potential, technical approach, and benefits for study in a timely manner. Although early in the development cycle, all concepts represent visionary, long-term ideas for technological maturation and are understood to be years away from potential implementation. The 12 awarded concepts support 3 of 8 key STMD technology areas: advanced life support and resource utilization; space robotic systems; and space observatory systems. Additionally, the concepts also support broader investments efforts in NASA's Asteroid Initiative and outer-planetary missions.

The full complement of 2014 Phase I awarded concepts are as follows:

- Swarm Flyby Gravimetry;
- Mars Ecopoiesis Test Bed;
- The Aragoscope: Ultra-High-Resolution Optics at Low Cost;
- 3-D Photocatalytic Air Processor for Dramatic Reduction of Life Support Mass & Complexity;
- WRANGLER: Capture and De-Spin of Asteroids and Space Debris;
- Titan Aerial Daughtercraft;
- Using the Hottest Particles in the Universe to Probe Icy Solar System Worlds;
- PERISCOPE: PERIapsis Subsurface Cave OPtical Explorer;
- Titan Submarine: Exploring the Depths of Kraken;
- Comet Hitchhiker: Harvesting Kinetic Energy from Small Bodies to Enable Fast and Low-Cost Deep Space Exploration;
- Exploration Architecture with Quantum Inertial Gravimetry and In Situ ChipSat Sensors; and
- Heliopause Electrostatic Rapid Transit System (HERTS).

Details of each concept are available at www.nasa.gov/content/niac-2014-phase-i-selections/#.U5INMvldWSo .

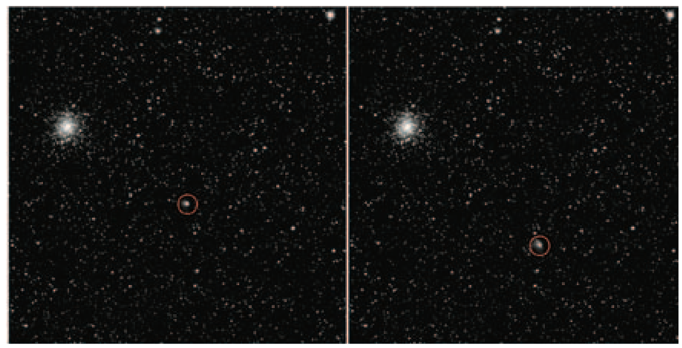

Figure 3 — These images, taken by the Optical, Spectroscopic, and Infrared Remote Imaging System (OSIRIS) camera aboard Rosetta*, show comet 67P/Churyumov-Gerasimenko in early May 2014 as the spacecraft closed the distance to 2 million kilometres. The comet is developing a dust coma, reaching approximately 1300 kilometres into space. Image: NASA/ESA.*

Rosetta begins to go to work

Three NASA science instruments aboard the European Space Agency's (ESA) *Rosetta* spacecraft, which is set to become the first to orbit a comet and land a probe on its nucleus, are beginning observations and sending data back to Earth. *Rosetta* currently is approaching the main asteroid belt located between Jupiter and Mars. The spacecraft is still about 500,000 kilometres from the comet, but in August the instruments will begin to map its surface.

"We are happy to be seeing some real zeroes and ones coming down from our instruments, and cannot wait to figure out what they are telling us," said Claudia Alexander, *Rosetta*'s U.S. project scientist at NASA's Jet Propulsion Laboratory (JPL) in Pasadena, California. "Never before has a spacecraft pulled up and parked next to a comet. That is what *Rosetta* will do, and we are delighted to play a part in such a historic mission of exploration."

The three U.S. instruments aboard the spacecraft are the Microwave Instrument for *Rosetta* Orbiter (MIRO), an ultraviolet spectrometer called Alice, and the Ion and Electron

Sensor (IES). They are part of a suite of 11 science instruments aboard the *Rosetta* orbiter.

MIRO is designed to provide data on how gas and dust leave the surface of the nucleus to form the coma and tail that give comets their intrinsic beauty. Studying the surface temperature and evolution of the coma and tail provides information on how the comet evolves as it approaches and leaves the vicinity of the Sun.

Alice will analyze gases in the comet's coma. Alice also will measure the rate at which the comet produces water, carbon monoxide, and carbon dioxide. These measurements will provide valuable information about the surface composition of the nucleus. The instrument also will measure the amount of argon present, an important clue about the temperature of the Solar System at the time the comet's nucleus originally formed more than 4.6 billion years ago. IES is part of a suite of five instruments to analyze the plasma environment of the comet, particularly the coma. The instrument will measure the charged particles in the Sun's outer atmosphere, or solar wind, as they interact with the gas flowing out from the comet while *Rosetta* is drawing nearer to the comet's nucleus.

Infrastructure funding enables lab to build high-tech instrumentation

An experimental cosmologist and long-wavelength instrumentalist employed at the Dunlap Institute for Astronomy & Astrophysics has received funding for the Dunlap Institute's Long-Wavelength Instrumentation Laboratory.

Keith Vanderlinde, an Assistant Professor at the Dunlap Institute and Department of Astronomy & Astrophysics at the University of Toronto, received the funding from the Canada Foundation for Innovation's John R. Evans Leaders Fund. The instrumentation lab at the Dunlap Institute will enable both the testing and development of microwave detectors destined for the South Pole Telescope and radio technologies critical to a new generation of digital telescopes.

"By studying large-scale structure within the Universe, we can track both the evolution of that structure and the accelerating expansion of space," said Vanderlinde earlier this year. "That acceleration, driven by a previously unknown "dark energy," is one of the most significant discoveries of modern cosmology."

Vanderlinde noted that infrastructure funding will help develop long-wavelength instrumentation technologies, making future observations ever-more precise. The overall aim is to help build cosmologists' understanding of the mysterious dark energy that appears to dominate the Universe.

The funding is being applied specifically to two primary systems of infrastructure necessary to enable Vanderlinde's research at the Dunlap:

- A cryogenic environment for cooling microwave detectors to -273 °C, as well as equipment for testing the detectors; and
- A radio-correlator and radio-generation and analysis test bed—equipment that will allow the development and testing of technologies required by a coming generation of "digital" telescopes.

Located in the basement of the Astronomy & Astrophysics building at the University of Toronto, the Long Wavelength Lab works with and develops long-wavelength instrumentation, ranging from millimetre microwave bands down to metre-wave radio. Its current activity targets three observatories:

- The Canadian Hydrogen Intensity Mapping Experiment (CHIME)—a project to probe dark energy via maps of the 21-cm signature of neutral hydrogen across half of the sky over a large portion of the observable Universe;
- The South Pole Telescope (SPT)—a 10-m microwave telescope surveying the sky at microwave frequencies to study the Cosmic Microwave Background, the remnant light of the Big Bang; and

- The Algonquin Radio Observatory (ARO), where the Lab has been working to re-commission a 46-m dish with new receivers and signal-processing backends. The work has included the design and building of two new broadband, low-frequency receiver systems for the ARO, installation of new digital backends to process and record the signals, and developing the new technique of pulsar scintillometry.

Laser communication era developing with ISS demonstration

The *International Space Station* (ISS) successfully executed a NASA experiment, beaming a high-definition video to Earth in early June 2014 via a new laser communications instrument. The test video message represented the first 175-megabit communication for the Optical Payload for Lasercomm Science (OPALS). The new instrument allows NASA to test methods for communication with future spacecraft using higher bandwidth than radio waves.

OPALS uses focused laser energy to reach data rates of between 10 and 1000 times higher than current space communications, which rely on radio portions of the electromagnetic spectrum.

Aboard a satellite orbiting the Earth at 28,200 km/h some 390 kilometres above the planet, data transmission for this laser experiment from the ISS required extremely precise targeting—comparable to a person aiming a laser pointer at the end of a human hair 10 m away and keeping it there while walking.

To achieve the needed precision during the demonstration, OPALS locked onto a laser beacon emitted by the Optical Communications Telescope Laboratory ground station at the Table Mountain Observatory in Wrightwood, California, and began to modulate the beam from its 2.5-watt, 1550-nanometre laser to transmit the video. Lasting 148 seconds, the transmission reached a maximum data transmission rate of 50 megabits per second, requiring OPALS 3.5 seconds to transmit each copy of the 30-second "Hello World!" video message. It would have taken more than 10 minutes using traditional downlink methods.

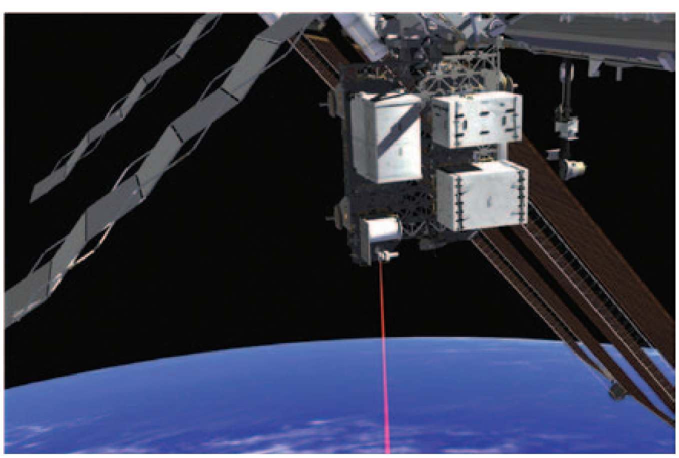

Figure 4 — An artist's concept illustrating how the Optical Payload for Lasercomm Science (OPALS) laser beams data to Earth from the International Space Station. *Image: NASA.*

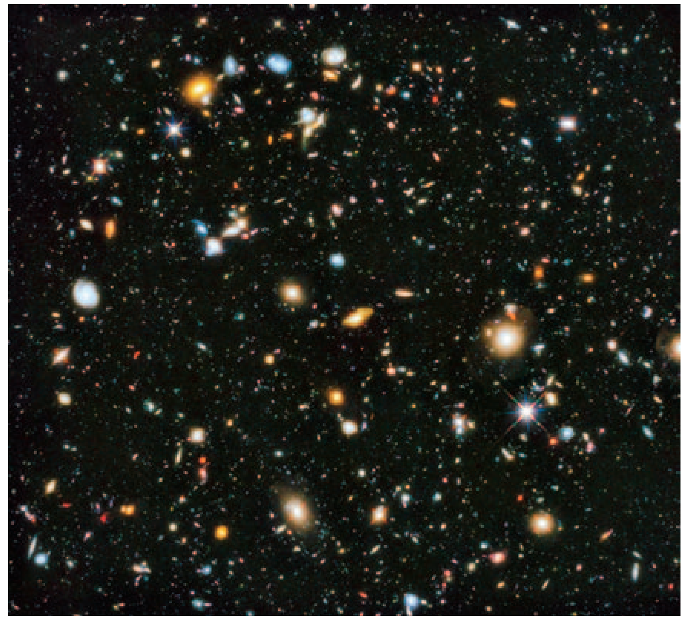

Figure 5 — The new Hubble *Ultra-Deep Field 2014, an update to the HST's previous deep-field image. The new image shows galaxies that are 10 billion times fainter than the naked-eye limit. Image: NASA, ESA, H. Teplitz and M. Rafelski (IPAC/Caltech), A. Koekemoer (STScI), R. Windhorst (Arizona State University), and Z. Levay (STScI)*

Hubble's latest ultra-deep image

The 24-year-old *Hubble Space Telescope* has added ultraviolet wavelengths to its "Ultra Deep Field" image of a small section of space in the constellation Fornax. When combined with previous images in visible and near-infrared frequencies, the new image has a full suite of "RGB" wavelengths to work with, and the new reconstructed image brings the deep Universe alive in glowing colours. The image is a composite of exposures taken between 2003 and 2012 covering 841 orbits of the spacecraft.

The new image contains around 10,000 galaxies, extending back to within a few hundred million years of the Big Bang. Ultraviolet light comes from the hottest, largest, and youngest stars and so astronomers get a look at the galaxies that are forming stars and where the stars are forming within them. UV data provides a look at intermediate-distance galaxies extending from 5 to 10 billion light-years. Starburst rates were already known for more distant galaxies, where UV fluxes are red shifted into visible and infrared wavelengths. Studying the ultraviolet images of galaxies in the intermediate time period enables astronomers to understand how galaxies grew in size. ✶

Andrew I. Oakes is a RASC member who lives in Courtice, Ontario.

In Search of Trends in Noctilucent Cloud Incidence from the La Ronge Flight Service Station (55N 105W)

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Abstract

The observations of noctilucent clouds (NLC) from the La Ronge, Saskatchewan, Flight Service Station (55.1° N 105.3° W) during the years 1990-2013 are presented. A cloud-correction system was developed using observer results dating back to 1988 from the NLC CAN AM surveillance network, and the statistical treatment was applied to the La Ronge data. No significant decadal trend in seasonal NLC-active nights was noticed. A significant lull in NLC occurred in 1992, and favourable weather that year suggests that the result was accurate. An anticipated, subsequent, low point in activity after sunspot maximum in 2002-2003 was manifested as a one-year drop in 2004. Overall, results suggest that even a small amount of foreground tropospheric cloud can have a detrimental effect on NLC visibility.

Figure 1 — Noctilucent cloud display seen on 2011 July 1-2 from Namao, Alberta. Photo by Mark Zalcik.

Introduction

Noctilucent clouds (NLC) are beautiful ice clouds that form in Earth's upper mesosphere. At heights of 80-85 km, they are the highest clouds on the planet and are seen as cirrus-like formations in the twilight sky (Figure 1) during the late spring and summer, typically mid-May to mid-August, with peak incidence at the end of June and early July (Gadsden and Schröder 1989). The most prominent displays of NLC can be truly memorable, covering the entire sky and reaching a brightness that enables one to read easily by the light they scatter. NLC are the equatorward extensions of a broader mass of mesospheric cloud, aptly called polar mesospheric clouds (PMC), that are now being monitored by satellites such as the *Aeronomy of Ice in the Mesosphere* (AIM) satellite launched in 2007. PMC/NLC are thought to consist of accreted meteorite dust and/or large ions coated with water ice; the water originates partly as ground-based methane that diffuses to Earth's stratosphere. In the stratosphere, the methane photodissociates due to the solar UV flux, oxidizing above 30 km to produce significant amounts of water vapour. This water in turn rises through the vertical breadth of the stratosphere and the mesosphere above (Thomas *et al.* 1989). Methane is an important greenhouse gas, and as levels of terrestrial methane have been increasing, it is possible that NLC frequency over time could reflect that change (Thomas and Olivero 2001). As such, NLC activity can be an indicator of climate change.

NLC reporting frequency has varied over the last 125 years (Gadsden and Schröder 1989; Dalin *et al.* 2012), since they were first observed in 1885. For example, reported sightings declined markedly during the world wars. Since the mid 1960s, sightings have been rising, to the point that now, according to compiled sightings on the NLCNET homepage (editor, Tom McEwan, www.nlcnet.co.uk), there are regularly over 50 active nights per season across the Northern Hemisphere, with some individual sites reporting more than 20 active nights. Part of this rise is probably due simply to more observers watching out for the clouds (Bone 2004). It has been a challenge over the last couple of decades to account for various effects such as observer interest in order to derive an accurate picture of NLC climatology. Some scientists argued that an increase in NLC frequency is occurring (Gadsden, 1990); other researchers have pointed to little or no increase (*e.g.* Romejko *et al.* 2003; Dalin *et al.* 2006; Dubietis *et al.* 2010).

Whatever the case, the length of the NLC season is set rather rigidly by the temperature profile of the upper mesosphere where the clouds reside. NLC incidence experiences an abrupt climb at the beginning of June and a corresponding abrupt drop-off at mid-August, both during the greatest rates of change in ambient temperature (Theon *et al.* 1967; Dalin *et al.* 2011). The result is a roughly 75-night period in each hemisphere during which NLC can form: June 1 – August 15 in the Northern Hemisphere and December 1 – February 15 in the Southern Hemisphere. If the annual number of active NLC nights were to significantly exceed this number, it would probably be due to a radical change occurring in the mesospheric climate.

Tropospheric weather is a critical factor in determining how many nights an observer typically sees NLC each season. The oft-quoted NLC high-incidence zone of 55-60N (Gadsden 1998) passes through both favourable and highly unfavourable climatologies. Observing sites along the same parallel can have widely varying average seasonal sightings due to the variability in cloud cover. In North America, the cold-water coasts of the Pacific and Atlantic Oceans, and Hudson Bay result in many cloudy summer nights; on the other hand, the most northerly reaches of the Canadian Prairies impinge upon the NLC zone, and thus the drier Prairie climate boosts the average sighting total in this zone to nearly 10 nights per season (Zalcik 1998). And yet, when compared with lower-latitude steppe or desert areas that have strings of clear nights, the Prairies are not so favoured, and the lower clear-sky incidence adds an element of doubt to evaluations of NLC frequency. In one NLC season, an observer may have a bumper crop of NLC displays—but was it due to it being a good year for NLC, or simply to good weather? The following season, the NLC total may plummet; to what degree can the change be blamed on tropospheric clouds, and how can one tell for sure?

As early as the 1960s, NLC climatological studies incorporated efforts to take tropospheric cloudiness into consideration. Bronshten and Grishin (1976) instituted a "detection probability system" that involved attaching correction factors to various levels of tropospheric cloudiness, and then deriving, for any specific interval of nights, a more accurate "cloud-free" evaluation of NLC activity for that period. The global convention for classifying tropospheric cloudiness has been to use four data bins. The area of the sky being judged is the so-called "twilight arch"—the blue zone of the sky in which NLC can be seen. The four choices are: A) twilight sky completely clear; B) twilight sky with scattered clouds; C) twilight sky cloudy with only a few clear areas; D) twilight sky completely overcast.

Another study that took varying weather conditions into consideration was that of Dalin *et al.* (2006). After studying trends of NLC occurrence over several years, they concluded that a slight positive trend in NLC frequency occurred in 1983-2005 in observations from Moscow and Denmark; however, the changes lacked statistical significance.

The North American surveillance network (NLC CAN AM) began collecting observations in 1988. Cognizant of the problems associated with observing NLCs within an unfavourable climate, we made it a key undertaking to maintain a record of coincident tropospheric cloud conditions. To this end, a section of the standard report forms for both weather stations and amateur observers was dedicated to judging cloud interference. The approach was somewhat different than the global system, and was instead based on the Canadian convention of estimating tropospheric cloud in tenths of the total sky covered. Since NLCs occur mostly in the northern half of the sky, for each sky check a system of estimating the amount of northern sky covered by tropospheric cloud, in fifths, was adopted. For weather and flight service-station forms, the observer is asked to check off one of the following cloud-amounts: 0, Tr, 1, 2, 3, 4, 5. For example, with an overcast sky (5/5), the column "5" is checked off. The "Tr" category is used for situations in which there are a few tropospheric clouds in the sky, but fewer than what would be judged as 1/5 opacity.

Advantages of this system, which we will now refer to as a "cloud-correction system," over the previous system are:

- more precision, with seven choices instead of four.
- a better-defined part of the sky for making an evaluation
- the use of trace (Tr) to allow additional precision between the 0/5 and 1/5 bins.

The disadvantages of this approach are:

- there are large parts of the half-hemisphere area, especially the areas overhead and due west and east, where NLC are seldom seen;
- a 5/5 designation leaves open the possibility that an observer may write down this value even though there may be holes in the tropospheric cloud where NLC may appear. It would have been preferable to add an eighth bin labelled simply "overcast," a condition under which there would be no chance of seeing NLC;
- The trace cloud choice is rather subjective, and may be interpreted as a single, tiny tropospheric cloud in the

twilight sky, or conversely a group of clouds close to a 1/5 designation; and

- With a low solar-depression angle (SDA, the number of degrees below the horizon the Sun sits), only a very small area, low in the north direction, is actually occupied by twilight and hence, NLC.

To derive a cloud-correction system from NLC CAN AM data, it became necessary to evaluate the chances of seeing NLC from a particular site given each of the seven possible tropospheric cloud conditions. During the initial development of the system, an attempt was made to also factor in the coincident SDA at the time of observation. The SDA essentially dictates how much of the sky within which NLC may be seen, the usual range being 6–16 degrees. At 6 degrees, over half of the sky may be occupied by NLC, but, being so close to dusk or dawn, the NLC are usually faint and difficult to distinguish from cirrus clouds. At 16 degrees, there is only a very small twilight dome hugging the horizon; NLC in this diminutive zone will be very low in the sky. The ideal SDA value, taking into consideration potential areas of visible NLC and favourable contrast with the background twilight sky, is around 8–10 degrees. For our weather-correction system, that 10-degree SDA range was divided into three zones: 1) 6–8 degrees; 2) 8–13 degrees; 3) 13–16 degrees. Hence, with seven tropospheric cloud bins and three SDA bins, each NLC sky check could be placed into one of 21 possible data bins.

Figure 2 — Two nearly coincident views of NLC on the night of 2012 July 19–20. Top: Photo by the AUGO-2 automated camera mentioned in the text, Athabasca, Alberta; Bottom: Photo by Mike Noble, Villeneuve, Alberta. Athabasca is 100 km from Villeneuve at an azimuth of 010 degrees. Note the similar appearance of the displays, and the interplay of an aurora in Noble's photo.

To evaluate the chances of a site seeing an NLC display with a given amount of foreground tropospheric cloud, tandems of two sites were chosen over the period 1988-2012, each tandem consisting of an "ob" site, where NLC were unequivocally seen at a specific time (usually on the hour, as the NLC check corresponded with the regular on-the-hour weather observation), and a "test" site, where a coincident regular observation was being made, to the NW, N, or NE of the ob site. Distances between the ob and test sites ranged from 5 km to 650 km, but were typically 200-250 km. The ideal two-site tandem will have the observing locations aligned along the same parallel, with the distant NLC cloud field and the below-horizon Sun approximately to the north. An example of how a display of NLC appears at two separate sites is shown in Figure 2. A datum in the analysis (Table 1) consisted of either a + or – sighting at the test site, the accompanying tropospheric cloud value as entered on the test site's report form, and the corresponding SDA zone value.

One can draw an interesting conclusion from Table 1: NLC were observed at both sites only during 5 of the 10 nights, even though 4 nights had semi-clear weather. Hence the probability of seeing NLC at both sites, separated by only 200 km, was only 50 percent for the 2009 season. The corollary is that NLC may consist of small patches about 100 km long.

Date	Time	La Ronge cloud amount ×/5	SDA	Test site observation result
May 28/29	0600	1	2	–
June 11/12	0600	1	2	+
	0700	2	2	+
	0800	1	2	+
	0900	Tr	1	+
June 21/22	0900	5	1	–
June 24/25	0800	1	2	–
	0900	1	1	–
June 26/27	0800	2	2	+
July 11/12	0600	Tr	2	+
	0700	Tr	2	+
	0800	1	2	+
	0900	1	2	+
July 15/16	0500	0	2	+
July 17/18	0600	1	2	+
July 20/21	0500	3	2	–
	0600	1	3	–
July 23/24	0500	5	2	–

Table 1 — Results in 2009, using Prince Albert Flight Service Station as the observation site and La Ronge as the test site. The dates and times indicated are those of the Prince Albert sightings. La Ronge lies 200 km from Prince Albert at a bearing of 010 degrees. This tandem was the most-used one in the analysis.

Between 1988 and 2012, a total of 657 data points represent 39 different participating observers were compiled and then placed into the 21 bins. A large number of the data points were provided by amateur observers, many of whom were members of The Royal Astronomical Society of Canada at locations such as Edmonton and Saskatoon. After compilation, it was determined that the (1) and (3) SDA zones did not contain nearly as many points compared with the (2) zone, so it was decided not to use the SDA zones in the analysis and instead refer to the original seven-bin analysis.

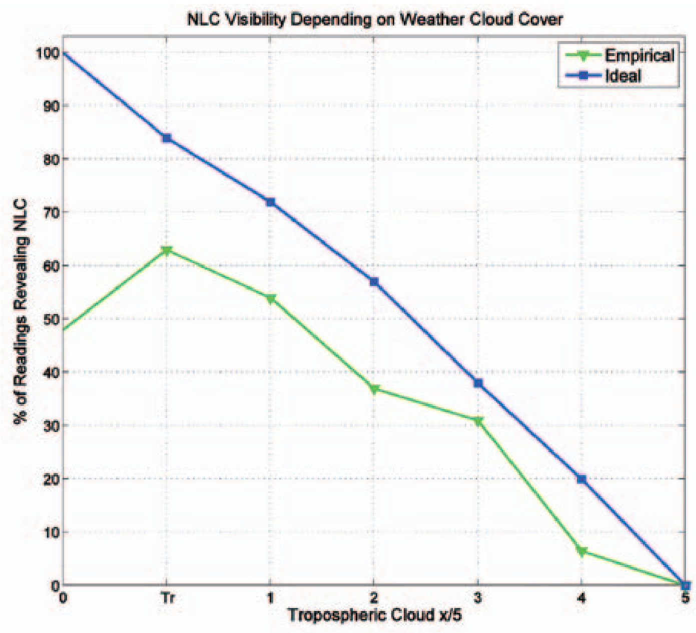

Figure 3 — Empirical (green) and ideal (blue) curves showing probability of seeing NLC under clear (0/5) through overcast (5/5) conditions from the 657 test cases presented in the text.

The results of the study appear in Figure 3. The derived curve is compared with the linear "ideal" curve, which starts at a 100 percent detection rate at 0/5 tropospheric cloud and ends at 0 percent for 5/5. This would represent the case where NLCs were always present at both sites. In contrast, though it was predicted that a high percentage of the data points would yield a positive NLC observation for the 0/5 tropospheric value (*i.e.* both stations saw NLCs), in the end, there were significantly more *negative* observations than positive ones. Only within the Tr/5 bin did positive observations outnumber negative ones. Within the 1/5 bin, positive and negative observations were nearly equal. Thereafter and unsurprisingly, with each increase in tropospheric cloud amount, the number of positive observations decreased. By way of example, Figure 4 illustrates a situation when a small amount of tropospheric cloud nearly blocks a patch of NLC.

Why was the percentage of positive observations at 0/5 so low? One reason could be an incorrect assumption that a test

Figure 4 — Photo of the NLC display of 2012 July 18–19 as seen from Villeneuve, Alberta. The tropospheric cloud value is only 1/5, but the weather clouds nearly block out the NLC. Photo by Mike Noble.

site 250 km or even 100 km distant from an ob site could see the same NLC field. As noted above, some NLC fields may have small areal extent, thus making coincident observations nearly impossible from two sites separated by these distances. Or, perhaps the NLC at the ob sight were faint, with minimal optical thickness, making them fainter or invisible at the test site. Yet another cause could be that a few test sites had consistently low numbers of NLC sightings because of other factors, which pushed down their positive observation percentages in this analysis. Those factors that may have reduced their sightings could have been ambient lighting, objects blocking the horizon, or observer interest. Clearly there are confounding factors that have prevented the paired-observations curve from reaching the ideal 1.0 value for clear tropospheric skies.

With this situation in mind, we combined the 0/5 and Tr/5 categories, assigning this new category with a factor of 1. To address the conflict associated with the low correction factor of 0.63 for the former Tr category, we next used this value as a baseline to derive new correction factors for the rest of the cloud conditions. For example, to determine the revised correction factor for the 1/5 bin, we took that value, 0.54, and, with 0.63 being the denominator, calculated a revised correction factor of 0.86. Finally, we deleted the 5/5 category as there were no sightings of NLC in the test cases. The corresponding correction factors are thus:

0/5 and Tr/5: 1

1/5: 0.86

2/5: 0.58

3/5: 0.49

4/5: 0.11

The final weather correction curve is shown in Figure 5.

The decimal values for the various bins are now the correction factors for our cloud-correction equation:

$$T = P \times \left(\frac{N}{a(1)+b(0.86)+c(0.58)+d(0.49)+e(0.11)} \right)$$

where:

T is the corrected number of positive nights in a given time interval (for this paper, the total positive nights during an entire season

P is the uncorrected number of positive observations for that time interval

N is the total number of observations (for this paper, the total number of hourly, on-the-hour observations)

a is the number of observations with 0/5 or Tr/5 tropospheric conditions

b – with 1/5

c – with 2/5

d – with 3/5

e – with 4/5.

The four principal cases that a cloud correction system could address are:

Case 1 – High NLC years aided by good weather

Case 2 – Low NLC years due to bad weather

Case 3 – High NLC years despite bad weather

Case 4 – Low NLC years despite good weather.

The overall term by which P is multiplied should give a clearer indication of what the degree of tropospheric interference was for the study period. In general, one would expect good-weather years (Cases 1 and 4) to yield a smaller correction factor than bad-weather years (Cases 2 and 3).

With a tropospheric cloud-correction equation now established, the next step was to employ it at a location well-situated for NLC monitoring, where observations had been undertaken on a regular basis over a long period of time. The first choice was the La Ronge, Sask., Flight Service Station (55.1°N, 105.3°W, Figure 6). Situated in the prime NLC observing zone, La Ronge is one of the few current NLC CAN AM locations that started with the network in 1988. The site has provided excellent hourly synoptic data since 1990 on a voluntary basis. The NLC CAN AM observing season runs from the night of May 21/22 to the night of Aug 10/11. Sky checks are made on an hourly, on-the-hour frequency in conjunction with the regular weather observation. Data, including the estimation of tropospheric

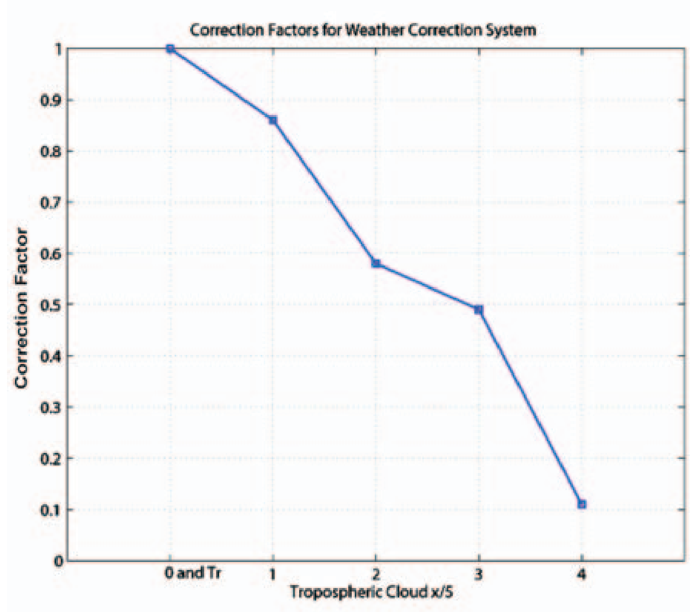

Figure 5 — Correction curve used in the La Ronge analysis.

Figure 6 — The La Ronge, Saskatchewan, Flight Service Station, where NLC have been monitored for 25 years. Image: Mark Zalcik.

cloud, are entered onto a form. At La Ronge, sky checks begin at 2300 MDT (0500 UT) and continue until 0300 MDT (0900 UT). For the month of August, the schedule is extended slightly, from 2200 MDT (0400 UT) to 0400 MDT (1000 UT). Perpetual summer twilight permits all-night observing at La Ronge until approximately the night of July 27/28. For each season, there are about 400 possible sky checks in total.

Data

Figure 7 shows the seasonal total of NLC sightings at La Ronge from 1990 to 2012 (lower blue curve). The middle orange curve shows the adjusted values, and the upper black curve shows total sightings from all NLC CAN AM observers. For La Ronge, the average number of sightings for the 23 seasons is 9.7 per season with a standard deviation of 2.9; the average corrected value is 14.2. The seasonal totals of sightings from 1990 to 1995 were systematically lower than the average value of 9.7 NLC-active nights per season for the whole period of 1990-2013. Thereafter, the totals have been generally

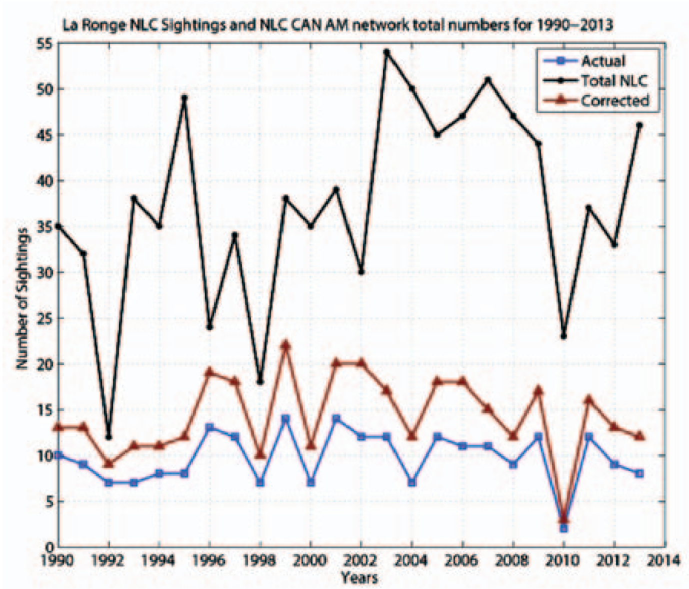

Figure 7 — Raw (blue) and corrected (red) NLC sighting numbers from the La Ronge Flight Service Station from 1990–2013. The black curve shows total sightings by all NLC CAN AM participants each season.

slightly higher with occasional returns to the pre-1996 totals. The only exception was the 2010 season, which had only two sightings; this season will be discussed below. Regarding the NLC CAN AM network totals, note that the years 2003–2009 had consistently strong NLC activity aided by late-season sightings at two high-latitude sites, Baker Lake (64.3°N 96.1°W) and Rankin Inlet (62.8°N 92.1°W).

Discussion

The corrected NLC sighting totals at La Ronge are consistently nearly 1.5 times greater than raw values. Where the corrected value is less than 1.5 times greater than the observed value, there is an indication that the weather was favourable during that season; conversely, when the factor was greater than 1.5, the suggestion is that weather was unfavourable.

The most noteworthy of the former situation, and hence a Case 4 as outlined above, was the 1992 season, when there were 7 active-NLC nights, with the corrected total being 9 (correction factor: 1.23). A look at the 312 non-overcast sky checks from that season shows that over 40 percent of them, 131, were under clear (*i.e.* 0/5) skies. Hence, the rather low sighting total of 7 could be said to be fairly accurate. The 1992 season was remarkable as, network-wide, there were only 12 active nights, by far the quietest season NLC CAN AM has experienced. Gadsden (1997) reported that sightings totals from northwest Europe were also low in 1992, and suggested the 1991 eruption of Mt. Pinatubo in Philippines to be the cause. There is speculation that the mesosphere was indeed warmer in 1992 due to Pinatubo (Thulasiraman and Nee 2002).

With regard to bad-weather seasons, specifically a Case 3 season (good NLC year despite bad weather), one of the most notable seems to have been the 2006 season, when there were 11 active nights at La Ronge, with a corrected value of 17 (correction factor: 1.59). Indeed, of the 265 non-overcast sky checks that season, only 55 were under clear or trace-of-cloud skies. Results from other sites that year suggest that it was a good year for NLC; the network-wide total was 47 active nights.

The most salient NLC-poor year was 2010, with only two active nights at La Ronge. The corrected total was 3 (correction factor: 1.58). Of the 309 non-overcast readings from 2010, 86 were under clear or trace-of-cloud skies. But, in this case, the situation of *when* during the season the best and worst weather occurred was important. As it turned out, 30 of the 86 clear readings occurred after July 20/21, *i.e.* toward the end of the NLC season The two 10-night intervals at peak season, June 21/22–June 30/July 1, and July 1/2–10/11, had poor weather. For the July 1/2–July 10/11 period, there were only ten clear or trace-of-cloud sky readings for the entire frame; for the Jun 21/22–30/Jul 1, there were *none*. In fact, the best reading in the latter period was one 1/5 reading—the rest were 2/5 or worse. Results from other sites indicated that there were some active nights during peak season; it was just too cloudy at La Ronge to see them. So with regard to the four cases above, the 2010 season would be a Case 2, but with the bad weather occurring only during *part of the season*. This situation exposes a flaw in this system: it is not sensitive to short-term lulls in NLC activity within the overall NLC season, further indicating that there is a significant random component still embedded in the cloud-correction equation.

An example of the last case not yet mentioned, Case 1 (good NLC year due to good weather) would be 2001; during that season there were 14 active nights at La Ronge, and the corrected total is 20 (correction factor: 1.40). La Ronge in 2001 experienced high numbers of readings in the 0/5, Tr/5, and 1/5 data bins.

Within the overall structure of the raw and corrected curves, one can search for the effect of the sunspot cycle on NLC activity. Our expectation is that during years of sunspot maximum, the attendant increase in UV flux reduces upper atmosphere water vapour and hence NLC activity; conversely, during solar minimum, there is a peak in NLC incidence, with a 1-2 year time shift between the minimum sunspot numbers and the maximum NLC numbers (Romejko *et al.* 2003; Dalin *et al.* 2006; Dubietis *et al.* 2010). The 24-year period of La Ronge observations covers two complete 11-year solar cycles, with maxima in 1990 and 2002 and minima in 1996 and 2007. There is an indication of an NLC activity minimum in the early 1990s with a nadir in 1992, perhaps as a consequence of both solar activity and the aforementioned Mt. Pinatubo effects. A one-year minimum also occurred in

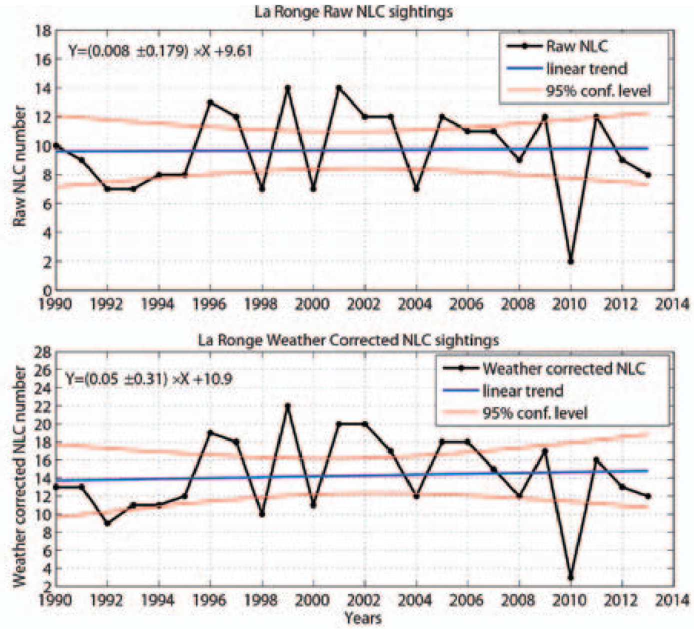

Figure 8 — Results from the regression analysis of the raw (top panel) and corrected (bottom panel) NLC sightings from La Ronge from 1990–2013.

2004, which is a two-year delay after the 2002 solar maximum, though NLC CAN AM network-wide activity, as noted above, was actually strong over a span of years encompassing 2004.

The lower sighting totals at La Ronge up to 1995 and the overall higher totals afterward would suggest that there has been a trend of increasing NLC incidence over the 24 years of surveillance. To evaluate this contention, we performed a robust linear regression analysis, the results shown in Figure 8. From this analysis, we found that with both the raw and corrected data sets, there is an indication of a slight increase in NLC incidence at La Ronge over the past two decades; however, the trends lack statistical significance. As mentioned before, similar analyses from long-term NLC data from Moscow, Vilnius, and Denmark (Dalin *et al.* 2006; Dubietis *et al.* 2010) have yielded similar results; that is, a slight decadal increase in NLC frequency, but with the trends not statistically significant.

With such a disparity between actual and corrected values of NLC sightings, one may ask what the nature is of all the "missed" displays. Are they just very small in area? Are they also faint? Or, do they even exist? Fortunately, in 2012, one of us (MN) conducted an aggressive observing campaign in the Edmonton area of central Alberta, Canada. On nights when the weather was not favourable in the city, MN, guided by images from weather satellites, drove, sometimes great distances, to locales where skies were clearer. A constant watch for NLC during the entire twilight period was made, and a digital camera was used for verification, recording the majority of sightings. The result was 30 active nights! Another of us (MZ), remaining in Edmonton, had a total of 11 active nights. Movement to clear skies enabled us to nearly triple the observations of NLCs.

Of the 19 additional active nights tallied by MN, 11 of those were on nights when it was cloudy in Edmonton. On 6 nights, when MN detected faint NLC, they were not noticed in Edmonton; on two nights when MN detected NLC, no observation was made at the same time in Edmonton. Considering that six of the 19 MN observations were of feeble NLC, one could conclude that: a) a significant proportion of overall NLC displays are not large, salient displays, but patchy ones, small in areal extent as suggested above, and/or b), MZ was not able to detect faint NLC.

Past observations of NLC from the Edmonton area by members of The Royal Astronomical Society of Canada concur with MN's observations that, in any given NLC season, the number of NLC-active nights increases in the Edmonton area with increasing numbers of observers. The situation is such that one observer may have a patch of NLC being blocked by tropospheric cloud, whereas another observer a few kilometres away has a positive observation. The overall success in any one season seems to depend on how many people observed and the sky-check frequency, be it once or twice a night, hourly, or constantly. And, of course, it depends on the weather!

Restrictions that occur on limits to human abilities can be readily overcome by making automated NLC observations with digital cameras. Currently, we have an NLC camera network that includes automated cameras located in Port Glasgow (Scotland), Athabasca-AUGO-1, and AUGO-2 (Canada), Kamchatka, Novosibirsk, and Moscow (Russia), Vilnius (Lithuania), and Silkeborg (Denmark). Each camera operates from the end of May until the middle of August and takes images nightly every 3 minutes at the beginning and end of the NLC season and every 1 minute during high NLC season (June 10–July 25). A detailed description of the network of NLC cameras and operation schedule can be found in Dalin *et al.* (2008) and Dubietis *et al.* (2011). An important feature is that these NLC cameras are located along approximately the same latitude circle of 53–56°N, providing NLC observations with comparable twilight illumination as well as very similar physical conditions in the mesopause, since temperature, and vertical and horizontal winds are latitude dependent. Additional benefits of automated camera networks, which are becoming easy and inexpensive to set up, can include stereographic 3-D profiling of NLC geometry (Dalin *et al.* 2013).

Conclusions

1. Observations at the La Ronge, Saskatchewan, Flight Service Station (55.1°N 105.3°W) from 1990-2013 indicate no statistically significant decadal trend in NLC-active nights.

2. The La Ronge observations suggest a marked dip in NLC activity in 1992 after the 1990 solar maximum; favourable weather that year supports the conclusion that the low number of active nights (7) was real. A subsequent one-year minimum occurred in 2004 after the 2002 solar maximum. Hence, there is evidence of a minimum of NLC activity two years after a solar maximum.

3. It appears that even a small amount of foreground tropospheric cloud can have a detrimental effect on the chances of seeing a display of NLC.

4. NLC tend to be patchy in nature, with small, localized displays (perhaps only 100 km long) far outnumbering large displays.

5. The weather-correction system employed in this analysis is not sensitive to short-term tropospheric cloudy periods within an overall NLC season, and hence it is necessary to assess the season's weather carefully to fully understand its effect on NLC detection.

6. In addition to interference by weather clouds, there are many other confounding factors affecting how many NLC displays may be seen at a particular site, including ones associated with the site (lighting, interference by objects on the horizon) and ones pertaining to the observer (experience, motivation, use of optical aid).

7. We recommend, for future efforts to merge our tropospheric cloud numeric recording system with the aforementioned alphabetical system that:
    - condition "A" with the previous system corresponds with the 0/5 and Tr/5 bins with the new system
    - condition "B" with the 1/5 bin
    - condition "C" with the 2/5, 3/5, and 4/5 bins
    - condition "D" with the 5/5 bin.

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The Value of Astronomy for a Civilized Society: Richard Adrian Jarrell 1946–2013

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Few are the scholars of whom it can be said that they crafted the dominant narrative of their discipline. Richard Jarrell was one of the few. *The Cold Light of Dawn: A History of Canadian Astronomy* (1988) remains the fullest account of the plantation, cultivation, and production of astronomy in Canada. The characteristically careful choice of a modest indefinite article for the subtitle does not obscure the watershed moment for the history of Canadian astronomy created by the work's publication. One could even speak of pre- and post-Jarrell eras. His contributions, however, went beyond authoring Clio's biography of her sister Urania's Canadian affairs.[2]

Figure 1 — Professor Richard A. Jarrell, with the statue of the Enlightenment naturalist Georges-Louis Leclerc, Comte de Buffon (1707–1788), in the Jardin des Plantes, Paris. Reproduced courtesy of Martha Jarrell.

Before The Dawn of Astrophysics

Rich Jarrell's *alma mater* was Indiana University, from which he graduated with a degree in history in 1967, but—significant for his professional career—he also read astronomy. He came to Canada to pursue a graduate course of study at the recently established Institute for the History & Philosophy of Science & Technology (IHPST), on the St. George campus of the University of Toronto. Jarrell arrived at the IHPST the year following its establishment (1968), where, in due course, he received his M.A. (1969) and Ph.D. (1972).

In Jarrell's day, the best-known figure (and in some ways most notable character at IHPST) was the indomitable Stillman Drake, former financier, noted bibliophile, and remarkable autodidact disciple of Galileo. Drake, a highly productive scholar of international repute, was recruited to the faculty about the time that Jarrell arrived, and became his doctoral supervisor (Buchwald & Swerdlow 1994). Drake believed in the virtues of archival work, the examination of the earliest extant editions of texts in conjunction with relevant manuscript material, and the close, *very* close, reading of sources. The first goal was to understand the material as it would have been understood at the time of its creation, early reception, and initial application. It was a sort of historian's moral imperative, and a veritable debt of the present to the past. Drake's scepticism towards unguarded acceptance of the oft-repeated story as the *true* story was marked. This example of a creatively sceptical scholar embodying the virtues and vices of exceptional autodidacticism would not be lost on Jarrell (in truth every successful historian—as every successful astronomer—has at some point to become a disciplined autodidact). Perhaps the example of a great authority, however skeptical and careful a reader, idolizing a scientific hero partly of his own making also proved instructive for the young graduate student. It was a temptation Jarrell successfully avoided throughout his career.

Jarrell's doctoral thesis was *The Life and Scientific Work of the Tübingen Astronomer Michael Maestlin, 1550-1631*, which he defended early in 1972 (1972b). The external examiner was C. Doris Hellman (1910–1973) of CUNY, best known now for the published version of her thesis *The Comet of 1577: its Place in the History of Astronomy* (1944) and for her translation of Max Caspar's *Kepler* (1959/1993), works that both retain their value. Maestlin is chiefly remembered—if remembered at all by professional astronomers—as Kepler's teacher by those who rush over the period to arrive at Newton, Halley, and Herschel. He was in fact a significant figure in the development of early-modern astronomy, with a deserved reputation as an observer, a mathematician, and as a teacher who enjoyed a Europe-wide correspondence and the respect of Tycho Brahe (the last no easy feat). In his mid-20s, Jarrell had produced a major study of a notable figure in the discipline. A recent paper modifying one of Jarrell's judgements notes that his thesis: "…remains the best monograph about the Tübingen astronomer to date" (Granada 2014, 91). The tragedy here is that it never saw the light of day as a book.

Another key influence on Rich was John W. Abrams (1913-1981), a formally trained astrophysicist, who was the founding Director of IHPST, and a professor of Mechanical and Industrial Engineering at the University of Toronto. He had also been the chief operational analyst for the Supreme Headquarters Allied Powers Europe in Paris (SHAPE, 1958-1961), and chief of operational research at the Defence Research Board in Ottawa (1961-1962). Abrams was a scholar of wide interests, who advocated an interdisciplinary approach to the history of technology. His attention to the interaction of scientists and their apparatus in the production of science was shared by his student (Sinclair 1982)[3].

Jarrell's first published paper appeared the year of his defence (indeed preceded it), and while not centred around Maestlin, was nonetheless on an early modern astronomical question, namely the dating of William Gilbert's *De mundo* (Jarrell 1972a). The subject of his thesis did feature in several published contributions, one on Maestlin's place in astronomy (Jarrell 1975b), and another on Maestlin within the Tübingen setting (Jarrell 1981). Jarrell was invited to contribute to the IAU's and IUHPS's (International Union for the History and Philosophy of Science) prestigious General History of Astronomy. This was meant to be the authoritative multivolume English language survey. Unfortunately, only three of the volumes were ever issued; fortunately one of them contained Jarrell's chapter on "The Contemporaries of Tycho Brahe" (of course Maestlin was among them; 1989b).

Jarrell's early won expertise in the area saw him appointed to the editorial team of Springer's *The Biographical Encyclopedia of Astronomers* (BEA; Hockey *et al*. 2007), as the content editor with responsibility for "Renaissance and Enlightenment Astronomers." Jarrell was also a major contributor of biographies to the project, although most were more contemporary than "Renaissance/Enlightenment" entries (31 of the former to 5 of the latter; interestingly enough, he didn't write the account of Maestlin; however, its author paid him bibliographical tribute). He reprised this task for the expanded second edition of BEA, which is expected out this summer (Hockey *et al*. 2014). Those of us whose contributions fell under Jarrell's oversight were grateful that he felt no need to impose a stamp of authority when none was needed—he was more of an Arago than a Le Verrier as editor, if one may be permitted the phrase (Lequeux 2008; Lequeux 2009).[4]

A New World

It cannot be said that the Canadian astronomical past was exhaustively chronicled by the time Jarrell was undergoing his scholarly formation, knee-deep in graduate work on the old-world achievements of Samuel de Champlain's contemporary, Michael Maestlin—far from it. There were few serious researchers who concerned themselves with the astronomical past of Jarrell's adopted country, virtually no research projects to gather, preserve, or analyze that heritage, and consequently, few publications of any real significance, particularly when compared to the state of things in other countries with traditions of front-line astronomical endeavour.[5] This fact was all the more curious given Canada's high standing based on the relative quality and quantity of its advancing state-of-the-art astronomical research since the rise of the DAO in 1918 (at present, the evidence for this is quantitative for the period after the mid-1990s, and qualitative for the preceding period; Pudritz *et al*. 1999, 42-43; LRP2010 Crabtree; Pritchet *et al*. 2011, 22-23. Crabtree is currently extending the quantitative analysis to earlier periods).

Prior to attracting wider scholarly notice, uncultivated and latent fields are not as visible in the historical landscape as they appear in the cold light of hindsight. Jarrell made the most of finding himself before such an undeveloped vista, to produce what may prove to be his most significant body of work in astronomical history and heritage. His writings on Canadian astronomy can be considered under two thematic headings: institutions and disciplines. He tended not to structure studies around individual astronomers' biographies, although he made use of biographical data in recounting the origin and course of institutions and disciplines where relevant.[6]

Early on, Jarrell produced a two-part survey of "Astronomical Archives in Canada" (1975a; 1977a), a necessary prolegomenon to writing a history of Canadian astronomy. Many of his subsequent papers on Canadian astronomy—the fruit of work in those very archives—were first statements of inquiries, queries, and conclusions later handled in *The Cold Light of Dawn*. These include articles on the origins of the Dominion Observatory (1975c), the commencement of Canadian astrophysics at the hands of J.S. Plaskett and collaborators at the Dominion Observatory (1977b), and the reception of Einstein's theory of relativity in Canada (1979; Crelinsten (2006), an excellent monograph, confirms some of Jarrell's conclusions).

It has already been remarked that the appearance of Jarrell's *The Cold Light of Dawn: A History of Canadian Astronomy* (1988) was a landmark event in the field. It was a larger and more ambitious survey than anything that had been attempted hitherto, and has not been subsequently superseded. He succeeded in providing Canada with a workable narrative of its astronomy from what he took to be the earliest colonial period (Cabot/Cartier in 1497/1534) to the discovery of SN 1987a. This was a major accomplishment. In common with most other pioneering efforts, there were errors of commission and omission, which Jarrell readily acknowledged—indeed, some of his significant later work was filling a few of the gaps he had left in the 1988 edifice, so to speak. The reviews were positive; Don Osterbrock, the former Director of Lick, remarked (1988) in *Science* that:

> *The book is well written. There are a few minor errors of fact….His description of J.S. Plaskett and J.A. Pearce's observational confirmation of the picture of differential galactic rotation, one of the great triumphs of Canadian astronomy, is particularly clear and vivid…Overall it is a good book….The Cold Light of Dawn should be read by Canadian scientists and historians of science, and by everyone with an interest in the history of science in Canada.*

David DeVorkin, now the senior curator of the history of astronomy and space sciences at the Smithsonian National Air and Space Museum, in a review (1990) in JRASC noted:

> *Any attempt at a disciplinary history of a nation's scientific heritage is, at the very least, demanding and fraught with potential hazards and pitfalls. It is only too easy to fall into the trap of chronicling the achievements of individuals and institutions…without adequate reflection and analysis. Too much history is written this way.…Very happily, Richard Jarrell's effort suffers from none of these negative characteristics and is replete with those that mark it as a fine work, establishing for the first time not only a broad-brush sense of Canadian astronomy, but a firm stage from which further research will no doubt build.*

And Alan Batten (1990) in the *Journal for the History of Astronomy* observed:

> *Most Canadian observational astronomers have seen the light of rather more cold dawns than they care to count, and the title of this first general history of Canadian astronomy to be published will immediately, if somewhat paradoxically, make them warm to the theme.…Disagreements about how to relate recent events are inevitable, but outright errors are few and none that I noticed is important.…I consider myself reasonably well informed on the history of Canadian astronomy, but I learned new things from this book and came to look at others in a new light. This book…will be essential reading for those who wish to pursue the subject further.*

Jarrell's post-*Cold Light* publications amply demonstrated that his interest in the broad and narrow subjects of his monograph didn't wane upon its appearance and reception.[7] He continued to write about the triumvirate of major Canadian installations culturally ancestral to the CFHT—the DO, DAO, and the DDO (1989a; 1991b; 1993; 1996; 1997a; 1999b; 2009b; Langford 1997, 189-190, 192-193). Certain sub-disciplines of Canadian astronomy attracted his particular attention after *Cold Light*; meteoritics and radio astronomy.

In his work on Canadian meteoritical science (2009a), Jarrell proposed a two-part division of meteoritics, with activity in the "first phase" (1933-1990) dominated by government scientists led by Peter Millman and associates, and a "second phase" (1990-) in which leadership passed to university-based scientists. He was led to posit the surprising conclusion that substantial lines of academic filiation, project continuity, and common goals between the two phases were notably absent, or if present, were tepidly weak. Given that more work is needed to evaluate the utility and indeed validity of his proposed model, it is unfortunate that he only managed to deal with the "first phase" at any length in print.

Radio astronomy had exercised a fascination on Jarrell for years, and he increasingly explored aspects of the topic in presentations and articles working up to his next monograph (*e.g.* 1991a; 1997b), which was to be a book-length survey of the history of radio astronomy in Canada. This topic is prime unmapped territory for a survey, aside from work done chiefly by Art Covington (*e.g.* 1975; 1984; 1988), A.J. Butrica (1996), and Woody Sullivan (2009). It is salutary to realize that Jarrell's book would have been the first monograph devoted to the history of *any* branch of Canadian astronomy. We don't make it easy for the public to know us; the historical record of astronomy in Canada remains seriously under-reported and furtive.

One beneficial result of Jarrell's research into the history of our radio astronomy was his work in gathering the oral histories of radio astronomers. His audio recordings provided the impetus for what became the CASCA Heritage Committee's video interview project, which was successfully developed thanks to the work of Randall Brooks and Paul Feldman, and latterly Elizabeth Griffin (Cassiopeia).[8] This important ongoing project owes much to Jarrell's example and initiative.

The Universe Beyond Canada

Jarrell's interests in the astronomical history and heritage of the modern period extended beyond the borders of Canada. He well realized that an effective "national" history of astronomy is adrift in its own peculiar space if it's not anchored to its international context.

His contribution to the American Astronomical Society's Historical Astronomy Division (HAD) centennial project, *The American Astronomical Society's First Century*, was an ample paper on the Canadian members of the AAS (1999a). Amusingly enough, one reviewer of the volume (the late Peter Hingley) remarked that the title Jarrell chose for his contribution, "Honorary American Astronomers: Canada and the American Astronomical Society," would set Canadian teeth on edge!

Not surprisingly, interest in radio astronomy engendered several presentations in this area. In "Radio Astronomy's Debut at the American Astronomical Society" (1999c), Jarrell maintained that a Canadian *équipe* gave the first such paper in 1947, and the high point of radio astronomy at the AAS in that pioneer phase was the 1949 meeting hosted by the Dominion Observatory, which featured visits to the Canadian radio astronomy facilities in the Nation's capital, and among other papers, a meteoritics session that included a report by McKinley on some of his radio observations. The formal representation of radio astronomy at AAS meetings then dwindled on the vine for the better part of a decade. This may have had something to do with the standing of the radio astronomy community among astronomers, something he explored in his next paper (2005).

Canadian involvement in the 1910 meetings of the International Union for Cooperation in Solar Research (Hale's child and predecessor of the IAU) and the Astronomical and Astrophysical Society of America (now the AAS) was also examined in print (2010). Jarrell took the opportunity to outline the role (not negligible) played by a young, ambitious, and capable J.S. Plaskett in gaining berths on international committees furthering radial-velocity measurements and concurrently advancing his career and the science. He also touched on the role of Plaskett's colleagues and protégés and the exemplary role of the DAO's 72-inch telescope in spawning progeny at home and abroad (this last was also dealt with in a paper given at the 189th AAS meeting in Toronto; Jarrell 1996).

As Willy Hartner before him, Jarrell was also concerned with the human values of the scientific enterprise. At a symposium held at Carleton University to celebrate the centenary of the incorporation of the RASC, he delivered "The Value of Astronomy for a Civilized Society"—certainly the best title among his papers, and one of his most wittily written pieces (1990). It is also one of his most serious. At one point, he asks:

> *Let us suppose that a future finance minister, in search of profound budget cuts…discovers astronomy in his supply bill. What would we say, if pressed to justify this support for astronomy?….Government scientific institutions were created with the practical payoff in mind; after all, our premier research organization, the National Research Council, was established to coordinate and encourage industrial research, not to undertake fundamental studies of nature…(317).*

He proceeds to speculate on what would happen if a government so minded attempted to re-engineer the Herzberg Institute into a for-profit enterprise. With the changed conditions that nearly a quarter of a century brings, his words have a prophetic chill to them.

What answer, then? Jarrell quotes someone who was eminently successful in procuring funding for a non-applied, pure-research, big-science installation:

> *It is in such additions to the cause of pure scientific research that the real progress of a country may be truly judged and if, as has been often said, the degree of civilization of a nation is measured by its support for astronomy, Canada takes a high rank and all Canadians should be proud of the position their country has taken and now holds in astronomical research (321).*

That man was John Stanley Plaskett, and the observatory was the DAO, but Plaskett wrote at what seems a time of myth, when cabinets supported such expenditures for reasons of national prestige, a time when opposition benches wondered why a bigger telescope wasn't commissioned for the predecessor DO. The response to the hypothetical finance minister that Jarrell advances is that astronomy as a pure research science reflects:

> *…the noblest intellectual, creative and emotional aspects of our species….We know, although perhaps we have not articulated this knowledge, that astronomy is important to a civilized people. If astronomy disappeared as a professional and amateur activity in Canada, we know that civilization as we know it would also have ceased to exist (319–323).*

It is a loss that we can no longer ask Jarrell what we might do if such an answer could no longer carry the day.

Legacy

Jarrell's legacy lies in enabling us to know significantly more about our astronomical heritage through his publications, through his example of teaching, and through his service to the scholarly community. If he had done nothing else, *Cold Light* and the genesis of CASCA's ongoing video-interview program would be a fully sufficient legacy. As a member

Continued on page 162

Figure 1 — André Paquette used a Celestron 14-inch telescope with a Starizona ƒ/1.9 Hyperstar adapter to capture this image of Comet 2012/K1 (Pan-STARRS). Exposure was 15×4 min using a Nightscape 8300 camera. Andre used a piggyback guide camera, and MetaGuide's "shift guiding" to adjust for the comet's motion. K1 will reach its maximum brightness in late August.

Figure 2 — Blair MacDonald used spring skies to save 3 hours (60×3m) of photons to produce this image of the face-on galaxy M101 in Ursa Major. M101 is notable for its bright HII regions, which appear as reddish clouds in this image. Blair used a Canon 60Da at ISO1600 at the prime focus of a Skywatcher 200-mm ƒ/5 Newtonian telescope from St. Croix, Nova Scotia. For processing tips, see Blair's column in this issue.

Figure 3 — Mark Zalcik has been collecting images of noctilucent clouds—the Earth's highest clouds—for many years from various locations in Northern Alberta. This image shows the complex dynamics at work in the Earth's uppermost atmosphere, with several cloud wave patterns superimposed one on the other.

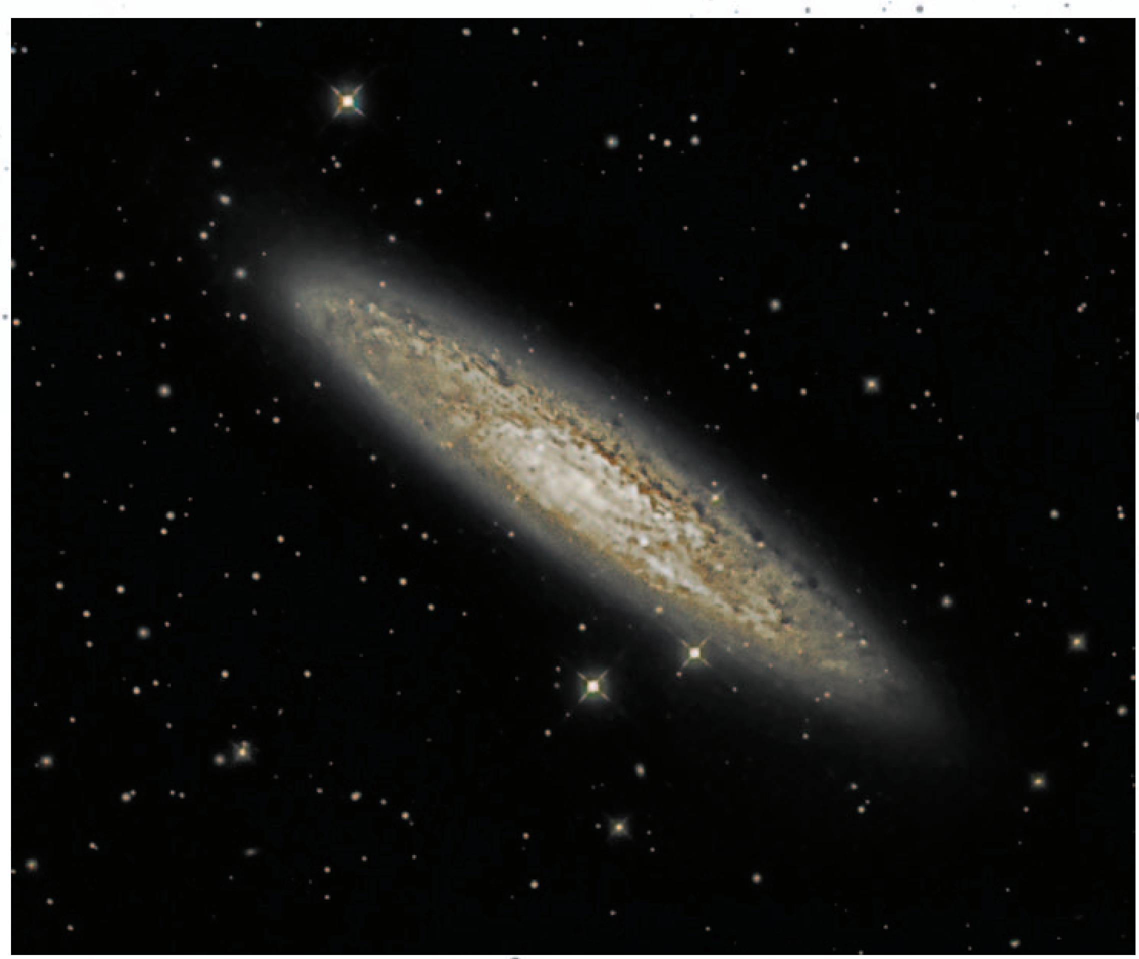

Figure 4 — NGC 253—the Silver Coin Galaxy—is one of the brightest galaxies in the sky, easily visible in binoculars. In a large telescope, it is notable for its mottled interior, making the spiral arms difficult to trace. Dalton Wilson, shooting from Rusty's RV Ranch in New Mexico, used an AstroTech 10-inch RC telescope and a QSI540wsg camera with exposures of 6×900 s in L, 4×600s in G, 5×600s in R, and 3×600s in B over three evenings.

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of the CASCA Heritage Committee (he was the longest-serving chair; *Cassiopeia*), the AAS HAD (including a term on its executive committee), and the Toronto Centre of the RASC, he contributed in various ways: organizational skill to the first two, and the reporting of research to all. Jarrell had many projects in course. He was involved in the preliminary stages of covering the Canadian portion of the HAD's Astronomy Genealogy Project; fortunately HAD member Peter Broughton is taking up where Jarrell left off. What of his *Nachlass*? It is to be hoped that the major works on which he had progressed will find those to carry them forward, particularly his monograph on the history of radio astronomy in Canada.

If astronomy has value for a society, then its history matters. Jarrell's historical work was nothing if not civilized.

Acknowledgements

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Endnotes

1 This memoir is a cooperative project of the CASCA Heritage Committee and the RASC History Committee.

2 This memoir is chiefly concerned with Jarrell's contributions to the history of astronomy. His work on the history of science and technology—perhaps one should say *histories* of science and technology—touched many areas other than astronomy. For a sympathetic account of his work in other areas see CSTHA | AHSTC.

3 I wish to thank Dr. David Pantalony, Curator, Physical Sciences and Medicine, Canada Science and Technology Museum, for pointing out Abrams's significance for Jarrell; email from D. Pantalony to R.A. Rosenfeld, 2014 June 3. Dr. Pantalony also remarked that "Rich was a key influence on the development of research and collecting policy at my museum. In the early days of the history of science in Canada, he was one of the few scholars who took Canadian history of science seriously. He was therefore a leading inspiration in the development of our Collection Development Strategy."

4 Other astronomy and astrophysics encyclopedias that Jarrell contributed to are Langford 1997 (see note 7 infra), and Murdin 2001, with articles on "Calendar in the Middle East and Europe," "Distances (from Antiquity to 1900)" written with Michael Hoskin, and "The Telescope (to 1950)."

5 Helen Hogg, Allie Vibert Douglas, Art Covington, and Ed Kennedy, figures of an older generation, started publishing on topics in the history of Canadian astronomy decades before Rich Jarrell became active, although their productive careers overlapped. None had the advantage of Jarrell's training in historical sciences. When writing of Canada's astronomical past, Ed Kennedy may have excelled Helen Hogg as to quantity, but certainly not as regards quality. Several of the offerings in the RASC's contribution to Canada's centenary, *Astronomy in Canada: Yesterday, Today and Tomorrow*, edited by Ruth Northcott (1968), include some history. Jack Heard's reminiscences originally published in the *DDO Doings* (eventually collected and republished by Don Fernie in 1979) were by their very nature the stuff of history. Don Fernie did not hesitate to treat Canadian subjects in his popular historical expositions. Alan H. Batten, Martin Beech, Roy Bishop, Randall Brooks, Peter Broughton, and Howard Plotkin began producing work of lasting value a little after Jarrell started. Throughout the years, JRASC has featured a smattering of papers of variable quality by others on aspects of Canada's astronomical history—the good, the bad, and the ugly. And so it goes.

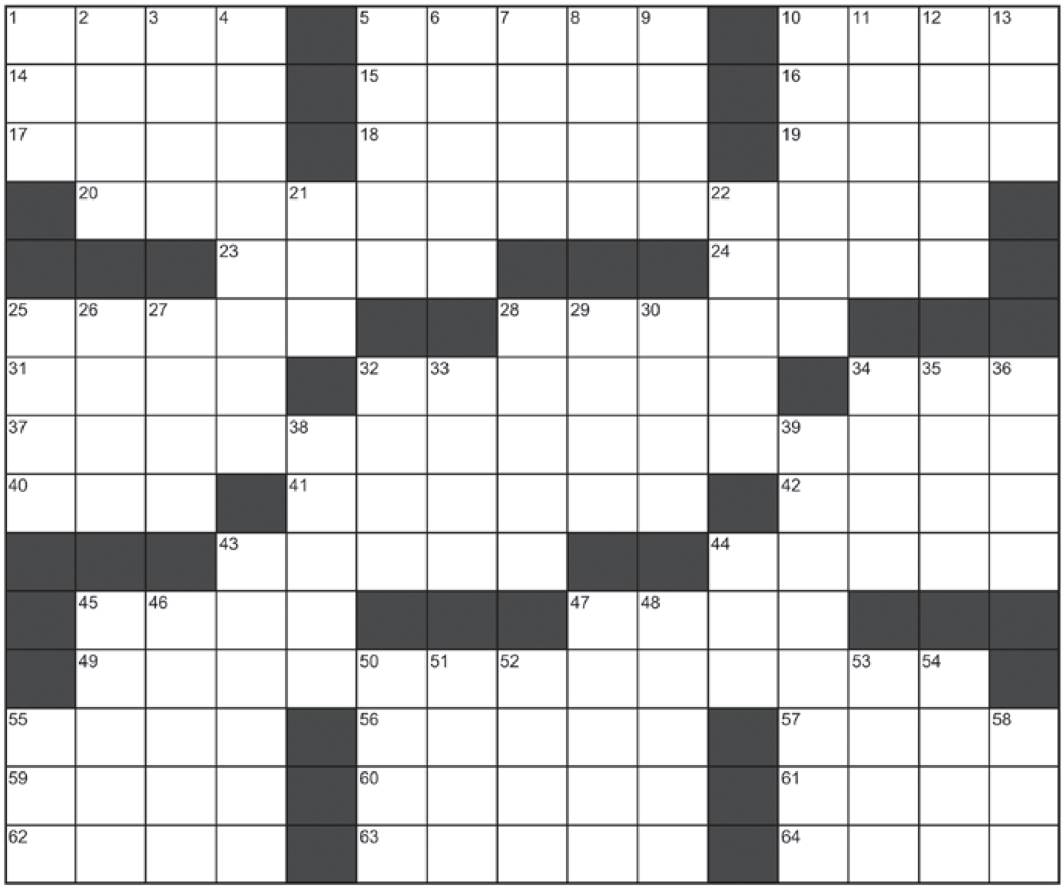
6 Exceptions are his doctoral thesis, and biographical entries for reference works—he latter dictated by genre.

7 He published another, briefer survey in Langford 1997, 110-114, his most substantial contribution to that work.

8 Email from R. Brooks to R.A. Rosenfeld, 2014 May 24. Interestingly enough, Dr. Brooks notes that the American Institute of Physics's Oral History Interviews program (Niels Bohr Library and Archives) was not in the first place the inspiration and model for the CASCA video interview project.

Quasars Crossword

by Naomi Pasachoff



ACROSS

1. Yoga equipment
5. Billiards shot
10. Bride's colour
14. Oliver Sacks's *The Man Who Mistook His Wife for* _ ___
15. Mt. Kent Observatory robotic telescope
16. Medical scans
17. ___ Orionis, brightest star in Orion's sword
18. Put an end to
19. Curse
20. Gravitationally lensed quasar
23. Darkest stage of twilight
24. Tennis great Arthur
25. Malicious burning
28. Paradisiacal places
31. Its half is better than none
32. Distance ______, measures of distance of celestial objects too far away to show measurable parallax
34. Unix-like computer operating system
37. Their nuclei generate an emission spectrum characteristic of hot, ionized clouds of gas
40. CIA predecessor
41. Super 8s, *e.g.*
42. Charitable gifts
43. Plain surface between the channels of a triglyph
44. Biblical witch of _____
45. Stride back and forth
47. Hue
49. Spectacular structure around active galactic nuclei and quasars
55. Verdi's *Giovanna d'*____
56. World famous Sacher _____
57. Bucket
59. Extremely
60. Protective covering (U.S. spelling)
61. Superseded freeware
62. Paleozoic, Mesozoic, and Cenozoic
63. Slightest
64. Benevolent and Protective Order of ____

DOWN

1. Half a rum drink
2. Millet's *Man with a* _ __
3. *Mr. Hulot's Holiday* filmmaker
4. Deadlock
5. Expenses
6. "Ornament of _ ____ and quiet spirit": *The First Epistle General of Peter*
7. Sitarist Shankar
8. Israel's ambassador to the United States
9. Painter Chagall
10. Decorate with a raised design
11. Shared fate of the *Challenger* and *Columbia*
12. Lather, _____, repeat
13. Utilize
21. Our star
22. Wife of King Abdullah of Jordan
25. In addition
26. Caviar and deer
27. Articulates
28. Line segments joining vertices
29. Like the controls on a king-size electric blanket
30. Units of length
32. Wedding checks should be written to __ __ Mrs.
33. ____ von Bismarck
34. Give a false brilliance to
35. Disney's *Finding* ____
36. Gorbachev was its last pres.
38. Muslim ruler (var.)
39. Shrewish wife of Socrates
43. Antagonists of the Hatfields
44. Conclusion
45. Peeling implement
46. Capital of Ghana
47. Namesakes of dog who visited Oz
48. Not readily reactive
50. Abbrev. used instead of a whole list of names
51. Ripped
52. ____ La Douce, Shirley MacLaine role
53. Constellation Vela, the ____
54. Quirk
55. Hail
58. ___ *Misérables*

Rising Stars

SkyShed's Wayne Parker Rocks Two Worlds

by John Crossen (johnstargazer@xplornet.com)

Whether it's the music world or that of amateur astronomy, Wayne Parker has rocked both. First was the world of music, where Wayne played bass in the 1980's band Glass Tiger. Over the course of a decade, the group from Newmarket, Ontario, topped the charts in Canada and America. The release of their first album went platinum four times in Canada and hit gold in the U.S. With a dozen hit singles and millions sold, they garnered five Juno Awards and a Grammy nomination. Within a few short years, they and their well-worn passports had travelled much of this world. But, that was just one of Wayne's worlds.

Thanks to his passion for astronomy, Wayne would carry a telescope with him as he toured with the band. He'd set up impromptu, public observing sessions wherever he went, creating fond memories of observing from some unlikely locales such as the roof of a Paris hotel or behind an arena in Calgary. He enjoyed sharing the view of the stars with others throughout his travels, totally unaware that a couple of decades later, his observatory designs would change the world of amateur astronomy.

Although Glass Tiger continued to play on occasion (as they do today), the 1990s allowed the band members time to focus on family and personal pursuits. For Wayne, astronomy came to the forefront.

So did Lorelei Power, a fellow amateur astronomer, when they met in the dark of a perfect observing night. With a life-long love of astronomy in common, they were soon observing as a couple. Wayne recalls; "On clear nights, we'd create a comfortable camp only to pack it up again several hours later, all bleary-eyed and tired. As we added equipment, setting up and tearing down became tediously time consuming. Lorelei and I wanted to spend more time observing and less time lugging gear back and forth. We dreamed of having our own observatory, where we could set up all our astronomy gear, safely stored and ready to use at a moment's notice."

Frustrated that they couldn't find an existing affordable, simple solution, Wayne decided to do something about it. He recognized that without a practical, secure solution, too many telescopes would sit neglected or be taken out only on rare occasions. Says Wayne, "Multiplied around the world, that's an awful lot of missed opportunities for astronomy!"

Sharing his ideas with Lorelei, Wayne was confident that if his observatory plans worked well for them, they would work well for others, too. Thus his mantra became, "To be observing in minutes!" Lorelei agreed, and in doing so, became the first astronomer sold. Together they committed to the business of observatories and making them more affordable and more available to everyone.

"After auditing the wants and needs of astronomers, I developed my first observatory design, a roll-off, which Lorelei dubbed the 'SkyShed.' We liked the name so much that we adopted it as the name of our company."

In 2003, SkyShed Observatories officially launched, offering Installs, Kits, Plans, and the SkyShed Pier, also an original design by Parker. Astronomers around the globe were using his *SkyShed Plans on CD*, a library of building plans with over 100 step-by-step construction photos.

Wayne had another hit as *Sky & Telescope* magazine awarded SkyShed the "Hot Product" Award 2005. Meanwhile, SkyShed had already begun research and development on Wayne's next observatory design, a "personal-sized" dome.

Three years later, they did it again. *Sky & Telescope* awarded SkyShed the "Hot Product" Award 2008 for Wayne's invention, the 8-foot SkyShed POD. It launched in 2007 to a pre-sold queue of about 500 astronomers. Wayne had named his dome design in homage to Arthur C. Clarke's *2001: A Space Odyssey* and fleshed-out "POD" to read "Personal Observatory Dome."

SkyShed POD delivered to rave reviews; astronomers loved their PODs. And, in 2010, the "Entrepreneur of the Year" Peak Award was presented to Wayne and Lorelei for SkyShed Observatories. According to Wayne; "There are currently over 7000 SkyShed observatories located in over 30 countries around the world. The impact this is having on astronomy is immeasurable, as it is still generating ripples into waves."

Explains Wayne: "POD was the first changeable observatory. It's a clam-shell designed for a 180°-wide view with a 360° rotation. It consists of ten fitted and inter-locking panels made of High-Density Polyethylene (HDPE), which is perfect for the harshest environments."

But, that's just the beginning: optional POD bays add additional space. Wall panels and POD bays are interchangeable. This allows a variable configuration that can be adapted to suit the observer's sense and space. There's even a GPOD (Green Personal Observing Dome) that's made from recycled High-Density Polyethylene.

Continuing to innovate, Wayne and Lorelei developed accessories for their changeable observatory, introducing the POD Zenith Table (PZT) that allows conversion to a "slide-off" dome, and the POD Visor, which turns the clam-shell view into a slot view within seconds. These functional accessories gave POD added flexibility and the ability to accommodate larger sizes and types of telescopes and mounts. All this was happening in the busy shop where SkyShed was working on a larger model to accommodate telescopes with mirrors as large as 32 inches in the soon-to-be-launched SkyShed POD MAX.

Wayne's observatory designs are a huge hit with professional and amateur astronomers alike and have been featured in international astronomy magazines and on TV. SkySheds are being used by universities, primary and secondary schools, families, and specialty clubs, and have been utilized in research projects by NASA, MIT, and IBM, to name a few.

With SkyShed POD MAX set to launch, it's no wonder that the astronomy community is excited. Wayne's latest observatory, a 12.5-foot diameter, slotted dome, is designed to accommodate individuals, clubs, schools, and sizable groups. Wall Panels and MAX Bays (3-feet deep) are interchangeable and are made from the same proven HDPE as the POD 8-foot, with up to six optional POD MAX Bays available.

A dual-chain drive provides a robust dome-transport system. SkyShed teamed-up with Kendrick Astro Instruments to create the electronic control and power systems for MAX, with vertical upgradeability built-in, so systems may be added over time. Custom-designed "Planisphere" MAX flooring will also be available as an option. With a few steps around the circumference, a representation of the stars above may be viewed below for any given hour, much like a hand-held planisphere.

Lorelei and Wayne are as excited about using their own POD MAX as they are about launching it this summer. Wayne describes MAX as being "much more than an observatory. I see it as an 'Earth-based space station' and a launch point for any number of science activities."

Wayne will continue to make appearances with his band, Glass Tiger, but this summer all systems are "GO" for SkyShed, rocking astronomy to the MAX! ✶

The SkyShed POD observatory is a perfect addition to every astronomer's backyard. Stan Runge owns this one.

John Crossen has been interested in astronomy since growing up with a telescope in a small town. He owns www.buckhornobservatory.com, a public outreach facility just north of Buckhorn, Ontario.

Second Light

Simulating the Universe

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

Cosmology has come a long way since I started graduate school in 1983. In particular, the large-scale structure of the Universe—with clusters of galaxies distributed along filaments and "walls"—has become apparent. Computer simulations of the effects of gravity over cosmic time, using only gravitationally interacting dark matter, have been quite successful in reproducing observations, and these models are used as important templates to interpret further the observational data. But, we do not see the dark matter—we see the atoms and molecules that make up gas, stars, and galaxies (the baryons, to use the term). Until now, it has been too difficult to simulate the physics that drives the growth of galaxies through gas accretion and star formation, so the models did not produce the observed population of galaxies. That has now changed, as Mark Vogelsberger of MIT and his colleagues from around the world have been able to simulate the growth of structures, including gas and stars in galaxies, from 12 million years after the Big Bang until the present day (see the 2014 May 8 issue of *Nature*). They have dubbed it the Illustris simulation.

Computationally, the problem is enormous. It took 16 million CPU hours to run on a supercomputer! If the simulation were run on a home computer, it would take over 2000 years. It is also very complicated to follow the baryons. Dark matter is about 95 percent of the mass of the Universe, but because dark-matter particles only interact through gravity (at least, that is the hypothesis of structure formation), it is relatively straightforward to follow their evolution. The same is not true for the atoms. Stars form from gas, and they put gas back into the galaxy through winds and supernova explosions. Hot gas gets blown out of galaxies. Supermassive black holes form. Galaxies collide and merge, stripping gas and causing bursts of star formation. This gives you an idea of how messy the real Universe is.

In order to simulate this properly, one needs to track a big enough volume to be representative of the diversity of the Universe—this is typically a box 100 million parsecs on a side (Vogelsberger's box was 106.5 Mpc on a side). Star formation happens on a scale of 1 parsec or less, but even with current computers, that would mean too many particles to follow, so they limit the spatial resolution to 48 parsecs (for gas effects) and 710 parsecs for gravitational effects in the present day. Unlike previous simulations, they can track the creation and distribution of elements heavier than helium.

At redshift 0 (the present day), the simulation contains ~41,000 galaxies that have enough "resolution elements" (one could think of them as computer pixels) to meaningfully say what kind of galaxy each is. For over 20 years, simulations have failed to produce galaxies like the Milky Way. Vogelsberger's simulation finally achieves that and reproduces the observed mix of elliptical and spiral galaxies. It turns out that the previous attempts to produce spiral galaxies failed because insufficient angular momentum was carried into the galaxies.

The "missing satellite" problem is often put forward as the strongest criticism of the standard cosmological model (with dark energy and dark matter—normally referred to as the Λ-CDM model). The issue is that earlier simulations produced far more dwarf galaxies around large galaxies than are actually observed around the Milky Way, M31, and other local galaxies. Some people have long suspected that the inclusion of baryons in the simulations would fix that problem, but attempts to include the effects of baryons suffered from a lack of resolution. Vogelsberger's simulation is the first to get the numbers and distributions of "satellite" galaxies in massive clusters about right. He takes this as a direct demonstration that baryons indeed were necessary to solve it.

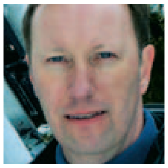
There are some other notable successes in the simulation. They find that the biggest model galaxies have the most metals and the least gas, just as observed. This is not as trivial as it might sound. While the metals are formed inside stars, and therefore the galaxies with the most stars should have the most metals, previous simulations were not in agreement with the observations. Of course, the problem—that we have tracked down observationally only about half the metals that have been created since the Big Bang—still remains.

There is other work ahead. Low-mass galaxies still pose a problem in that the age of the model stars is too old. Other simulations have the same problem—the gas gets into the galaxies too soon. Vogelsberger suggests that better stellar feedback models might solve the problem. But, accurately modelling the interaction between stellar winds and the surrounding gas will require much finer resolution than they have achieved so far. If you have a box 10^8 parsecs on a side, and want a resolution of 1 parsecs, you have to track 10^{24} resolution elements—14 orders of magnitude more than they were able to do. Computers will have to be much faster than they are today in order to achieve that. Or alternatively, select a region of the bigger box for higher resolution studies. This has already been tried, with limited success. One of the problems is that the area selected for higher-resolution modelling might not be representative of the wider Universe. To insiders, this is called "cosmic variance," and it is an issue that bothers observers and theorists alike.

Astronomy has always progressed as a collaborative effort between theory/simulation and observations. Theorists now have a powerful new tool in the Illustris simulation, and are sure to be mining it until the next big thing comes along. ✶

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

Multi-mask Stretching



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

This edition continues a group of Imager's Corner articles that will focus on a few techniques that are useful in processing astrophotos. Over the next several editions of the *Journal*, I'll continue with a guide to the techniques that I find most useful.

In my last column, we looked at a way of generating starless masks that can be used for masked stretching. In this edition, I'll show a way of using multi-masked stretching to bring out the faint stuff. I'll show the process in *ImagesPlus* using split-star processing, but it can be done in any layer-capable image processor with a little more star bloat.

In this article, I'll demonstrate the technique using a great image of M81 and M82 with plenty of the integrated flux nebula (IFN), kindly provided by Scott Rosen (www.astronomersdoitinthedark.com). Scott is a co-moderator on the dslr_astro_image_processing Yahoo group and images from the dark skies of California's Pine Mountain Club.

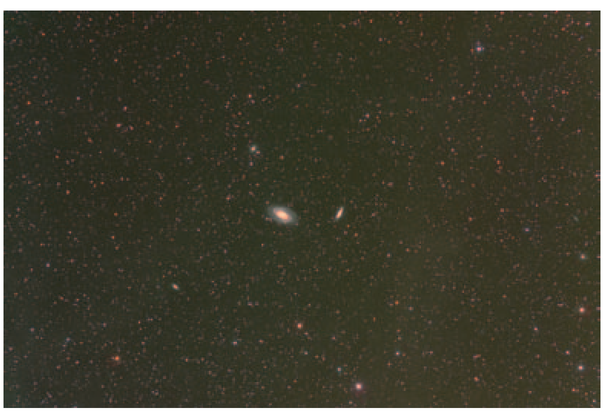


Figure 1 — Simple Arcsinh Stretch

The idea is to use an iterative process to gradually increase the contrast of a mask that can then be applied to a masked stretch of the original image. Let's start with Scott's great M81/M82 image and apply a normal arcsinh stretch to see the problem.

In order to maintain any detail in the galaxies, the IFN is barely visible and the brighter stars have become badly bloated. To solve this problem, we need a mask that limits the stretch to the IFN and galaxies in order

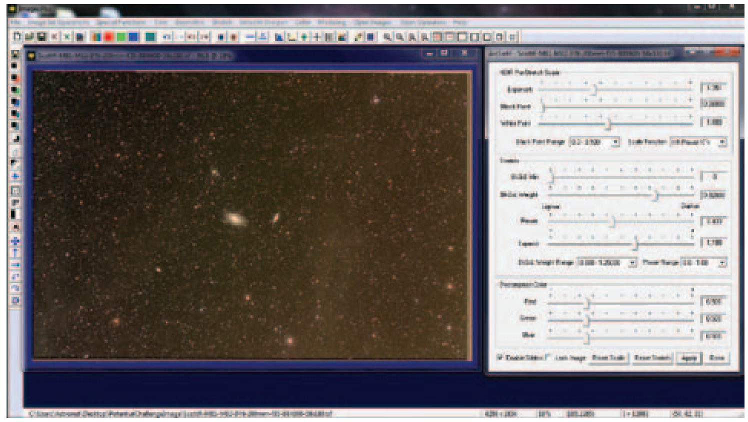


Figure 2 — Initial Stretch

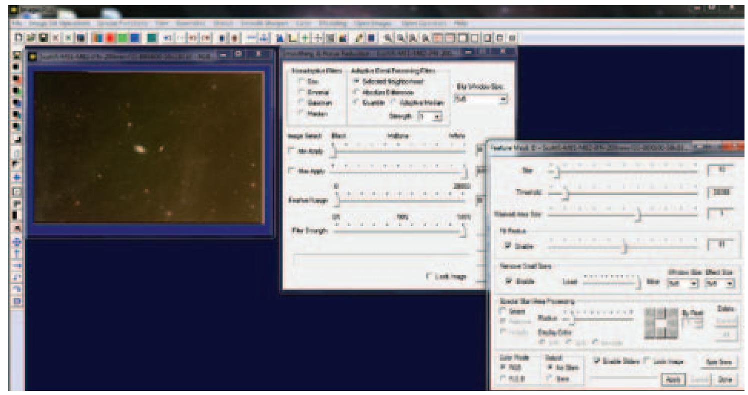


Figure 3 — Feature Mask and Noise Reduction

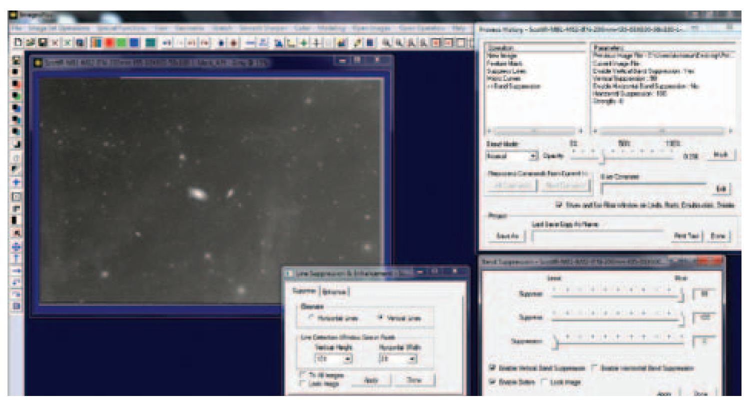


Figure 4 — Line and Band Suppression

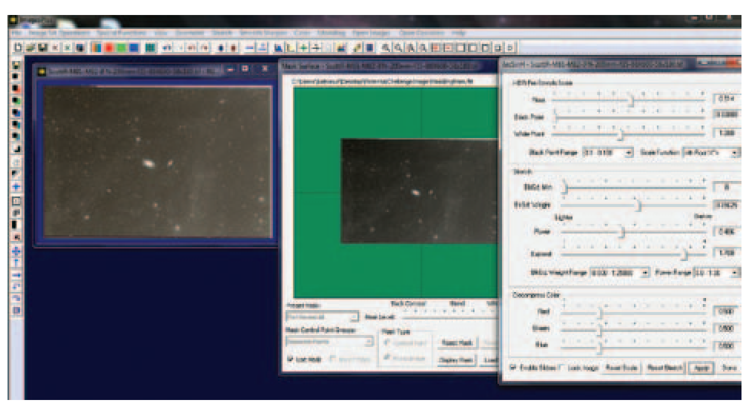


Figure 5 — Masked Arcsinh Stretch

to bring out the faint detail. The first step is to apply the same arcsinh stretch but really push the stretch at the expense of bloated stars and noise. (Figure 2)

Next use the feature mask tool to remove the stars and then smooth the image to remove much of the noise. (Figure 3)

The stretch leaves some fine line noise in the image, and it is important to remove it, as any detail in this mask will be imprinted on the final image. Both the line- and band-suppression tools are used to clean up the image. First the line suppression was applied at 100 percent opacity and the band suppression was applied at 25 percent. Next the image is converted to a luminance mask. (Figure 4)

The mask is then applied to an arcsinh stretch of the original image to imprint the faint IFN detail on the image. The feature mask tool is again used to remove the stars and make a new version of the mask with a little more contrast on the IFN. (Figure 5 and 6)

The next step is to improve the contrast of the mask a bit. Use Micro Curves to lower the level of the dark areas slightly. Remember that the key to this whole technique is to take baby steps and not do too much in any one step, or the noise will increase and make the background lumpy. (Figure 7)

Next step is to remove the leftover halos with cloning, and then smooth the background using your favourite noise-reduction technique. Here I used the frequency filter to smooth the background without destroying the IFN detail. (Figure 8)

Save this mask and use it for the next iteration of arcsinh stretching of the original image to impart more IFN contrast. (Figure 9)

As with the previous iteration, use the feature mask and microcurves to finish off the mask. (Figure 10)

Convert the image to a luminance mask, and remove the diagonal gradient using the background compensation or the multi-point flatten tool. (Figure 11)

Now we have a mask that has a fair amount of IFN contrast and very low noise. I'll stop here, as I like a smooth, slightly lower-contrast look to my images, but if you want the IFN to overwhelm everything else in the image, use another couple of iterations to really make it pop.

Using this mask, I apply another arcsinh stretch to produce part of the final image. (Figure 12)

The multi-point flatten tool is used to correct the background colour to a neutral gray. Several points are

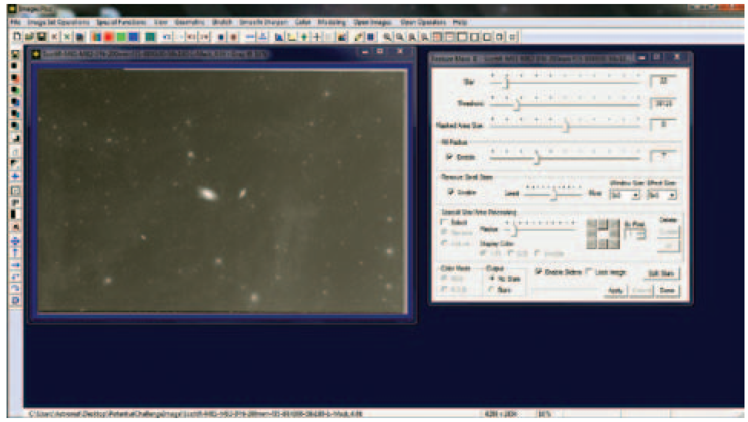


Figure 6 — Feature Mask to Remove Stars Again

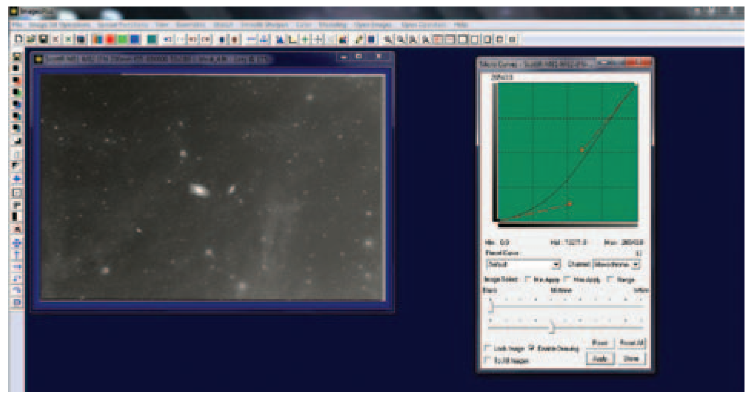


Figure 7 — Contrast Boost using Micro Curves

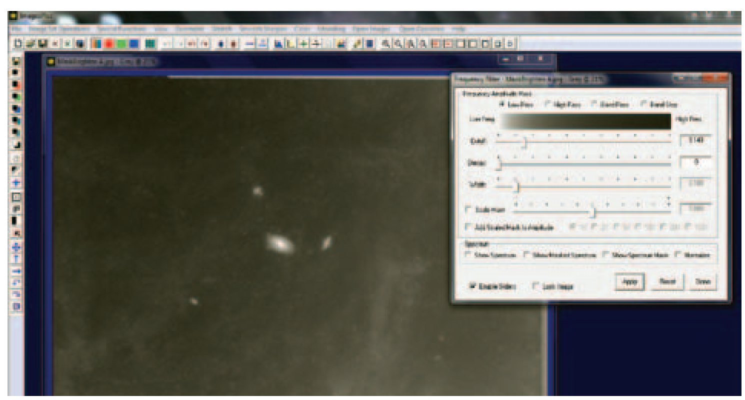


Figure 8 — Noise Reduction

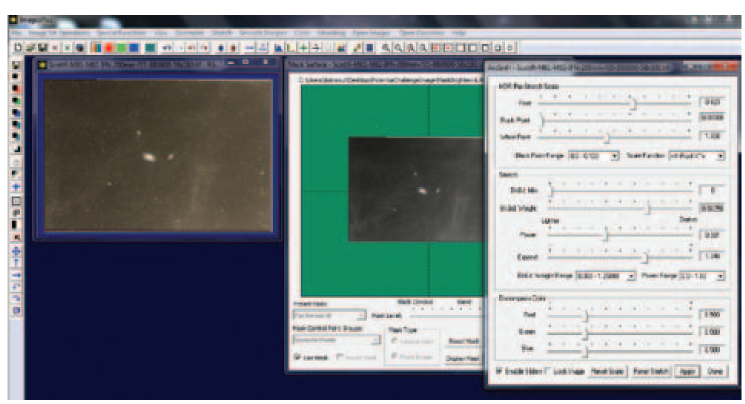


Figure 9 — Masked Arcsinh Stretch

selected with the tool, all in darker areas to normalize the background. (Figure 13)

Now we get to see the real power of the feature mask tool. All the stretching of the data has washed out the colour of the stars and bleached the colour out of the main galaxies in the image. You could carefully clone out the galaxies in the mask to avoid the problem, but there is a simpler approach. First, use the feature mask to remove the stars from the above image and call this *image A*. (Figure 14)

Next, carefully apply an arcsinh stretch, without any mask, concentrating on maintaining as much colour as possible and avoiding star bloat. This means that you must limit the total stretch; none of the IFN will be visible. (Figure 15)

Correct the background colour as shown. (Figure 16)

Use the feature mask to split this image into two, one containing the stars and another containing everything else. Use your favourite technique to boost the star colour. I simply made a star mask and used it on a saturation boost. Save this image as *stars*. Now go to work on the galaxy, sharpen it, increase its saturation, and don't worry about what it does to the rest of the image. Concentrate on making the main galaxies look the way you want. When you are happy with this, save it as *image B*. (Figure 17)

Finally, make a mask covering the two main galaxies, and blur it using a large-radius Gaussian of about 90 or so; use it in a stack with the combined images using blend mode, opacity, and masks tool. (Figure 18)

Now you have the best of both worlds: an image that has lots of faint IFN; lots of colour; and detail in M81 and M82. From here, I applied a gentle stretch using Micro Curves to improve the contrast a bit more. Finally, merge this image with the processed star image using the *merge split* blend mode to produce the image. (Figure 19)

From here, you can further enhance the image if you want, but I was rather happy with the result, so I didn't go any further. One of the nice things about the technique is the quiet background produced. This means that additional stretches are possible without having the image break down and become a mess of noise. You don't have to use so much noise reduction that you get an overly smooth and artificial look.

Don't worry about the exact tool settings that I used (they are in the screen captures). For the most part, it is the workflow that is important. I left out a screen capture of the final Micro Curves adjustment before

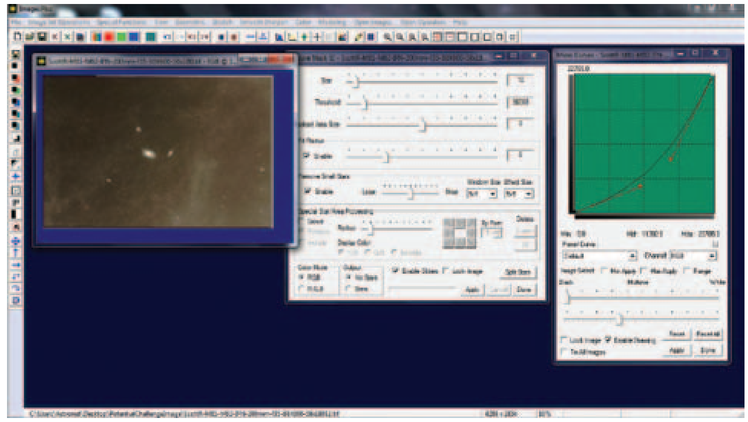


Figure 10 — Second Iteration Processing

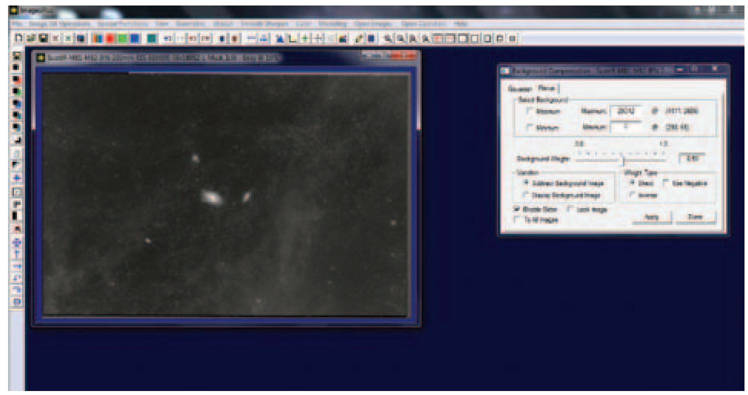


Figure 11 — Gradient Removal

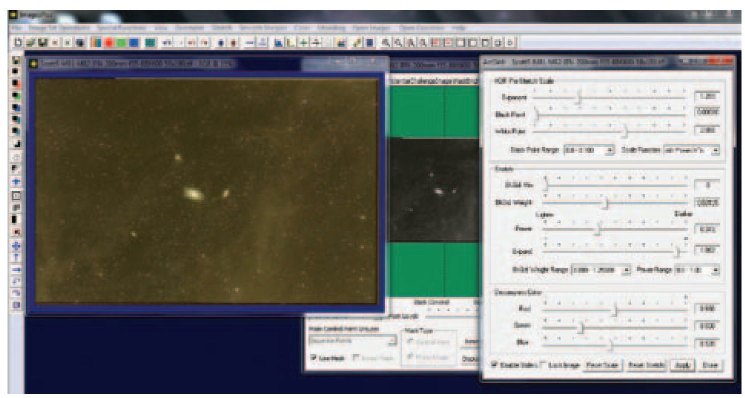


Figure 12 — Final Iteration Stretch

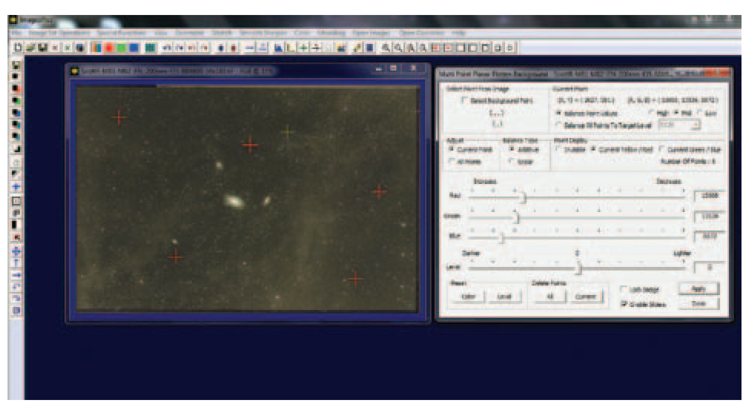


Figure 13 — Background flatten

the background and star layer combine, as you simply stretch the image to taste. If you want more IFN contrast, then add in a few more iterations to the masked stretching. You can also apply a simple "S" curve adjustment to the final image to make things stand out a little more, but be careful not to wash out the subtle star colour.

For those without *ImagesPlus*, you will have to work a little harder to use the technique, but all is not lost. You can generate starless masks using the technique on my tips page at www3.ns.sympatico.ca/b.macdonald/gallery/StarlessMask-Generation.htm. Curves can be used in place of the arcsinh stretch. Generating the split-star images is a bit more difficult, but www3.ns.sympatico.ca/b.macdonald/gallery/Stars&DSOs.htm will give you a place to start.

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.

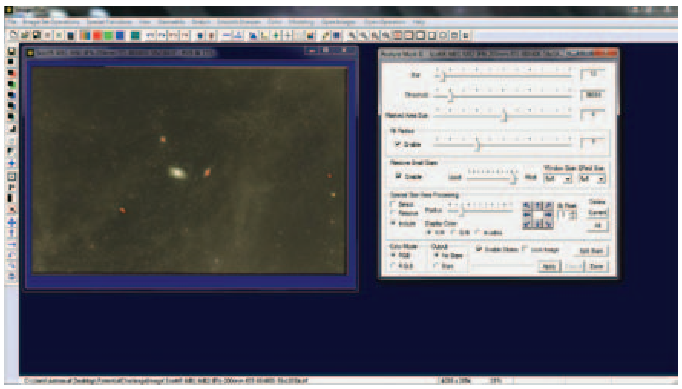


Figure 14 — Making Image A

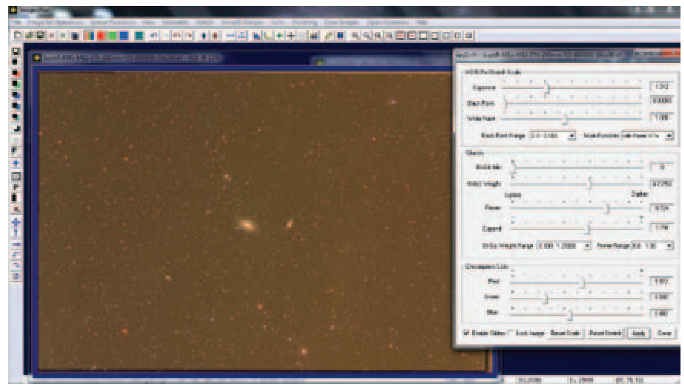


Figure 15 — Unmasked Stretch

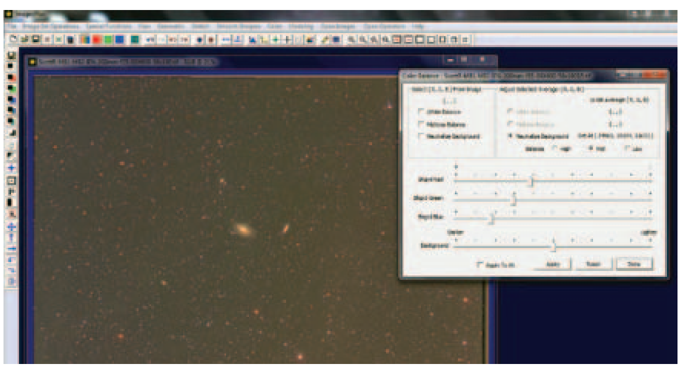


Figure 16 — Background Correction

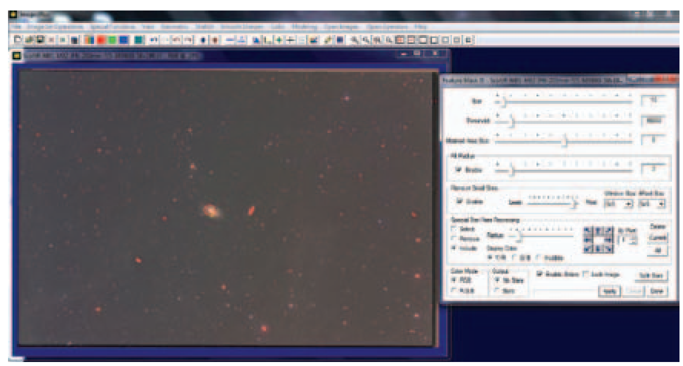


Figure 17 — Building Image B

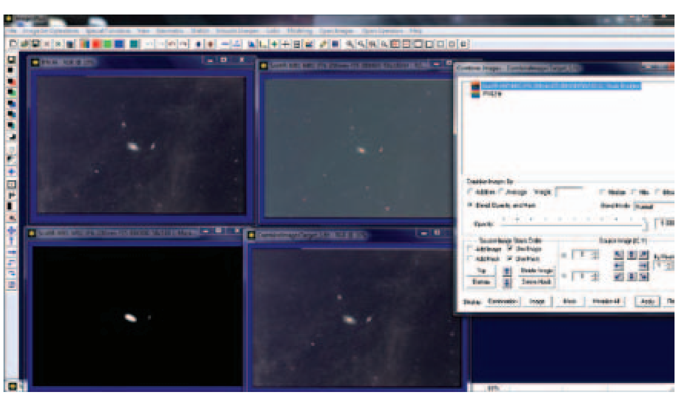


Figure 18 — Making the Final Background Image

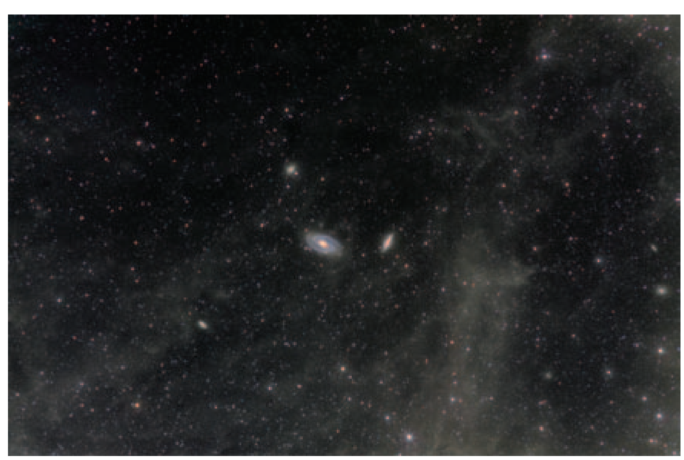


Figure 19 — Final Image

John Percy's Universe

Polaris—More than Just the North/Pole Star

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

During my half-century of research on variable stars and stellar evolution, my students and I have studied a large fraction of the brightest stars. My first astronomical research paper (Demarque & Percy 1964) was "A Series of Solar Models." I then turned to the β Cephei Stars (aka β Canis Majoris Stars), a class of pulsating B stars with a large representation of α and β stars. Then it was δ Scuti Stars, and then Be (γ Cas) stars—hot stars with emission-line spectra—of which there are several hundred among the naked-eye stars. Then it was on to pulsating red giants, initially ones that were bright enough for photoelectric photometry by the American Association of Variable Star Observers (AAVSO). Recently, my students and I have been using AAVSO visual data on pulsating red giants, most of which are well below naked-eye brightness. Amidst all this, we have studied some bright binary stars (including the mysterious ε Aurigae), magnetic stars (α^2CVn is the prototype), and bright Cepheids—including Polaris— α UMi. You get the picture: α, β, γ, δ, ε….

Yes, Polaris is a Cepheid pulsating variable star with a four-day period, the nearest and brightest of its class (see Turner (2009, 2012) for excellent reviews). The "father" of Cepheid research at the University of Toronto, and beyond, was Don Fernie, my Ph.D. co-supervisor (and RASC National President 1974–76), so it's not surprising that I developed an interest in these stars.

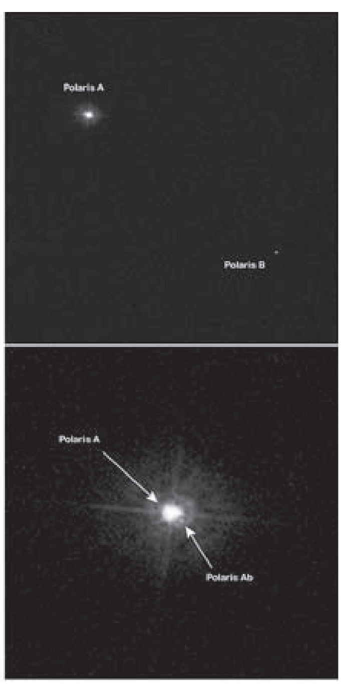


Figure 1 — Hubble Space Telescope images of Polaris A and B (top) and Polaris Aa and Ab (below). in this image, the separation between A and B is 18.217 arcseconds; that between Aa and Ab is 0.172 arcseconds. Image: NASA/ESA/HST.

Polaris is the best-known star in the northern sky—even though it's a historical accident that we live at a time when Earth's rotation axis points near this bright star. Some people mistakenly think that it's the *brightest* star in the night sky. It figures prominently in many cultures, whether in references in Shakespeare or in the Inuit language as "the star that never moves." But it's also astrophysically interesting and warranted a special session at the 2012 summer meeting of the American Astronomical Society. It pulsates (with changing period and amplitude), evolves, loses mass—and continues to mystify astronomers.

Polaris is also a triple star (Polaris Aa, Ab, and B; Figure 1) and this proves useful in several ways. Aa (the bright Cepheid component) and Ab are in a 30-year orbit. Spectroscopic observations of the radial velocity of Aa and *Hubble Space Telescope* observations of the separation between Aa and Ab provide a mass for Aa of 4.5 ± 1.8 suns—the first purely dynamical mass measured for any Cepheid (Evans *et al.* 2008). Furthermore, Ab and B are garden-variety F6 and F3 main-sequence stars, respectively. The absolute magnitudes of such stars are well-known from nearby examples. These absolute magnitudes, combined with the observed apparent magnitudes, give the distances to Ab and B, and hence to the Cepheid. This provides yet another calibration for the famous period-luminosity relation—now known as the Leavitt Law after Henrietta Leavitt (1868-1921), who discovered it. The Leavitt Law is one of the cornerstones of modern observational cosmology. Many important studies of Cepheids in binary and multiple systems have been carried out by Nancy Remage Evans (Ph.D. University of Toronto 1974).

Polaris has been known to be a small-amplitude Cepheid for over a century, but it was not until 1983 that Armando

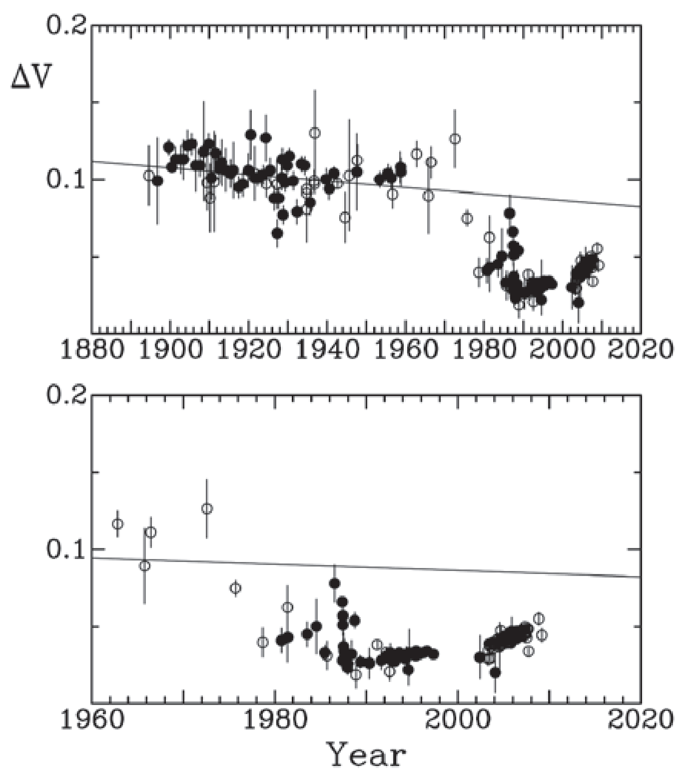


Figure 2 — The changing photometric (V) amplitude of Polaris (Turner 2009). Graph courtesy of D.G. Turner.

Arellano Ferro (1983) noted, in the course of his Ph.D. research at the Dunlap Observatory of the University of Toronto, that Polaris's amplitude was decreasing, and that Polaris might well become an ex-Cepheid by 2000 (Figure 2)! This prompted intensive observation and wide-ranging speculation about the cause of the amplitude change. The initial hypothesis was that Polaris's evolution was carrying it out of the regime of temperature and luminosity where pulsations were excited but, now that the pulsation amplitude is increasing again (Figure 2), there are alternative theories based on the possibility that the amplitude variations are cyclic and due to interference between close pulsation periods or some other complexity in the pulsation process.

Polaris's change in *amplitude* is unusual, but it is also changing in *period*, and that's normal in Cepheids. They are changing in radius as they evolve, and the pulsation period depends strongly on the radius of the star. Since the evolution of stars takes many millions of years, you might wonder how astronomers can measure changes in pulsation period within a lifetime. The secret: the changes in period cause a *cumulative* "error" in the measured time of maximum brightness compared with the time predicted if the period was constant. Consider the following analogy of two watches: a Rolex that is perfect and a Brand X that is slowly running down by one second each day. At the end of day 1, Brand X is wrong by 1 second; at the end of day 2, it is wrong by 1 + 2 = 3 seconds; at the end of day 3, it is wrong by 3 + 3 = 6 seconds; at the end of day 4, it is wrong by 6 + 4 = 10 seconds. The error accumulates as the *square* of the elapsed time and soon becomes noticeable if the observed time (O) on Brand X is compared with the correct or calculated time (C) on the Rolex. The so-called (O-C) diagram is parabolic. Figure 3 shows the (O-C) diagram for Polaris. The period is increasing by about 4.3 seconds per year. David Turner of Saint Mary's University in Halifax is a leader in studying the period changes and evolution of dozens of Cepheids in this way (*e.g.* Turner *et al.* 2006).

The evolution of stars like Cepheids is complicated. They spend most of their lives as "main sequence stars" on the famous Hertzsprung-Russell Diagram (HRD) of luminosity *versus* surface temperature, producing energy by fusing hydrogen into helium and not changing much. As they run out of hydrogen, they expand and move from left to right ("first crossing") on the HRD. As they begin to fuse helium, they rapidly contract and move from right to left ("second crossing"), then slowly expand again ("third crossing"). Some models also display a fourth and fifth crossing. When they expand, their pulsation period increases; when they contract, it decreases. The rate of period change may vary during each crossing, so the (O-C) diagram may be only approximately parabolic. The first crossing is about a hundred times faster than the third, so it is much less likely that we would observe a star in the rapid stage.

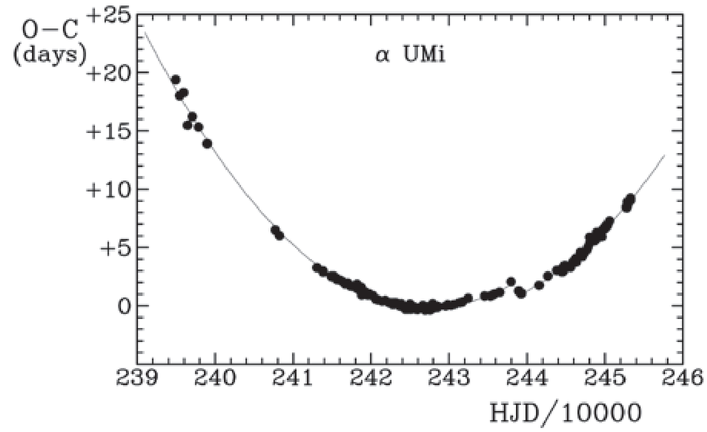


Figure 3 — The increasing period of Polaris, expressed as the difference (O-C) in days between the observed time of maximum brightness and the calculated time (using the ephemeris JD(max) = 2428260.727 + 3.969251 E), plotted against Julian Date in days (Turner 2009). Graph courtesy of D.G. Turner.

Evolution explains the smooth parabolic variation in Polaris's period, but there was also a "glitch" in period sometime between 1963 and 1966 (Figure 3) and a slight change in the rate of period change. The cause of the glitch remains unknown. By the way: observation of Polaris is not easy! The photometric and radial-velocity amplitudes are now very small. And it's difficult, with many large professional telescopes, to observe an object so close to the North Celestial Pole!

Comparison between theoretical evolution models and observed properties of Polaris, including its four-second-per-year period change, do not yield clear and unambiguous results. Canadian astronomer Hilding Neilson and his colleagues (Neilson *et al.* 2012) have made a detailed comparison between the observed rate of period change in Polaris and the rate expected from new evolutionary models. They conclude that there can only be agreement if Polaris is losing mass at a substantial rate. This is consistent with observations of interstellar material in the vicinity of Polaris.

The latest (but not necessarily last) words on Polaris are by Turner *et al.* (2013) and by Neilson (2014). They do not see eye to eye about the distance of Polaris (99 ± 2 or 129 ± 2 parsecs?), about its evolutionary state (first crossing or third crossing?), its pulsation mode (fundamental or first overtone?), and possible membership in a sparse cluster. I shall not attempt to review the evidence but refer you to those experts' papers: Turner *et al.* (2013) and Neilson (2014). Their lack of agreement is a reflection of the challenges of observing this or any other star, and the many complex factors that affect the star's properties and evolution.

An even more intriguing possibility was presented by Scott Engle, Ed Guinan, and colleagues at the 2014 winter meeting of the American Astronomical Society: has Polaris's brightness been steadily increasing for centuries and perhaps even millennia? This would be quite unexpected and quite unexplained. The interpretation of brightness measurements in historical star catalogues, however, is fraught with difficulty, and Engle, Guinan *et al.*'s work has not yet passed the hurdle of peer review. So stay tuned …

If you want to follow the ongoing discussion, or if you want complete information about Polaris or any other star, an excellent resource is the SIMBAD Database, at the Strasbourg Astronomical Data Center.

Next time you look at Polaris, or show it off at a star party, you can be assured that it's more than just the North Star, it is rich in astrophysical mysteries.

Acknowledgement

I thank Professor David G. Turner for reading a semi-final draft of this article. ✶

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RASC Awards 2014

Fellow Award:	Dr. James Hesser, Victoria
Chilton Prize:	Nathan Gray, Halifax, Kathryn Gray, Halifax
Qilak Award:	Dr. Howard Trottier, Vancouver
President's Award:	Robert Dick, Ottawa
Service Award:	Greg Lisk, Belleville Dave Gamble, Okanagan Chris Stevenson, St. John's Susan Gagnon, Kingston Dr. James Hesser, Victoria Jay Anderson, Winnipeg Mary Lou Whitehorne, Halifax

Greg Lisk (Belleville Centre)

Greg's nomination is based on his sustained contribution to the Belleville Centre of the Royal Astronomical Society of Canada. In 1994, Greg joined the Belleville Astronomy Club, which later transitioned into the Belleville Centre of the RASC on 2003 June 27.

Greg served the last eight consecutive terms as the President for Belleville Centre. As Centre President and key contributor, Greg leads the local Centre meetings and personally delivers segments reviewing current astronomical news, a highlighted observing object, and a featured topic for the evening. Serving as the Centre's Observing Chair, he organizes the monthly observing sessions and advertises them on the Centre's Web site.

Greg organizes the Astronomy Day booth at the local mall, setting up and operating the public information exhibit, and displaying his own meteorite collection and telescopes. In addition to staffing the daylong event, he also coordinates the Public Observing Session that follows in the evening.

Greg receives requests for speaking engagements and viewing sessions from local schools and groups and personally fulfills these public outreach commitments. After a recent request from the Air Force Museum in Trenton, Greg prepared a space-related, indoor, static display, created a permanent outdoor scale model of our Solar System, and coordinated public observing sessions.

Greg arranges the Centre's late-summer picnic and southern-sky public observing session—Star-B-Q—at Presqu'ile Provincial Park. Greg participates in and helps coordinate the autumn weekend dark-sky observing session—Fall'n'Stars—held jointly with the Kingston Centre. He has organized numerous field trips, such as visits to the Hayden Planetarium, NEAF, and AstroCATS for the benefit of the Belleville Centre members.

Greg designed a series of accomplishment pins and forwarded the idea to RASC National that became the wearable awards for the RASC Observing Certificate programs (*e.g.* Finest NGC, Messier).

Greg judges the astronomy-related entries at the regional Science Fair and awards a series of prizes to students, including the Arlyne Gillespie Memorial Prize. Greg will either donate a commercial telescope or one that he personally refurbishes as the first prize in the local competition. He also donates meteorites from his own collection for some of the lesser prize winners.

Greg Lisk is the driving force for the Belleville Centre and truly deserves recognition for his significant, long-lasting, and tireless contributions to not only the Belleville Centre but also to the local community.

Dave Gamble (Okanagan Centre)

Dave Gamble has contributed in a great many ways, but his most noteworthy accomplishments were in the design and building of the Okanagan Observatory's primary telescope, a 25-inch tracking Newtonian.

Mr. Gamble has served on the Okanagan Centre executive, including a recent term as Centre president. He updated and maintains the Centre's Web site, and added image galleries to showcase members' works. Dave is one of the Centre's leading astrophotographers and observers, and has encouraged and coached those activities. He has provided observing sessions for Summerland schools for many years

Dave designed a 25-inch folded Dobsonian telescope with a three-mirror system that does not require most viewers to climb a ladder. He built much of the telescope himself and donated some components. He regularly makes the long trek from Summerland to Okanagan Observatory to maintain the instrument. The Gamble 25-inch is used for very popular, public observing sessions every clear Friday evening between early May and late October. Observations made with this telescope have been published in *Sky & Telescope* magazine.

Dave Gamble has been Chair of the Okanagan Observatory telescope committee since August 2006, designing and building most of the 25-inch telescope, driving to Edmonton to retrieve the Zerodur mirror, obtaining a 25-inch replacement mirror, equatorial platform, and push-to system, laying the Okanagan Shortline (the shortest railroad in B.C., all 8 m of it!). Dave was President November 2010 – November 2011, Centre Webmaster, and Director of the Kelowna section in 2008.

Chris Stevenson (St. John's Centre)

Chris Stevenson has been a member of the RASC for more than 30 years and has been an Executive Committee member of the St. John's Centre for more than 11, including 6 years as President. Our Executive is challenged by limited access to speakers and other resources to which larger centres have ready access. The President's position in the St. John's Centre is especially challenged by our remoteness. The constant efforts to attract and retain members have always been important to Chris. His dedication to the Centre is noteworthy.

In a small Centre and remote Centre such as St. John's, recruiting and keeping Executive members is perhaps more difficult than for most Centres. In an era of volunteer burnout, recognition for long-term dedication is sometimes lacking but sorely needed.

As an employee of Memorial University, Chris is an enthusiastic liaison for the St. John's Centre, allowing us to keep university-supplied benefits such as parking, meeting space, speakers, and equipment storage space at no cost. These benefits help to allow our small Centre to continue to exist and serve its members and the general public. Given the infamous St. John's weather, our public monthly meetings serve a role when our sky-challenged activities fall short.

Chris is a frequent expert speaker, writer, media contact, and liaison with other groups. With a young family, job responsibilities, choir, and orchestra interests, Chris has been very generous to our Centre with his limited free time and leadership. He is a valued member of the St. John's Centre executive and frequently called upon to perform a variety of tasks. Our Centre's efforts to establish an observatory are being helped tremendously by Chris's expertise and experience. This observatory will be a major part of our public outreach activities, essential to our Centre's future.

Chris has given freely of his time and energy for the advancement of astronomy at the local and provincial level. He is a deserving candidate for the RASC Service Award.

Susan Gagnon (Kingston Centre)

Susan Gagnon is a good example of what flying under the radar can accomplish. What she has done is committed herself over two decades to the Kingston Centre fulfilling many roles. If we look at the last 20 years without her service, it is an eye-opening view. Below is the historical aspect of what Susan has done to enhance the RASC-Kingston Centre.

Susan joined the RASC-Kingston Centre on 1993 January 1. Since then, she has slowly eased her way into learning astronomy and committing herself to helping the Centre grow. Some of her roles in the Centre:

1995-1997 Kingston Centre GA Committee

1998-2000 National Council Rep

2000-2002 Kingston – Secretary

2008-2009 Kingston – Vice President

2010-2013 Kingston – President

Though she stepped down as President after two consecutive terms, Susan is still coordinating the Kingston Astronomical Outreach Network (KAON). This is a monthly open house and public observing session that is held in conjunction with the Queen's University Observatory. She has been dependable, regular volunteer at least as far back as 2003 and a Coordinator since 2007.

She has always been present with other volunteers at public outreach events: "Sky is the Limit" festivals and Astronomy Days in the parks, libraries, and various shopping malls. She has also helped out at the Charleston Lake Observing Sessions, accompanyingTerrance Dickinson on his August Astronomy Nights. Susan has also made presentations at the Cataraqui Conservation Area (February 2011) (http://crca.ca/) and the Kingston Field Naturalists Bio Blitz (June 2012) (http://kingstonfieldnaturalists.org/)

Susan has presented countless sessions to schools, Girl Guides, and Girl and Boy Scouts. She has also presented astronomy to the elderly in retirement homes. She arranged overnight observing sessions at Elbow Lake Environmental Education Centre (http://elbowlakecentre.ca/). Susan is also a regular member on the Fall'N'Stars (http://rascbelleville.ca/fallnstars/) Star party Organizing Committee for the last 12 years.

She helps out where ever she can when we are short volunteers and has an infectious smile and laugh that welcomes all who come into her presence. To us she is Super Woman, but she is terribly modest and self-effacing. Best of all she is our friend and well deserving of this award.

Dr. James Hesser (Victoria Centre)

Dr. Hesser is well known to the RASC, a member for nearly 30 years, and the Honorary President from 2009 to 2013. He is Director of the NRC Dominion Astrophysical Observatory (DAO), where he has been for more than 30 years. Dr. Hesser is Past President of the Canadian Astronomical Society (CASCA) and of the Astronomical Society of the Pacific. He is Past Vice-President of the American Astronomical Society. He is recipient of numerous awards, including, most recently, the Qilak Award for his "outstanding contribution to public appreciation and understanding of astronomy." He was one of the first to receive the prestigious Michael Smith award, given by NSERC Canada to recognize those who inspire through the promotion of science to the general public. The list goes on and on.

Dr. Hesser, as Director of the DAO, brought to it the Centre of the Universe, an important and popular science outreach site in this community. Dr. Hesser was the first recipient of the Newton-Ball Award, Victoria Centre's own service award (2001). In 2008, due in large part to Dr. Hesser's wise counsel, Victoria Centre was able to build an observatory on the grounds of the DAO. He has made easy our Centre's continued participation in public outreach on the hill (coming up on 100 years).

Dr. Hesser worked tirelessly to lead the International Year of Astronomy (IYA2009) efforts within Canada (2005-2009). He guided this highly visible and highly successful international project by serving as the country's "single point of contact" and as Chair of the Executive Committee and Advisory Board for IYA within Canada. Under his direction, IYA2009 provided "Galileo moments" to more than two million Canadians through more than 3600 separate events. Jim was often found at events dressed as Galileo himself, antique telescope in hand.

Dr. Hesser has long served on Victoria Centre Council as liaison with the NRC/DAO. His energy seems endless. Upon recently announcing his upcoming partial retirement from his post at the DAO, Jim showed up at a meeting of several of the organizational committees working on GA 2014 with a "well, finally I have some time to help with this!"

Your nominators cannot imagine a more worthy recipient of this award. Jim is a true gentleman, and for some 30 years has proudly and energetically promoted science in general, astronomy in particular, and the RASC and its Victoria Centre, across Canada, and in his community. His contribution to the efforts of the RASC has been profound.

Jay Anderson (Winnipeg Centre)

Jay has contributed to all facets of the Winnipeg Centre, and at the National level for a very long time. He originally joined the RASC in the early 1970s, and renewed his latest membership term in 1990. During this period of time, he has served as Winnipeg Centre President, Councillor, Secretary, National Representative, and is currently the Centre Treasurer. Jay is also serving his second five-year term as Editor-in-Chief of the *Journal*, a monumental task.

Jay's role with the Winnipeg Centre may best be described as a stalwart builder, both physically and mentally. He was a key participant in the initial construction of our observatory at Glenlea, and the subsequent rebuilds, which followed the incapacitating floods to the site. He is a key participant in the maintenance of, and annual upgrades to, the building. He's often dropping by to cut grass or shovel snow before any of our Centre-sponsored events at the site.

Jay is constantly trying to improve the Winnipeg Centre. As President, he made wholesale changes to our meeting format; setting the stage for a friendlier and more inviting meeting for new members. Jay participates by regular presentations at the meetings, plus monthly updates on the upcoming astronomical events that are worth enjoying. He regularly participates in the Centre's public observing sessions, bringing his expertise and his various telescopes. He also encourages others to travel to view events such as occultations, transits, and eclipses.

As one who enjoys bringing people together, he regularly lends out his house for Centre Council meetings, the Annual Winter Potluck dinner, and as a backup site in case of rain for our annual June Barbeque. Jay enjoys helping others to improve their observing skills. He is generous in lending out equipment and helping others develop their imaging skills.

Jay's contributions extend well beyond the Winnipeg Centre. He is an expert on solar eclipses, co-authoring the former NASA Eclipse guides. He is still sought out for his opinion on where to go to view eclipses, utilizing his long-term experience as a meteorologist.

Jay also significantly contributes with his writing and editorial skills. He is the author of many articles seen in our *Journal* and *Sky and Telescope* magazine. Jay also achieved a long sought goal, in tailoring the *Journal* into a more membership-friendly publication. He has solicited others to contribute with numerous monthly columns on amateur interests.

He has been involved as Chairman of the organizing committee for the past two General Assemblies in Winnipeg.

Jay does all this with a large smile on his face. His presence offers warmth, patience, and expertise to help others become the best astronomers they can. Winnipeg Centre is lucky to have him in our fold, and we are proud of his achievements.

Mary Lou Whitehorne

Mary Lou Whitehorne has had, for more than 25 years, a major and positive impact on The Royal Astronomical Society of Canada, both at the Halifax Centre level and at the National level.

While as a Medical Laboratory Technologist and mother of two young girls, Mary Lou read in an astronomy column by Terence Dickinson that one could see the Galilean moons of Jupiter with a pair of binoculars. She looked, and became hooked on astronomy!

She joined the Halifax Centre in 1985 and has since become a Life Member. Her sparkling personality and growing interest in the heavens inevitably led her into many executive positions within the Centre over a 14-year period, including as Councillor, Secretary, Observing Chair, and three years as Centre President (1990, 1991, and 2002), plus chair of the committee that hosted the 1993 RASC General Assembly in Halifax. Over the years, she has also given numerous presentations to the Centre on a wide variety of astronomical topics.

Mary Lou advanced her knowledge of astronomy with courses at Saint Mary's University. Her observations of B-e stars with the telescope at the Burke-Gaffney Observatory resulted in two papers in the RASC *Journal*, and the Chant Medal.

As a mother and amateur astronomer, Mary Lou became keenly interested in science education. Among her many endeavours in that regard, including being chair of the national Education Committee from 2004-2006, she, with other Centre members, established the Nova Scotia Planetarium Advisory Committee (which later became the Atlantic Space Sciences Foundation). She led this organization for several years, while it developed and ran a successful *Starlab* mobile planetarium program in Nova Scotia. The planetarium was later donated to Halifax's Discovery Centre, resulting in a legacy of astronomy being added to their continuing programs.

She has been continuously active in public outreach activities in the name of the RASC, with many other organizations. These include the Girl Guides of Canada, the Nova Scotia Museum of Natural History, Halifax's Discovery Centre, the Halifax Planetarium, and the Nova Scotia Department of Education.

A highlight of her work in promoting formal astronomy education is her book *Skyways, Astronomy Handbook for Teachers*. First published in 2003 by the RASC, the book is now in its second edition, with both English and French versions. She also authored the new *Moon Gazers' Guide* and edited the sixth edition of *The Beginner's Observing Guide* after the death of author Leo Enright. Over many years, she was also a contributor to the *Observer's Handbook* and the *Observer's Calendar*.

Mary Lou's major national service began in 2006, when she offered to run as a candidate for the position of RASC 2nd Vice-President. Upon her election, she began an eight-year sequence of service to the Society as 2nd Vice-President, 1st Vice-President, President (2010-2012), and most recently, Past President and Chair of the Awards Committee.

A rare moment in Mary Lou's life occurred during those years. At the 2007 General Assembly in Calgary, she was rendered speechless by the announcement that asteroid 144907 had been named "Whitehorne" in her honour.

Mary Lou was our 1st Vice-President during 2009, the International Year of Astronomy, when the RASC partnered with CASCA and the FAAQ to coordinate activities and produce several bilingual outreach publications. In addition to being the inspiration for the *Mary Lou's New Telescope* children's book, Mary Lou continued the legacy of IYA2009 by joining the Beyond IYA Committee, which continues the outreach partnership between the three organizations.

The years Mary Lou has spent in the presidential and vice-presidential positions were unusually busy ones for the Society, and at times turbulent. She took the executive lead to respond quickly to the Canada Revenue Agency crisis in 2008, when the Society had to seek the guidance and advice of corporate counsel. Mary Lou acted as the Society's liaison and spearheaded meetings between the Executive, National Council, and the lawyer.

Among other issues facing the Society during those years were government-legislated changes in the governance structure of the Society; changes in staffing at the Society Office; and the transition of the office from its own building (with landlord responsibilities) into rental accommodations. These issues and others demanded much of Mary Lou's time and talents. The successful outcomes were in no small way the result of her initiative, good judgment, and tenacity.

One of Mary Lou's lasting legacies is the creation of the professional Executive Director position. Mary Lou had a vision that the Society needed such a person to move the Society forward. Working in concert with the Executive Director and others, Mary Lou was also instrumental in creating the first Strategic Plan that the Society has seen in many years.

Over the years, the RASC has been fortunate to have several distinguished ladies as presidents, including Allie Vibert Douglas, Ruth Northcott, Helen Hogg, and Mary Grey. In the early years of the 21st century, our Society has again benefited from a lady's perspective, determination, and grace. It is with deep thanks and appreciation that we recommend Mary Lou Whitehorne for the RASC Service Award.

Dr. James Hesser (Victoria Centre)

In recognition of Dr. Hesser's decades-long term contributions to the RASC, his leadership in building partnerships, bringing amateurs and professionals together and leading joint initiatives, the depth and scope of his contributions, and their broad national and international impact regarding the Society's objectives, mission and vision, the Awards Committee recommends that Dr. Hesser also be named a Fellow of the RASC.

Kathryn & Nathan Gray (Halifax Centre)

It is with great pleasure and pride that, on behalf of the Halifax Centre Council, we submit the following nomination to the RASC National Awards Committee.

The Chilton Prize is awarded to an amateur astronomer, resident in Canada, in recognition of a significant piece of astronomical work carried out or published during the year. The Halifax Centre has two members, sister and brother, whom we believe qualify admirably for the award. In 2011, Kathryn became the youngest person, at age 10, to discover a supernova, when she found SN 2010lt in galaxy UGC 3378 in the constellation of Camelopardalis. In November 2013, Nathan has now become the youngest by 33 days (he is now 10 years old) with his discovery of SN 2013hc in galaxy PGC 61330 in the constellation of Draco. Both young astronomers received galaxy images taken by astronomer Dave Lane at his Abbey Ridge Observatory.

With their father's help, both Kathryn and Nathan learned to identify supernovae in photos using special computer software. With images taken at Abbey Ridge Observatory, Kathryn searched through 7761 photos taken over 81 nights in 2011 and 2012. Nathan joined the hunt this year, and since then, Nathan and Kathryn have searched through an additional 5936 images taken over 40 nights. With amazing dedication to their search, Kathryn and Nathan have searched 13,697 images and found one new supernova each.

As a result of her discovery, Kathryn was asked in May 2011 to be Honorary Parade Marshal for the Grand Street Parade of the Apple Blossom Festival. She was asked in June 2011, to take part in the opening of the Starmus Festival in Tenerife, Spain (in the Canary Islands), a unique scientific, artistic, and musical event, where she met Neil Armstrong and many other astronauts and leading astronomers. In August 2011, Kathryn won the Bring Home the Bacon Award, which was presented at Starfest, the largest star party in Canada. In November 2011, Kathryn was named one of *Glamour* magazine's 21 Amazing Young Women of 2011. Kathryn has fielded many interviews from the world press and given numerous talks about her discovery. Nathan's recent find has led to many press interviews and a few presentations as well.

Despite the achievements of these two young astronomers, we feel that their greatest contribution to astronomy has been in how they have inspired so many young people to look at science as something that they too could be able to do. Many RASC members have done outreach events in school classrooms and libraries and have been both amazed and gratified to see Kathryn's picture up in the classroom as well as the large number of both young and old who have heard of Kathryn's and Nathan's discoveries. The poise, enthusiasm, and obvious understanding of their accomplishment that Kathryn and Nathan have shown during their many interviews and presentations make us proud to have these two young astronomers as members of our Halifax Centre.

Both Kathryn and Nathan are continuing their supernova hunt with images that Dave Lane continues to take for them from his Abbey Ridge Observatory whenever the nights are clear. Their dedication to this often-tedious task shows us what can be accomplished by today's youth. With the inspiration that these two young astronomers have given to both young and old, we of the Halifax Centre are pleased to nominate both Kathryn and Nathan Gray as worthy recipients of the Ken Chilton Prize.

Qilak Award

Dr. Howard Trottier (Vancouver Centre)

The Vancouver Centre nominates Dr. Howard Trottier for the Qilak Award for Astronomy Outreach and Communication. Howard is our departing president of RASC-Vancouver as well as a physics professor at Simon Fraser University. Although not a professional astronomer and working at a university that does not have an astronomy program as of yet, Howard managed to bring his passion for astronomy both to the faculty and students of SFU, and also a very great number of school-age children, their parents and teachers, along with the general public.

Howard started a program five years ago called Starry Nights @ SFU. Starry Nights consists of two programs in one. First Howard hosts evening star parties at the university campus with the help of a dedicated group of volunteers from RASC-Vancouver and SFU's Student Astronomy Club, who bring along telescopes, equipment, and knowledge. These star parties are free to the public and have become hugely popular around the Metro Vancouver area. Howard's mailing list of people wanting to be kept informed of their schedule now numbers in the thousands.

During the day, he has hosted and continues to host astronomy workshops for school-age children at SFU's campus. With his volunteers from the faculty and student body of SFU, along with RASC members, whole classrooms of children learn the history of astronomy, basics of the night sky, how telescopes work, and, depending on the age of the group, possibly some astrophysics. This is all done on his own time while still fulfilling his teaching duties. He was able to get his astronomy program included within SFU's Science in Action program. This increased the number of schools interested in taking part in this free program.

Howard's hard work at seeking sponsorship for the Starry Night's program has also paid off in the participation of two telescope stores as well as private donors and the support of RASC-Vancouver members. This has allowed Howard to offer free telescopes to every school that participates as well as free telescopes for families that show enough interest to also attend at least five Starry Nights star parties or other qualifying event.

Somehow, Howard has also made time to host the Starry Nights Webpage. On the Web site, parents and kids can check out the events they and their classmates have been to. They can also keep an eye out for upcoming Starry Nights events. Sponsors and volunteers are also recognized on the site. Howard writes a blog of the events and includes a photo gallery of the "Astro Grads" and events.

We feel he has been responsible in starting and maintaining the most successful astronomy outreach programs ever in Metro Vancouver. Howard's efforts have resulted in bringing the night sky to thousands of students, their families, their teachers, the faculty, and student body of SFU, as well as a very large number of the public.

We invite the committee to check out the Starry Nights Web page at www.sfu.ca/starrynights/index.html ✶

Society News

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

After Melissa Mascarin left our Society Office, we began a search in Toronto for a replacement, screening several prospective applicants. We hired Julia Reeser as our new Marketing Coordinator, beginning in mid-July. Please make her feel welcome if you happen to call the office.

The General Assembly will be just a memory by the time you read this, but we had some great times and a great gathering in Victoria. We'll put some photos into the October *Journal* for your viewing pleasure.

This is the lineup of the Executive and Directors for 2014/2015, stemming from the Annual General Meeting:

President	James Edgar
1st Vice-President	Colin Haig
2nd Vice-President	Dr. Chris Gainor
Treasurer	Denis Grey
National Secretary	Dr. Karen Finstad
Directors	Dr. Randy Boddam Robyn Foret Craig Levine Dr. Paul Schumacher
Executive Director	Vacant

This is my last Society News, having withdrawn from the National Secretary position, so now I'll go write the President's Corner! ✶

Planets Crossword Answers

by Naomi Pasachoff

A	T	L	A	S		F	R	A	Y		A	R	A	D
C	O	A	S	T		R	E	N	E		M	E	L	U
R	O	C	H	E	L	I	M	I	T		I	C	A	N
E	T	E		E	I	D	I			E	D	A	M	S
			G	R	E	A	T	R	E	D	S	P	O	T
E	M	B	A	S	S	Y		A	W	E	T			
T	A	I	L				O	V	E	N		A	K	A
W	I	L	L	I	A	M	H	E	R	S	C	H	E	L
A	L	L		D	I	E	M				H	E	L	P
			S	A	M	I		S	C	R	I	M	P	S
S	H	E	P	H	E	R	D	M	O	O	N			
A	U	D	I	O			R	E	S	T		P	E	A
I	G	E	R		E	Q	U	A	T	O	R	I	A	L
D	E	M	I		M	U	I	R		R	I	N	S	E
A	R	A	T		P	O	D	S		S	P	A	T	S

Madawaska Highlands Observatory Corp. Inks $3M Investment

by Frank Roy / CEO and Founder, Madawaska Highlands Observatory Corp.

Ottawa – June 2014. The Madawaska Highlands Observatory Corp. (MHO) has inked its first major investment deal. Oakville Hydro Energy Services Inc. (OHESI) is investing over $3,000,000 into the Madawaska Highlands Observatory. OHESI is a wholly owned, non-regulated business subsidiary of Oakville Hydro Corporation that invests in the development, operation, and long-term ownership of sustainable, community-based, energy and related infrastructure assets. The MHO is very pleased that the OHESI is investing in this landmark project. It was the Visitors' Centre off-grid nature that OHESI found particularly attractive and is an extremely good fit for them. ✶

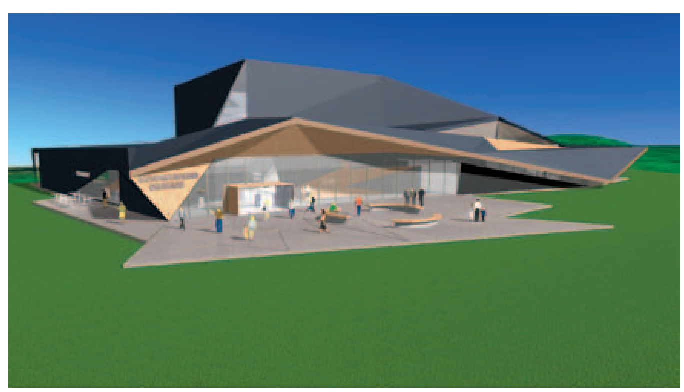
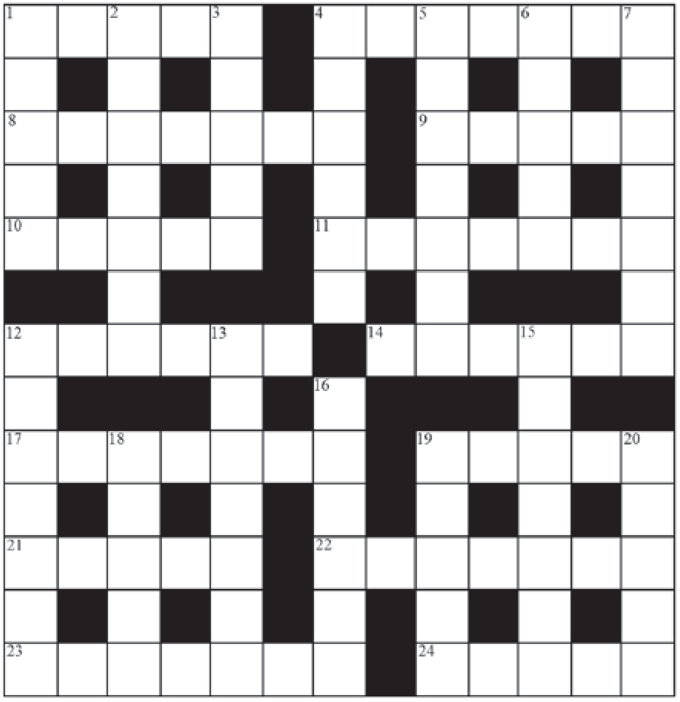


Figure 1 —Visitors Centre June 2014. Christopher Simmonds Architect Inc. Rendering by Shadow Forge Animations.

Astrocryptic

by Curt Nason



ACROSS

1. Half of astrolabes reassembled by a Dominion Astronomer (5)
4. Sky King never lands in Canada (7)
8. Google gave me links to Messier's pal (7)
9. Misconstrued topic of the eye (5)
10. Told of a disturbance in Saturn's rings (5)
11. Half return time reversal from a source of gamma rays (7)
12. Price a star in Musca (3, 3)
14. Vulpecula ran around inside the furnace (6)
17. Endless electric scrambling device in a 1x finder (7)
19. Bear paw stars follow Vincent's Bebop tune (5)
21. Hot stellar type in odd zero age main sequence stage found in Leo (5)
22. Hubble's constant supporter had mixed agendas (7)
23. Ridpath turned in the farmer's place north of Posidonius (7)
24. They're great for stargazing or observing erratic bison (5)

DOWN

1. Cepheid type stars give first billion to masked men behind home (5)
2. Mould clay by one famous sister (7)
3. Relative size of a map of Piscis Austrinus? (5)
4. Odd race around North Carolina to sidewalk constellation (6)
5. Nickelback in picture of a fermion (7)
6. Old socioeconomic database abandoned in Vesta trail (5)
7. X-rays scatter about carbon monoxide around Uranus (7)
12. Altar placed between end of first and last letter on the eagle's shoulder (7)
13. Tat lace coat to make a milky way (7)
15. Let nun name strange lines in iron meteorites (7)
16. Parallax pioneer, could be, with not as much in return (6)
18. Unusual stony star in the Cosmos (5)
19. It formed within a stellar nebula in Aries (5)
20. Project NEAT looked south for Earth-crossing asteroids (7)

Answers to June's Astrocryptic

ACROSS

1 MERCURY (Hg pun); **5** VENUS (reverse); **8** ARNEB (Arne + B); **9** RETICLE (2 def); **10** EMANATE (hidden); **11** CETUS (Cletus-L); **12** NICKEL (nick (name) + el); **14** GNOMON (g+anag+n); **17** AESOP (anag); **19** OBSERVE (OB+Ser+Ve); **22** HIRUNDO (H(I run)D+o); **23** LYDIA (Groucho song); **24** SABIK (anag+K); **25** ANTENNA (2 def)

DOWN

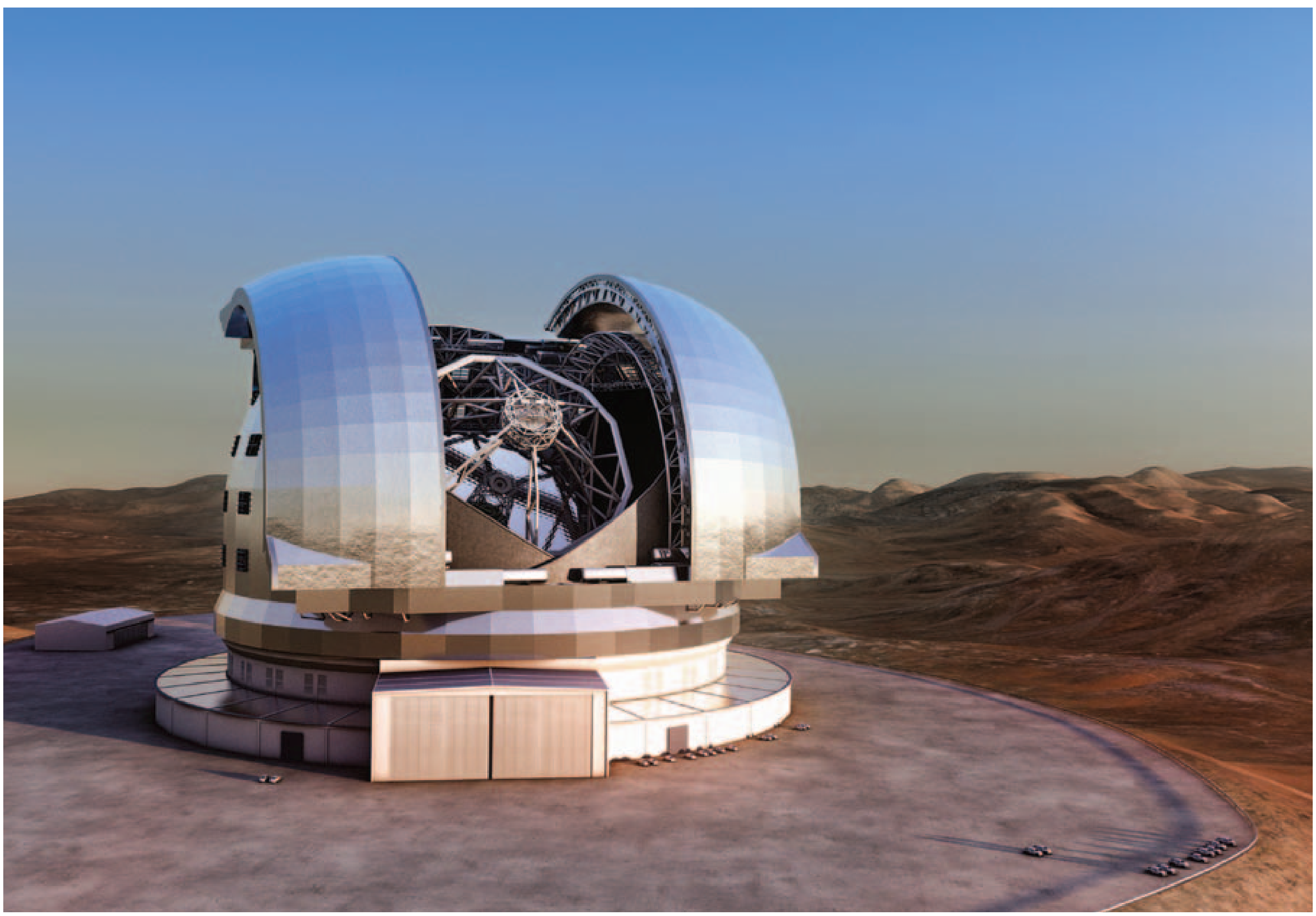
1 MEADE (m(E)ade); **2** RING ARC (R+anag); **3** UMBRA (mu(rev)+bra); **4** YERKES (anag-ie); **5** VATICAN (anag-o); **6** NACHT (anag); **7** STETSON (2 def); **12** NOACHIS (anag+o); **13** ESPENAK (e+anag+n); **15** MARSDEN (anag+n); **16** CORONA (2 def); **18** SCRUB (s+Cru+b); **20** SPLIT (sp(L)it); **21** ELARA (le(rev)ara)

It's Not All Sirius

by Ted Dunphy

I'm just saying... you might be getting a little obsessed with the Isabel Williamson Lunar Observing Program.

Great Images



Another era in astronomy opened in June with the preparation of the grounds for the European Extremely Large Telescope (E-ELT), shown in this artist's concept at its location in the Chilean Andes. The design of the new telescope calls for a 39-metre ƒ/10 — ƒ/20 segmented main mirror with a 4.2-metre secondary, the equivalent of 37,394 Celeston 8s. Many wonderful things are promised for the $2 billion project.

Great Images

Ron Brecher loves "coming back to favourites to see how different equipment, conditions, and my improving processing skill affect the quality of my images." This is his third version of NGC 891, an edge-on spiral in Andromeda about 30 Mly distant. Ron used a 10-inch ƒ/6.8 astrograph and an SBIG STL-11000M camera. Exposure was 14×10 m in L, and 6×10m in each of R, G, and B for a total of 5h 20m.