The Journal of The Royal Astronomical Society of Canada

# Journal

Le Journal de la Société royale d'astronomie du Canada

PROMOTING ASTRONOMY IN CANADA

June/juin 2012
Volume/volume 106
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Madawaska Highlands Observatory

Astronomy the Babylonian Way

Universe Starter Kit

Stargazing in a Rush

*CASTOR*

Flat Frames

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75th Birthday—Valentina

*Captured: A Ghost in Cepheus*

# Astrophotographers take note!

This space is reserved for your B&W or greyscale images; a new feature in the *Journal*. Give us your best shots!

*Tony Peterson is captivated by Hα images and provides us with this photo of the California Nebula in Perseus. The image was caught using a Parsec 8300M camera through a 7-nm filter attached to a Tele Vue 85-mm refractor scaled to f/5.6. The image is a combination of two stacks, one totalling over 6 hours of exposure, the other of 4.7 hours. Tony's site is only 8 km from the Parliament Buildings, well inside Ottawa's light dome.*

Journal

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Royal Astronomical Society of Canada

Société Royale d'Astronomie du Canada

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***Front cover*** *— This image of vdB 141—the Ghost Nebula—is the result of approximately 15 hours of exposures by Howard Trottier at his Cabin in the Sky Observatory in the South Okanagan, B.C. Howard used a PlaneWave Instruments CDK17, operating at f/4.5, and an SBIG STL-4020M camera to accumulate 6 hours in luminance (unbinned) and about 3 hours in each of R, G, and B with 2x2 binning. The Ghost is a reflection nebula and molecular cloud complex lying about 1200 light-years away in Cepheus.*

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

*Mary Lou Whitehorne*
*President, RASC*

As I sit down to write this column, it is hard to believe that my term as President is winding down. This is my last *President's Corner*! I look forward to reading what our next President will have to say in this space of the *Journal*. It has been an honour to serve on the RASC's Executive Committee for the last six years and to have spent two years representing the Society as its President. It has been a genuine pleasure to work with so many talented, energetic, generous, and committed volunteers toward the goals of the Society.

Over the last two years, the RASC has initiated an impressive number of significant changes, additions, and projects to the workings of the Society. Together these will place the RASC in a position of strength and leadership as we look to the future with optimism and energy. These changes include:

- Hiring our first Executive Director, Deborah Thompson, who brings professional management skills and experience to everything we do as a Society
- Putting in place a full National Office staff with the needed knowledge, skills, and experience to handle Society business effectively and efficiently
- Crafting a new strategic plan and marketing communications plan to guide our activities
- Successfully implementing new business practices, policies, and procedures to improve membership services and business operations
- Reducing operating costs through comparison shopping and the RFP bidding process for large items like printing contracts and insurance services
- Receiving a $25,000 marketing grant for the *JRASC* through the Canadian Periodical Fund and applying for a second grant this year to publish a special *JRASC* edition devoted to light-pollution abatement
- Successfully renewing our joint, three-year RASC/CASCA/FAAQ NSERC PromoScience grant to fund development and delivery of the *Discover the Universe / À la découverte de l'Univers*, our free bilingual webinar training program for teachers and informal educators
- Strengthening and broadening the reach and scope of our mutually beneficial EPO partnerships with CASCA, the FAAQ, and most recently, with the Dunlap Institute

- Further developing an excellent working partnership with Parks Canada through the certification of more Dark-Sky Preserves, putting Canada in a leading role globally, with more and bigger DSPs than any other country

- Establishing a good working relationship with Transport Canada on the issue of green-laser pointers

- Enhancing our EPO programming with the addition of two new educational resources (the *Moon Gazers' Guide* and the Transit of Venus materials)

- Beginning the challenging-but-necessary process of migrating to the new Canada Not-for-profit Corporations Act (CNCA), which will result in the creation of completely new governance documents and structure for the RASC

- Fully implementing the iMIS office and membership management system

- Refreshing, updating, and expanding our Web site to improve the user's experience

- Publishing the David Levy logbooks on our Web site for the benefit of everyone

- Enhancing the value of the *Observer's Handbook* by including the special edition ECU-OH planetarium software with the book

- Joining the world of social media with Twitter and Meet Up, with more to come in the future.

At the time of this writing, the annular/partial solar eclipse and the Transit of Venus are fast approaching. Both events represent golden opportunities to showcase the RASC and its work to Canada and the world. With new resources and organized effort by many volunteers, these events promise to be great successes for us.

Looking a little further ahead, the new CNCA legislation and the changes it will bring to our governance model will involve some difficult decisions and much hard work. The incoming Executive Committee is uniquely suited to embrace this challenge and successfully complete the transition from old to new legislation. It will be worth it in the end.

As I complete my term as President, I extended my deepest appreciation to my colleagues on the Executive Committee, and to our wonderful staff, Deborah, Renata, and Emily, for their unwavering support and selfless generosity to the RASC. I thank our hard-working committee chairs, our dedicated members of National Council, our Centre executive members, and all of our members who support and participate in the life of the Society. I ask of everyone that they continue to do everything they can to support our new national President and his executive team as they work to meet new challenges and to expand and strengthen the RASC into the future.

I will conclude by saying the bedrock upon which the Society foundations firmly stand is you, our member-volunteers. Without you there would be no RASC. We enjoy an unequalled international reputation for quality, authority, and integrity that has been built by RASC volunteers over our 144-year history. This is no small achievement. Please do carry on, and…

*Quo Ducit Urania!* ✶

# News Notes / En manchettes

*Compiled by Andrew I. Oakes*
*(copernicus1543@gmail.com)*

## Serpent Dust Devil

In late spring of this year, the High Resolution Imaging Science Experiment (HiRISE) camera on NASA's *Mars Reconnaissance Orbiter* snapped a picture of a towering dust devil travelling over the Martian surface in the Amazonis Planitia region of northern Mars (at 35.8°N latitude, 207°E longitude). The orbiter's image of the dust devil (Figure 1) spans a distance of about 640 metres, with north toward the top. The length of the dusty whirlwind's shadow indicates that the plume reached more than 800 metres in height and was about 30 metres in diameter. According to researchers who analyzed the photo, a westerly breeze partway up the length of the dust devil produced a delicate arc in the plume.

Amazonis Planitia, a dusty plain, is a well-known site for the formation of dust devils and was targeted deliberately to find whirlwinds for study. Past images, obtained serendipitously, have shown wind speeds of 105 km/h in the circulation around

*Figure 1 — NASA's* Mars Reconnaissance Orbiter *snapped a picture of a towering dust devil travelling over the Martian surface in the Amazonis Planitia region of northern Mars on 2012 February 16. Image: NASA/JPL-Caltech/University of Arizona*

the devils. The northern hemisphere of the planet was just entering its summer season in February, and further examples are expected as the season advances.

HiRISE is a telescopic three-color high-resolution camera that provides the sharpest imagery of the Martian surface yet collected from orbit. The University of Arizona, Tucson, USA, operates the HiRISE camera, which was built by Ball Aerospace & Technologies Corp., Boulder, Colorado.

## First Earth Trojan asteroid identified

Astronomers have located the first Earth Trojan asteroid having long suspected that such a Solar System body would eventually be found sharing Earth's orbit. Known as 2010 TK7, the asteroid was detected by NASA's *Wide-field Infrared Explorer* (*WISE*) mission, and followed by ground-based observations with the Canada-France-Hawaii Telescope (CFHT) to confirm the asteroid's Trojan classification.

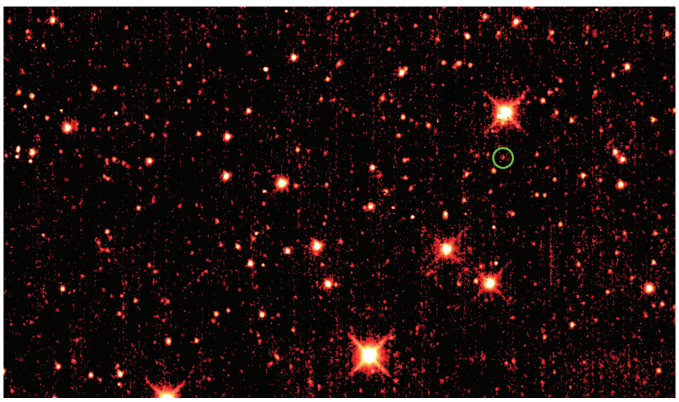

*Figure 2 — Asteroid 2010 TK7 is circled in this single frame taken by NASA's* Wide-field Infrared Survey Explorer (WISE). *The image was taken in infrared light at a wavelength of 4.6 microns. Image: NASA/JPL-Caltech/UCLA*

The discovery was made by a research team led by Martin Connors, Canada Research Chair, Space Science, at Athabasca University, Alberta. Other team members included colleagues Paul Weigert, Department of Physics and Astronomy, the University of Western Ontario, and Christian Veillet, Director of the 3.6-metre Canada-France-Hawaii Telescope in Hawaii. Details of the long-awaited discovery were highlighted in the 2011 July 28 edition of *Nature* magazine.

Dr. Connors, who is in charge of the Athabasca University Geophysical Observatory in northern Alberta and is a world-renowned expert in asteroids and near-Earth objects, notes that the discovery is important because it proves that Trojans can exist in orbit around the Sun in a very Earth-like orbit.

A Trojan asteroid not only shares its orbit with a planet but features an almost identical orbital period. When a Trojan is viewed from the related planet, the asteroid appears to oscillate about one of the stable points in front of, or behind, the planet. Trojans were previously known to exist in association with Jupiter, Neptune, and Mars. Thousands of Trojan asteroids share Jupiter's orbit, while Saturn is orbited by a few groups of Trojan moons.

Asteroid 2010 TK7 remains on the leading side of the Earth as both go around the Sun at almost precisely the same average

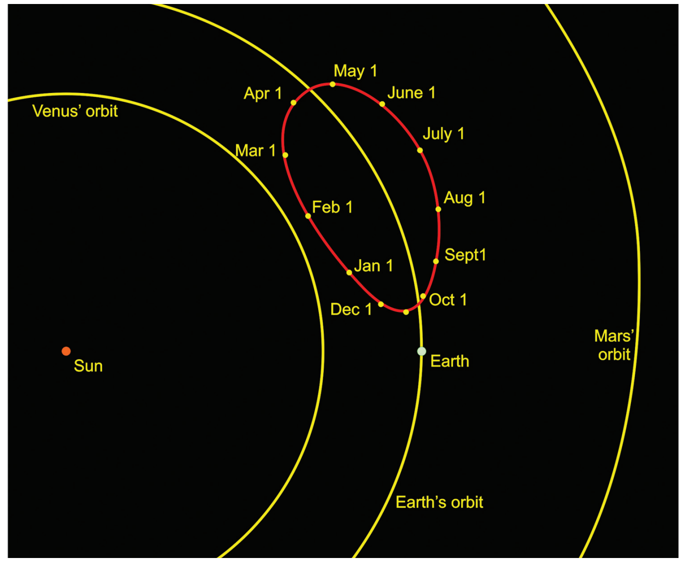


*Figure 3 — This diagram depicts the motion of 2010 TK7 in 2011 relative to Earth, looking down from above the Solar System. Although Earth and the Trojan asteroid both actually orbit the Sun, the relative motion appears as a large loop. Image: NASA/JPL Near-Earth Object Program Office.*

rate. The asteroid's orbit is both quite eccentric and inclined to the Earth's orbit, causing TK7 to appear to loop around an empty point in space when viewed from the Earth, taking one year to complete the cycle.

The Earth's Trojan is about 300 metres (1000 feet) wide and sits about 80 million kilometres (50 million miles) in front of Earth. At its closest point to Earth, 2010 TK7 is still many times the distance to the Moon, much further than other asteroids that occasionally pass by our planet.

It is estimated that in the next 10,000 years, 2010 TK7 will not approach Earth any closer than 20 million kilometres, over 50 times the 384,000-kilometre distance to the Moon. Earth Trojans have not been spotted before as they tend to be relatively small and to lie in the general direction of the Sun as seen from Earth, making them hard to spot in the star's glare. 2010 TK7's orbit takes it far enough away from the Sun for telescopes to spot it.

## List of five-year technology development priorities to assist NASA planning

The Washington-based National Research Council (NRC) has identified 16 top-priority technologies necessary for NASA's future activities. In a report titled *NASA Space Technology*

*Roadmaps and Priorities*, the NRC recently provided NASA with findings and recommendations on where best to invest in technologies needed to enable NASA's future missions in space. The National Research Council is the principal operating agency of the National Academy of Sciences and the National Academy of Engineering; the study was sponsored by NASA and is expected to help define the agency's technology development priorities.

The NRC chose the 16 top-priority technologies from its own ranking of 83 high-priority technologies out of approximately 300 previously identified in a set of NASA roadmaps. The top activities include radiation mitigation; guidance, navigation, and control; nuclear systems for both power generation and transportation; and solar power generation (see accompanying table).

The identified priorities align with three main facets of NASA's overall mission:

- Extending and sustaining human activities beyond low Earth orbit;
- Exploring the evolution of the Solar System and the potential for life elsewhere; and
- Expanding understanding of Earth and the Universe.

The NRC report also recommends emphasis on flight demonstrations for technologies that are nearly ready and a 10% allocation from the existing program budget to advance and refine early emerging technologies.

The next step is for NASA's Office of the Chief Technologist to lead an agency-wide analysis and coordination effort to update the agency's technology-area roadmaps with the NRC report's findings and recommendations. The report notes that in order to further foster collaboration, the Office of the Chief Technologist should make the scientific and technical data that NASA has acquired from past and present space missions and technology development more readily available to U.S. industry.

Table 1 — The highest-priority technologies for research and development over the next five years include the following:

| **Objective A**<br><br>**Extend and sustain human activities beyond low Earth orbit** | **Objective B**<br><br>**Explore the evolution of the Solar System and the potential for life elsewhere** | **Objective C**<br><br>**Expand understanding of Earth and the Universe** |
|---|---|---|
| Radiation Mitigation for Human Spaceflight | Guidance, Navigation, and Control | Optical Systems (Instruments and Sensors) |
| Long-Duration Crew Health | Solar Power Generation (Photovoltaic and Thermal) | High-Contrast Imaging and Spectroscopy Technologies |
| Environmental Control and Life Support Systems | Electric Propulsion | Detectors and Focal Planes |
| Guidance, Navigation, and Control | Fission Power Generation | Lightweight and Multifunctional Materials and Structures |
| (Nuclear) Thermal Propulsion | Entry, Descent, and Landing Thermal Protection Systems | Active Thermal Control of Cryogenic Systems |
| Lightweight and Multifunctional Materials and Structures | In-Situ Instruments and Sensors | Electric Propulsion |
| Fission Power Generation | Lightweight and Multifunctional Materials and Structures | Solar Power Generation (Photovoltaic and Thermal) |
| Entry, Descent, and Landing Thermal Protection Systems | Extreme Terrain Mobility | |

## Ten-year study shows melt of 4.3 trillion tons of global land ice

Scientists who investigate changing developments on planet Earth have completed a comprehensive satellite study leading to calculations of how much Earth's melting land ice is adding to global sea level rise.

A University of Colorado at Boulder-led team used data from the NASA/German Aerospace Center *Gravity Recovery and Climate Experiment (GRACE)* twin satellites to measure ice loss in all of Earth's land ice between 2003 and 2010, with particular emphasis on glaciers and ice caps outside of Greenland and Antarctica.

According to the research, the total global ice mass lost from ice caps and glaciers during the study period was about 4.3 trillion tons (4170 cubic kilometres), adding about 12 millimetres to global sea level. This amount of ice melt is enough ice to cover Canada to a depth of 0.4 metres.

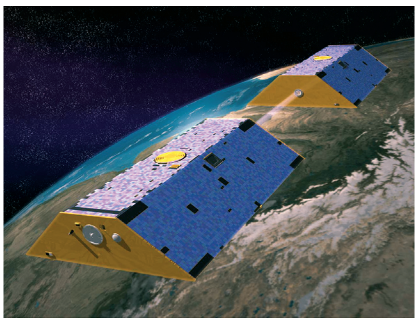

*Figure 4 — The GRACE mission has two identical spacecraft (satellites) flying about 220 kilometres apart. Image: NASA*

John Wahr, a physics professor at University of Colorado Boulder who helped lead the study, noted that the Earth is losing a huge amount of ice to the ocean annually. The results from the satellite data are helping scientists answer questions about sea rise and how our home planet's cold regions are responding to global change.

Scientific analysis has shown that:

- About a quarter of the average annual ice loss came from glaciers and ice caps outside of Greenland and Antarctica (roughly 148 billion tons, or 163 cubic kilometres);
- Ice loss from Greenland and Antarctica and their peripheral ice caps and glaciers averaged 385 billion tons (417 cubic kilometres) a year;
- The world's small glaciers and ice caps in places like Alaska, South America, and the Himalayas contribute about 0.5 mm per year to sea level rise; and
- Ice is being lost from around the globe, with just a few areas in precarious balance.

The *GRACE* spacecraft—twin satellites launched in March 2002—are in the same orbit approximately 220 kilometres (137 miles) apart. They track changes in Earth's gravity field by noting minute changes in gravitational pull caused by regional variations in Earth's mass. These changes in ice mass are tracked by measuring variations in the distance between the two satellites to one-hundredth the width of a human hair.

Developed by NASA's Jet Propulsion Laboratory, the *GRACE* twin satellites are intended to help lead to discoveries about gravity and Earth's natural systems.

## Supernova in M95

On March 16, Italian observer Paolo Fagotti reported a possible supernova in the outer reaches of the galaxy Messier 95. The presence of the new star was quickly confirmed by a host of amateur and professional astronomers, and spectral analysis soon identified it as a type IIP. The new star lies 2 arcminutes southwest of the galaxy core.

Type II supernovae are caused by the catastrophic collapse of massive stars—at least eight times the mass of the Sun—that have exhausted fuel reserves in their core and can no longer generate the pressure to support the core's overlying layers. The result is a sudden implosion of the outer layers, compression of the core, a runaway nuclear reaction fueled by the remaining nuclear material in the core, and a star that blows itself apart. Or something like that, as the precise mechanism is still uncertain.

*Figure 5 — An image of M95 by Roman Kulesza showing the supernova on March 27. This image is an integration of 1.4 hours of exposure with a 10-inch f/5 homemade Newtonian telescope and a modified Canon XSi.*

RASC observers and photographers were quick to turn to the galaxy—which was only one degree southeast of brilliant Mars at the time—and on-line discussions were dominated by visual reports and photographs through the rest of March and into mid-April.

*Andrew I. Oakes is a long-time unattached member of RASC who lives in Courtice, Ontario.*

# Feature Articles
Articles de fond

## Astronomy Outreach in Cuba: Trip Three

*by David M.F. Chapman, Halifax Centre*
*(dave.chapman@ns.sympatico.ca)*

### Preamble

"It's complicated." This is not the national motto of Cuba, but it easily could be, based on the history of our travels there. Despite all the planning my wife and I do to prepare for my astronomical activities, we have found that it is necessary to be flexible and to "go with the flow," which turns out to be most of the time! For example, on our first trip (Chapman 2010) we took 12 donated Galileoscopes (www.galileoscope.org) that were immediately impounded at Cuban Customs, eventually released to our Cuban friends two months after we returned to Canada. (We successfully conducted our public workshops with a "personal" Galileoscope buried in our luggage.) On our second trip (Chapman 2011), several anticipated activities were cancelled or modified by a combination of poor communications and the lack of a proper visa, but

Figure 1 — Reunion of amateur astronomers in Havana (L-R): Chris, Dave, Jorge, Alejandro, Reynero, and Martin (kneeling). (photo: Chris Hanham)

nevertheless we were able to promote responsible lighting in protected areas, donate a Sky Quality Meter (www.unihedron.com/projects/darksky), and launch the Cuban version of the RASC's *Explore the Universe* observing program (www.rasc.ca/observing/eu).

Our third trip was planned for March 18–24, partly to avoid the Pope's visit and partly to take advantage of Cubana Air's cheap, direct flights in and out of Halifax. We planned more activities in Havana, and branched out to include activities with amateur astronomers in Villa Clara province, coordinated by Prof. Rolando Cardenas Ortiz of The Central University of Las Villas, Santa Clara. Plans were going well, including the request for a "proper" visa, insisted upon by government and university officials. After the visa was unfortunately delayed and misplaced several times, I was finally invited by the Cuban consulate in Montreal to send my passport to them for processing (along with a money order to expedite the matter), six working days before our flight to Cuba. This I politely declined, explaining to my Cuban friends that I had no confidence that my passport would be returned in time, and that without my passport, there would be no trip, a risk I was not willing to take. They fully understood, and the activities were re-planned to include only those that I could undertake as a tourist without anyone having to ignore the regulations. Despite this turn of events, we still had many interesting adventures, as I will describe. It's complicated!

#### Phase 1 (Havana)

On previous tips, we found that staying at tourist hotels and resorts outside of Old Havana was inconvenient, mostly due to the difficulty in sending and receiving telephone calls and/or messages, including email. This time, we stayed at a *casa particular*—a kind of Cuban bed & breakfast—walking distance from most places we were interested in visiting. Our host Roberto had a driver waiting for us at the airport

*Figure 2 — The dome of the observatory at the University of Havana now opens and rotates.*

who took us to the *casa*, where we were warmly welcomed by the entire family who lived there. Our room was excellent (and relatively inexpensive) and Roberto took special care of us, including contacting our friends, taking messages, and allowing them to visit us.

Our contact at the National Museum of Natural History, Alejandro Jiménez, was the first to visit. He was terribly busy mounting an exhibition all day, but dropped in on his way home. I presented with him with some donated items (see Acknowledgements, below): a second Sky Quality Meter (SQM), a replacement AC adaptor for an external hard disk, a Meade lunar and planetary imager, some Mylar® solar-filter material, and a copy of the *Observer's Handbook 2012*. The next day, we met Alejandro and some friends at the museum: Martin, Jorge, and Reynero, the last two being amateur astronomy friends from previous trips. Martin is very enthusiastic about the concept of dark-sky preserves (DSPs), and would be a key player in any such project, being the "inside man" at a protected area near Viñales in the west of Cuba. We all agreed that he should borrow the SQM to make some preliminary measurements. We discussed how Cuban DSPs could be accredited, proposing that the best strategy for Cuban amateurs might be to create their own DSP specifications, using the RASC guidelines as a model. Everyone went away with a copy of the updated bilingual (English/Spanish) presentation "Responsible Lighting for Natural Protected Areas," the one that I was not able (as a tourist) to present myself.


*Figure 3 — The entrance to the new planetarium in Havana, a project for International Year of Astronomy 2009.*

After this meeting, several of us went to the University of Havana, to visit the observatory being restored there. Progress by Cuban volunteers since last year was obvious, as the dome has been refurbished and now freely rotates and opens. The 1948 Perkin-Elmer refractor is still not usable, and the 15-cm objective has been sent to Mexico for maintenance. The goal is to restore the observatory for public outreach, not research.

Later, at the *casa*, we had an unexpected visit from Dr. Oscar Alvarez of the (Cuban) National Academy of Sciences, whose office is only a few minutes walk away at the Capitolio. (Oscar is one of the recently elected Honorary Members of the RASC, see www.rasc.ca/honorary-members.) Our host Roberto did not let Oscar in at first, as he appeared to be a stranger, but when I said he was a friend, Roberto admitted him. When Oscar removed his sunglasses, Roberto's jaw dropped in recognition, as Oscar is a well-known science personality on Cuban TV. Over coffee, Oscar invited us to visit his home town of Cojimar, just east of Havana.

The next day, Chris and I took in a show (in Spanish) at the new planetarium, which we first visited in 2010 when it was closed for maintenance. The displays and shows were OK, and the Japanese-supplied projector worked well, but the material was a couple of months out of date, as the positions of the planets in the sky did not match the actual configuration, and they totally missed the opportunity to highlight the close approach of Venus and Jupiter, happening that week! Both Alejandro and Oscar were heavily involved in the IYA Project to install the planetarium, but are currently not associated with the project, for some internal political reason that they don't care to talk about. Also in the *Plaza Vieja*, we visited the *Camera Oscura*, at the top of a tall building, which showed excellent views of the city using a periscope-style flat mirror and a pair of 40-cm lenses that project a large, bright, and clear image onto a curved projection screen.

On the Saturday after we arrived, there was a public observing event on the roof of the National Museum of Natural History, but I could not attend, owing to a mysterious dizziness that overcame me that day. I recovered quickly, but my great regret from this trip is that I was not present to see Alejandro award an *Explore the Universe* certificate and pin to Eladio Miranda Battle, the first Cuban to earn this distinction since the RASC National Council agreed to let Alejandro administer the program in Cuba on behalf of the RASC. Eladio completed this observing program from the roof of his apartment in

*Figure 4 — Venus, Jupiter, and the Pleiades in the Zodiacal Light, 2004 March 17, Trinidad, Cuba (foreground lighting supplied by glare of resort security lights).*

Havana using no more optical aid than binoculars. Eladio, a friend from previous visits, has vowed to now tackle the Isabel Williamson Lunar Observing Program (www.rasc.ca/observing/williamson-lunar-observing-certificate).

The next day we drove with Oscar and a friend to Cojimar, a small village on the sea beside the mouth of the Cojimar River, the inspiration for *The Old Man and The Sea* (Hemingway 1952). A committee of local professionals is attempting to create a protected area, and Oscar's dream includes an observatory at the proposed protected area, for the use of amateur astronomers and for teaching young people. The site looks good, on a plateau high above the sea with a good skyline, although there are some apartment buildings on one side, about 1 km distant. It is an unlikely place for a Dark-Sky Preserve, but perhaps it could be something like an Urban Sky Park? Oscar and I discussed what sort of observatory and telescope would be best, and I suggested that a cost-effective first step would be to set up an "outdoor planetarium" where people could gather and observe the sky from seated positions around the edge of a low deck, with a concrete pad at the centre to support a portable telescope. This could evolve into an observatory as resources allowed.

A couple of days later, we said *adiós* to our Havana friends and headed off for the Caribbean coast, a five-hour taxi ride.

**Phase 2 (Trinidad)**

The Hotel Costasur beach resort is 12 km south of Trinidad, a historical town dating back nearly five centuries and a UNESCO World Heritage site. The visit here was meant to be a four-day "break" from the hustle-bustle of the cities, and that it was, but it was also a surprisingly good place from which to observe. The sky was clear, with ocean to the south and west, and not much sky glow from the surrounding sparse settlements. The local glare from the typically bad security and safety lighting posed a problem, but I solved that by wrapping my beach towel around my head and tripod-mounted binoculars. With this setup, I was able to observe in my shorts and T-shirt, searching out open clusters and nebulae in portions of the "winter" Milky Way not seen from home, in dark skies, registering about 21.3 magnitudes/arcsecond$^2$ on the SQM. Early in the morning, I observed Crux hanging about the southern horizon, Alpha and Beta Centauri, and the impressive globular cluster Omega Centauri, so bright it has been given a star label! One night, just before dawn, I was able to photograph Scorpius, Sagittarius, and the Milky Way. At night, the security guards were out and about, but they were friendly, and quickly became accustomed to my peculiar nighttime ramblings! On the feedback form, I mentioned the dark skies and the poor lighting—will it do any good?

After four relaxing days and four busy nights, we were off—again by taxi—to Santa Clara and another *casa* owned by Over (the taxi driver) and his family. On the way, we observed part of the annual spring migration of millions of land crabs over the roadway. Creepy!

**Phase 3 (Santa Clara)**

In Santa Clara, our astronomical host Prof. Rolando Cardenas met with us to review our six-day schedule of activities. There was something on every day, but not all day, so there would be time for a bit of sight-seeing as well. Rolando received two of the Sky Quality Meters I brought down: one for his university research program and one to lend to the several groups of amateur astronomers with whom he is in contact. (Now there are four SQMs in Cuba: two in Havana and two in Santa Clara.)

On the evening of the first day we went to the university to observe with some young pre-engineering students, but it was cloudy (typical!). Instead, we gave a short presentation on light pollution and how to use the SQMs. There we also met Renán Martin, a veteran amateur astronomer, now aged 83 years, who is founder and leader of "Meridiano 80," one of the first amateur groups in Cuba. Alejandro also joined us, having come from Havana for the week. The next morning, we walked with Alejandro to a park near an elementary school, where we joined Renán with a group of students he works with. I was not sure what we were going to do exactly, but in the end we took apart a Galileoscope—right there in the park!—and explained the workings of a telescope. Then we had the students take turns putting it together, and we observed some terrestrial objects with it. Suddenly another group showed up, and we did it again! The students enjoyed the activity and their teacher was very appreciative. At this time, we presented Renán with some solar filter material, as he was planning a Transit of Venus public observing event.

The next day, we went to the ecological station at the university again for a workshop on light pollution and biological effects with some physics and biology professors, researchers, and students in attendance. At this event, I formally presented Rolando with the SQM for his research. I did not follow all of the subsequent discussion in Spanish, but there seemed to be a couple of biologists who were interested in incorporating the device into their work. Prior to the workshop, we were escorted around the natural arboretum at the university, and learned a lot about the native plant species.

On the fourth day, we went on a road trip with Renán and Alejandro (in Over's taxi) to Sagua la Grande, an hour's drive north, where there is an active amateur astronomy group "le Gentil" run by a couple, Mario and Elena. Renán stayed to visit, while Mario joined us to head off to the Mogotes de Jumagua, a nature reserve about 10 km west of town featuring some unusual limestone hills and cliffs. We enjoyed a hike rich in flora and fauna with Ivan, a biologist, who showed us some rare palms that only grow in this part of Cuba and some unique Cuban birds. The amateur astronomers are interested in promoting this spot as a dark-sky site.

*Figure 5 — Alejandro and Dave assist Renán Martin (in ball cap) in an open-air Galileoscope workshop with schoolchildren in Santa Clara. (photo: Chris Hanham)*

*Figure 6 — Reunion of amateur astronomers in Sagua la Grande (L-R): Over (driver), Alejandro, Elena, Mario, Renán. (photo: Chris Hanham)*

Over a superb authentic Cuban supper cooked by Elena and her mother, we presented the group "le Gentil" with a used PC laptop that had been donated for Cuba. This group is a leader among the Cuban amateurs and—through consultation with the others—it was decided that they would benefit most from the gift. Naturally, they were speechless! After supper, members of the group launched water rockets outside the apartment block to the delight of the local residents, and we set up a Galileoscope to observe Jupiter. Afterwards, we returned to the Mogotes to record SQM measurements and to photograph a sky-glow panorama.

It was a good thing we had visited during daylight hours, as we had a heck of a time finding the unmarked and unlit entrance road from the highway! Finally we arrived, and with the aid of Ivan, we set about our work. The zenith SQM measurement was a respectable 21.1 magnitudes/arcsecond$^2$, but there was quite a bit of variation, especially in the direction of the town. The sky-glow photographs showed significant light pollution, possibly from lighting along the highway. In that easterly direction, it was easily seen by eye, plus there were one or two local sources of glare. (Within the town itself, the sky background had been measured at 19.9, not bad for an inhabited place.) Although this site shows good potential for a public observing venue, it would likely fall short of qualifying as a Dark-Sky Preserve by RASC standards. The evening was hazy, with light cloud, so the measurement and photographs should be repeated. After a busy afternoon and late evening, we returned home to Santa Clara.

On our last full day in Cuba, along with Alejandro and Rolando, we went on another road trip (in Over's taxi) to Sancti Spiritus, another lovely town about 90 minutes east. Isbel Gonzales runs the planetarium in the museum and is leader of the "Graffias" astronomy club. As he is an astrophotographer, I gave a short talk on getting started in wide-field astrophotography with simple equipment, and demonstrated my MusicBox EQ star-tracker mount (discontinued). At the end, I gave Isbel a copy of the *Observer's Handbook 2012.* On our way back to Santa Clara, we stopped by his house, where—incredibly—he has a German-made 5-inch refractor on an equatorial mount in a rooftop observatory! The telescope was rescued from a university and has a lens made by Fraunhofer, if I understood Isbel correctly. We were treated once again to a delicious meal prepared by Isbel's mother, and we said our goodbyes to Rolando, who had so capably organized our visit. (He was travelling on to visit his own

*Figure 7 — Sky glow from Sagua la Grande looking east from the proposed observing site in the Mogotes de Jumagua. Saturn and Spica in centre, Arcturus at left, Corvus at upper right.*

*Figure 8 — Near Sancti Spiritus, amateur astronomer and astrophotographer Isbel Gonzalez rescued a classic refractor from a university and installed it on his rooftop.*

mother, not returning with us.) I gave him my copy of *Strange New Worlds* (Jayawardhana 2011) that I had just finished.

**Home Again**

The next morning, after 18 wonderful days in Cuba, we flew home from Santa Clara direct to Halifax, a short flight under 4 hours. This had been our longest, most complex, and most rewarding trip to Cuba. Complicated, yes, but worth it! In the end, not having the proper visa did not seem to hinder things (at least from our viewpoint), and we enjoyed a lot of new experiences and met a lot of new friends. Such warm, generous, passionate, and friendly people! The Cuban amateur astronomers do not belong to a single national organization, but they are bound by natural camaraderie and mutual respect. We do not know if we will go back next year, but if we do, it is the people who will draw us there. ✶

## Acknowledgements

The following individuals and organizations are thanked for their generous support of this outreach initiative over the last three years: RASC National Council, Mary Lou Whitehorne (President), Chris Beckett (Chair, Observing Committee), Robert Dick (Chair, Light-Pollution Abatement Committee); Ian Anderson, Roy Bishop, Mike Boschat, Robert Bussieres, Frank Hendsbee, Wesley Howie, John Jarvo, Alex Lecreux, John Liddard, Quinn Smith, Chris Young (RASC Halifax Centre); Joe Carr, Brian McCullough, Richard Newman; Prof. Rob Thacker (Saint Mary's University); David Lane (Nova Astronomics); and Babek Sedehi (Canadian Telescopes Inc.). Many thanks to my wife and travel partner, Chris Hanham, for copyediting my article and sharing her photographs.

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# Madawaska Highlands Observatory: A Tourist Facility and Major Observatory

*by Frank Roy, Madawaska Highlands Observatory Corp.*
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## Introduction


*Figure 1 — Simulated Road Sign From Hwy 401 at Napanee [Hwy 41]*

Since our update report on the Madawaska Highlands Observatory (MHO) in the February 2010 *Journal*, planning and fund-raising activities have progressed to the point where construction is poised to begin. This account will apprise readers of the *Journal* of the most recent plans for the facility.

The Madawaska Highlands Observatory has been designed to be a world-class tourist facility with two major state-of-the-art observatories. The facility will be located in the Madawaska Highlands of Ontario, one-and-a-half hours west of Ottawa and a similar distance north of Napanee (Figure 1). The 100-acre site sits on a 450-metre hill (Figure 2) overlooking the Madawaska River near Griffith, Renfrew County, easily accessible from Provincial Highway 41. This particular area has an extremely low level of sky brightness (SQM 21.90 mag/arcsec$^2$, August 2010); it is the most southerly part of Canada that offers such a dark night sky.

The facility will include several advanced telescopes, some for public use and others for research. It will integrate with the surrounding landscape, maintain a low environmental impact, celebrate the night sky, and reward those who make the effort to visit and use the facility.

The venture has much to offer the amateur astronomy community. The MHO concept lies somewhere between those of major observatory's visitors' centres, science centres, and planetaria. After a thorough study of existing facilities across North America, integrating the best elements that each had to offer and then moving up several notches, it was decided that the MHO's focus would settle on the visual experience—the real night sky. We believe the offering will be the best of its kind in the world.

## The Concept

The theme of the MHO is to "Experience Infinity" in a very literal sense. At the core of that experience will be the definitive combination of an extraordinarily dark night sky and very-high-quality 1-metre telescopes surrounding a Visitors' Centre that combines display and lecture facilities with the amenities needed to make a popular tourist destination. The facility and its setting will provide the context that will deliver a very inspirational and "spiritual" astronomical experience.

## The Facility

The heart of the facility will be focused on a world-class 1000 m$^2$ Visitors' Centre (figure 3) designed to secure an LEED Platinum rating (Leadership in Energy and Environmental Design). The Centre will have a 140-seat HD theatre, displays, exhibits, washrooms, a boutique, rest area, office space, logistics, telescope control room, astronomers' quarter on the lower level, native star-lore display, and a lookout platform with a spectacular view from some 200 m above the Madawaska River Valley. The facility will be off-grid, using a combination of photovoltaic and solar thermal to meet the electrical and heating needs. Backup and stand-by energy and heating will be provided by storage batteries and a propane electric generator

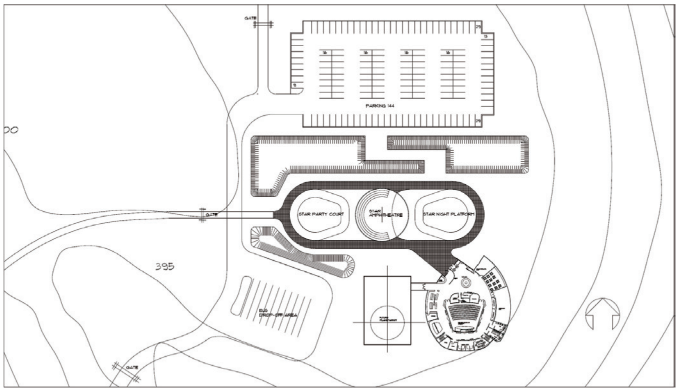

*Figure 3 — Site Layout Detail*

Figure 2 — 360º Panoramic, Arrowed - 1.6 Km away, Viewed from County Access Road

and heater. Onsite construction material will be used as much as possible, especially granite and oak. Water will be supplied from a well. Data and communications will be available via high-capacity wireless. The facility will have charging stations for electric and plug-in cars, as we anticipate that such vehicles will become very popular within the next ten years.

For public use, the facility will also host two 1-metre f/3 folded Newtonian telescopes, each with a true field of view of up to 0.8 degrees. These telescopes will be located on top of the hill adjacent to two 1-m professional observatories and mounted on a platform ~1.5 m high with clam-shell domes. They will have built-in tracking and GoTo capability; experienced interpreters will be on hand to answer questions and direct guests. The combination of very dark night skies and high-quality telescopes will give visitors spectacular views of the heavens. The telescopes will be bookable on line.

Just north of the main facility will be a campground where telescopes will be available for rent; campers will have access to the Visitors' Centre as part of their package. The camping area will also lie on the hill's edge with an overview of the Madawaska River. On-site chalets will be available as package deals with the "star-night" 76-cm or 1-m telescopes. The chalets will be fully equipped for a single or multi-night stays and will have running water, washroom, lounge, kitchen, and washer/dryer combination.

## Science Facilities

Supplementing the Wide-Field Telescope (WFT) noted in the February 2010 *Journal* update will be a 1-m f/7 Ritchey-Chrétien telescope with dual Nasmyth foci, effectively doubling the total available science time. It will be housed in a Calotte-style ¾-sphere dome and equipped with a 112-Mpixel camera providing 0.8° x 0.8° FOV with 0.25"/pixel. On the south side of the Visitors' Centre, at ground level, will be the astronomers' quarters with four beds in two bedrooms, fully equipped with separate washrooms, kitchen, lounge, study area—and underground access to the 140-seat HD lecture stage. The control room for the major observatories will be located near the front entrance of the Visitors' Centre. A percentage of the science telescope time will be made available for educational purposes and to amateurs.

## The Experience

The Visitors' Centre Complex has a view of the Madawaska River Valley from its location on the edge of the hill. A First Nations star-lore display will acknowledge the deep spiritual meaning that the local natives have with the night sky and will focus on the Great Bear, which figures prominently in their legends. One of our objectives is to promote and highlight research conducted at the facility. To do this, scientific work conducted at MHO will be put on display and astronomers will be invited to give presentations in the 140-seat HD theatre.

Displays within the facility will use touch-sensitive high-resolution monitors that will present continuously updated material. Within the Visitors' Centre, range-activated Wi-Fi audio, available through an app or by renting a portable device, will broadcast a description and explanation of the displays. One exhibit will feature the unique technologies used at the MHO, including the open-back cellular mirror, active-optics system, the world's biggest CCD imaging chip, and how the two professional observatories are designed for optimum performance. Large flat-screen displays, updated regularly, will display images from the telescopes; they promise to be among the most spectacular wide-field images in the world, reaching as deep as 27th magnitude over a five-square-degree field of view.

From April until October, the facility will host interpreter-assisted "star nights," where guests will be able to observe with one of several 76-cm (30-inch) f/2.5 telescopes equipped with tracking and GoTo capability. These telescopes do not require step ladders, offering maximum security and comfort. The short focal length offers up to 1.2 degrees true field of view. These star-night telescopes will be operated from a dedicated platform 30-metres north of the Visitors' Centre (Figure 3). Heated clothing, gloves, and boots will be available for winter viewing, as the facility will be open year round. The 76-cm and 1-m telescopes will be offered occasionally for private use to interested parties.

Some unique technologies will be used for extremely high-resolution views of the planets with the 1-m visitors' telescopes; at times the resolution could reach 0.13˝. This is expected to be extremely popular with visitors.

Guided tours will be offered of the Visitors' Centre, 1-m visitors' telescopes, and the two major observatories. Package deals will be available with Calabogie Peaks Resort, 40 minutes away. We are also looking into the possibility of package deals with hotels in the Ottawa and Kingston areas for day trips. Secluded and located on the Canadian Shield, the beautiful site is surrounded by Crown land, giving us the opportunity to offer guided geo and nature walks after an introductory presentation in the theatre.

## Key Tourist Attraction

The MHO is expected to become a key tourist attraction in Eastern Ontario. With 20 provincial parks and a large number of cottages and campgrounds within 200 km, we expect that a significant number of guests will make an annual pilgrimage to visit the site and take a look through the large telescopes. Some 3 million persons live within an easy day trip of the site and we estimate upwards of 80,000 annual guests, 60% from within the region (<200 km), with the rest arriving as destination (overnight) travellers.

The facility will also have a strong educational component to cater to school trips from the surrounding communities. The Visitors' Centre (Figure 4) will make special arrangements for these groups in terms of logistics and the provision of educational material. The facility will also welcome group tours and may occasionally be reserved for special events.

## Impact on Astronomy in Canada

We believe the presence of the facility will have a strong positive effect on Canadian astronomy at the professional, amateur, general interest, and educational levels.

At the professional level, the facility's two major state-of-the-art observatories will provide researchers with the most powerful telescopes in Canada, providing a convenient training ground and hands-on experience for future astronomers and helping to fill the huge gap in available research facilities in the country. Also important is the facility's proximity to Ottawa, as visits from federal politicians and their families will help give astronomy a more prominent place on the Federal agenda, especially with the expected large public interest in the MHO.

At the amateur and general-interest level, the facility will expose millions to the night sky over the course of its lifetime. It will provide a focus and drive membership in astronomy clubs and get young people interested in careers in science and technology. The views through high-quality large telescopes under a dark night sky will have significant impact on visitors, and be a welcome educational tool for school tours.

## Longer Term

We have long-range plans to add a digital planetarium that will be connected to the Visitors' Centre for logistics and access. The planetarium will have several HD projectors to augment the experience; this could materialize by year five. However, it's amazing to think that the actual night sky will be more impressive than the simulated sky—unknown in other Canadian or American planetaria!

There is sufficient space on top of the hill to allow for a significant star festival—some 50 acres could be made available. A location close to key Canadian population centres (Ottawa,

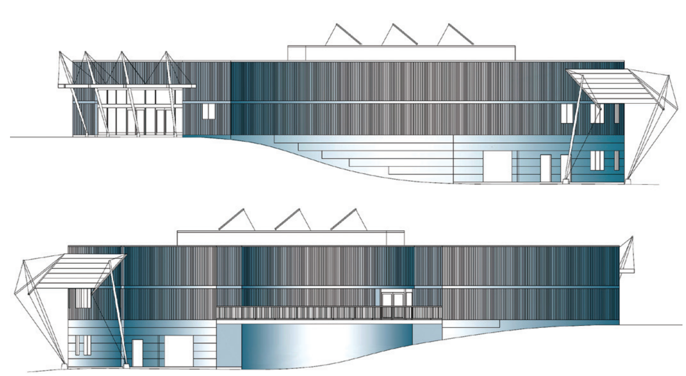

*Figure 4 — Visitors Centre East and West Elevations*

the greater Toronto area, and Montréal), only 2.5 hours from the U.S. border (at Thousand Islands), and within 6 hours of large U.S. centres makes the facility convenient to a large number of people. Coupling the dark sky with the MHO's substantial amenities and logistics could lead to a spectacular star festival; we expect it could rival the largest. The long-term weather maps indicate we are in a relatively dry area with 25% higher probability of clear skies compared to areas nearer the Great Lakes.

With the available space, larger observatories can be accommodated, and there is a possibility of co-locating with major institutions. Larger tourist telescopes, perhaps in the 1.5-m (60-inch) class, and co-location with amateur astronomers and other groups is also feasible. We are exploring on-site overnight dormitory-style accommodations for schools from areas further out, thus making the facility more accessible. Down the road, we would like some type of active solar display, possibly a high-quality large solar telescope in the vicinity of the Visitors' Centre.

## Conclusion

The Madawaska Highlands Observatory integrates tourism and astronomical research through its two main observatories, so that the public component actually carries the science and makes the venture possible. This is unique in the world of major observatories but absolutely necessary to achieve our goal of a major research facility within Ontario. As planned, the facility will certainly be first-class, and we believe the premiere of its type in the world in terms of the guest offering. A strong international interest is expected.

The facility will give a huge boost to astronomy in Canada and play a major economic role in the region by attracting significant volumes of tourists to the area.

MHO believes the night sky is very important to humanity; it connects us with our origins and our destiny, it literally is infinity. We believe that the night sky is a universal experience that touches the soul, and, with an offering and setting designed to maximize that experience, that all of our guests will want to return on a regular basis.

An on-line survey has been setup to gauge the offering:

http://fs18.formsite.com/Madawaska_Highlands_Observatory/form3/index.html

For more information on the tourist offering please see here:

www.madawaskahighlandsobservatory.com/Downloads.html✶

# Astronomy the Babylonian Way

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Some time past, in the distant recesses of human history, likely in the second millennium B.C., the first observer began to mark the motions of the Sun, Moon, and stars. From this unknown beginning, probably in ancient Mesopotamia or China, grew the record of astronomical observations that led to the present ability to predict the position of planets and anticipate eclipses.

Sumerians were the first to leave a record, and today our museums possess a legion of clay-baked cuneiform tablets marking the passage of daily life in the fertile plains between the Tigris and Euphrates Rivers, some few of which tell of the positions of the Sun and Moon, and occasionally of the planets and stars. Babylonian motivation for astronomical recording seems to have been primarily calendrical at the beginning, but quickly became a religious conduit between the Earth and the Heavens. Sumerian astronomy and record keeping were adopted by their northern neighbours, the Babylonians, after conquest and absorption, and from these early beginnings—around 2500 BC—we have a nearly continuous pathway to the present state of astronomy.

*Figure 1 — A cuneiform tablet from the library of Ashurbanipal containing astronomical observations and omens associated with the planet Venus (Venus tablet of Ammisaduqa). This tablet is a part of the Enuma Anu Enlil and dates from the 7th century BC. Image © Trustees of the British Museum and used with permission.*

Astronomical observations were crucial for the development and correction of the calendar, which was lunar-based and subject to an ongoing need for adjustments as the months outran the seasons. The average lunation (time from new Moon to new Moon or other phase) is 29½ days, which does not fit evenly into the length of a year. Short by eleven days, the lunar calendar is in need of adjustment by more than a whole month every three years. Corrections—intercalary months—were added at irregular intervals initially, according to the state of the crops, and usually at short notice. A document from the times reveals the ad-hoc nature of the method (and the age-old influence of the tax-man):

> *Thus Hammurabi speaks: "Since the year is not good, the next month must be noted as a second Ululu. Instead of delivering the tithes to Babylon on the 25th of Tishirtu, have them delivered on the 25th of Ululu II*

Irregular calendrical corrections gave way to a more routine adjustment as Babylonian astronomy and measurement progressed through the centuries. Mathematical schemes, eventually very sophisticated, developed alongside the astronomical knowledge. After the Hittite conquest in 1530 BC, the new masters were absorbed by the old culture, and astronomical traditions were greatly strengthened. Catalogues of heliacal risings of the Moon and stars appear. Tablets left from the era between 1500 and 1250 BC speak of methods for calculating the position and appearance of Venus, a relatively simple pattern to discern that repeats at intervals of approximately eight years (thus the 8-year interval between transits: Figure 2). These tablets are a part of an extensive set of omens known as the *Enuma Anu Enlil*, a set of astrological compilations and related omens that may have been taken from sources as much as a thousand years earlier.

Catalogues of heliacal risings continued to be compiled beyond the Hittite and Cassite eras (1530-1250 BC), and by the 7th century BC, timings of lunar eclipses appear in the record (specifically 721 BC March 19). By the 5th century BC, the Babylonians had developed the beginnings of a celestial coordinate system in the form of the zodiac—12 constellations of 30 degrees each. Addition of intercalary months became standardized on a 19-year cycle. The day was divided into ever-finer time units, initially related to the position of the Sun and stars, and later on to sophisticated water clocks. By the time of Cambyses (521 BC), the phases and positions of the Moon were recorded to within a fraction of an *ush*, a time unit about 4 minutes in length.

After the fall of the Assyrian empire (612 BC), during the revival of Babylon under the Chaldeans, and then the rise of Persia (539 BC), a systematic observation of planetary events began, a facet of astronomy that had been largely ignored in the early years of Babylonian record-keeping. The ensuing diaries of important events, both celestial and cadastral, extend for nearly 700 years beginning in 731 BC, becoming gradually more detailed and precise. Cycles appear in the cuneiform accounts, some very sophisticated, mostly based on the manipulation of the synodic and sidereal periods of the planets and the Moon.

By the Persian era, Babylonian astronomy was aware that the circumstances of oppositions of Jupiter repeated at 80-year intervals, Mars at 47 years, Venus at 8 years, and Saturn at

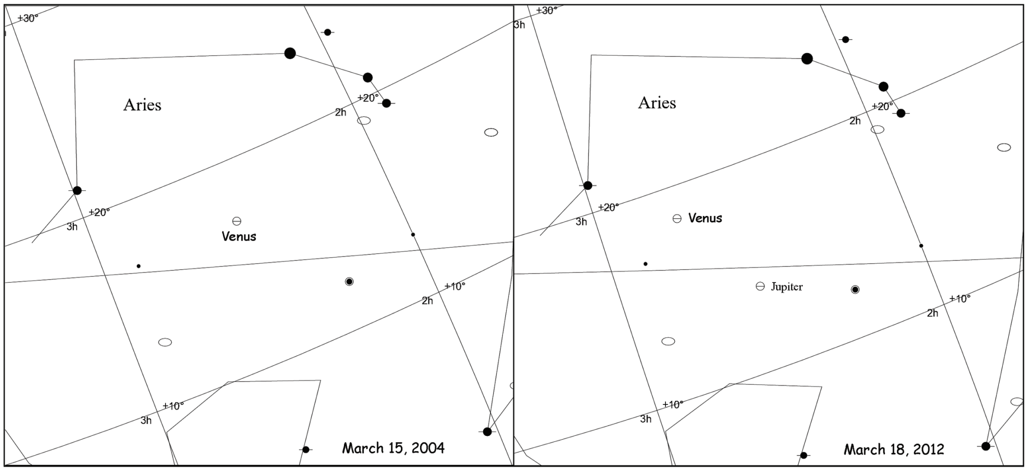


*Figure 2 — ECU-derived charts of the position of Venus in 2004 (L) and 2012 (R) at the Goal-Year interval of 8 years less 4 days.*

59 years. Tablets appear in which the planets are arranged according to their synodic periods. Prediction began to join observation as the records grew in length, and eventually it was possible to derive a relatively simple ephemeris of the planets by returning to the accounts from several years or decades before. One damaged tablet from Persian times contains the following account:

> *… Dilbat (Venus) 8 years behind thee come back… 4 days thou shalt subtract… the phenomena of Zalbatanu (Mars) 47 years… 12 days more… shalt thou observe… the phenomenal of Sag-ush (Saturn) 59 years… come back for day shalt thou observe…* (Pannekoek, 1961)

The planetary periods are precisely fixed: Venus will repeat its appearance after 8 years less four days (thus the binary nature of transits of Venus), Mars after 47 years and 12 days, and so on (Table 1). These patterns eventually made their way into a collection of "Goal-Year Texts" around the time that Babylonian astronomy passed into Greek hands. In the goal-year texts, planetary positions were predicted for some future date (the goal year) according to past positions recorded in the diaries. The Goal-Year Text for 2013, for instance, would contain the diary entries for Mercury from 1967; for Venus, from 2005; for Mars, from 1966; for Jupiter, from 1930; and for Saturn, from 1953. The patterns were quite accurate (Figure 2); the modern return interval for Venus is 8 years less 2.44 days.

| Goal-Year Periods in Babylonian Astronomy | |
|---|---|
| Mercury | 46 years |
| Venus | 8 years |
| Mars | 47 and 79 years |
| Jupiter | 83 and 71 years |
| Saturn | 59 years |

*Table 1*

Eclipses must have been a powerful event for the early skywatchers, and their recurrence, though not their pattern, would have been quickly apparent. There is evidence that attempts were made to predict eclipses before the calendrical system was in place. According to Steele (2000, 76), the earliest attempts were based on liver and oil divination, halos, the untimely appearance of the new Moon, and the presence of fog. In the *Enuma Anu Enlil*, reference is made to observations of the Moon's visibility at the end of the month in order to predict an eclipse two weeks later:

> *[Observe his (the moon's)] last [visibility] on the 28th of Nissanu, [and on] the 14th day of Ajaru [you will predict] an eclipse. [The day of last visibility will sh]ow you the [the eclipse.(Enuma Anu Enlil 20;* translated by Rochberg-Halton, quoted in Steele, op cit, 76)

Steele (*op cit*, 78) proposes, based on work by Neugebauer and others, that this cuneiform inscription refers to observations of the setting times of the Sun and Moon on the last day of the lunar month. Since the Moon will be close to the ecliptic (that is, the node) if an eclipse is imminent, the setting times will depend primarily on the difference in Right Ascension between the two bodies. This explanation is tough to accept, as the setting times of the Sun and Moon depend on many factors, one of the most important being the angle that the ecliptic makes with the local horizon. This angle varies through the seasons. Critical times could be teased from the eclipse record and the recordings of rising and setting times, but it is not a simple task. The process is complicated by the small difference in setting times between eclipse and non-eclipse months, occasionally as little as a few minutes, and Babylonian time measurements were not accurate enough to capture such a small difference.

From the Babylonian perspective, eclipse recurrences have a very simple pattern—they occur at one-, five-, or six-month intervals (lunations). The latter are most common, with six or seven for every five-month interval (Figure 3). One-month intervals are much less frequent and except in rare moments, involve only partial eclipses. Some of these would be penumbral lunar eclipses, and Babylonians do not seem to have observed these glancing passages through the Earth's shadow. The absence of a scheme to predict future intercalary months would make it difficult to precisely fix the time of year of a future eclipse, but the number of months in the future that it might occur was easily ascertained. The question of whether to expect an eclipse at five or at six month intervals seems to have been solved by watching for both months:

> *Concerning the watch of the sun about which the king, my lord, wrote to me, it is (indeed) the month for a watch of the sun. We will keep the watch twice, on the 28th of Marchesvan and the 28th of Kislev. This we will keep the watch of the sun for 2 months.* (Parpola, 1993 quoted in Steele, *op cit*, 77)

The calendrical system provided the skeleton on which eclipse observations could be placed, but political and administrative resources were required to gather, record, and preserve the sightings so that patterns could be determined. Babylon and its later masters—the Assyrians, Hittites, and Greeks—maintained an extensive set of records that allowed the discovery of complex and long-term periodicities and the eventual prediction of eclipses. Great libraries were established to hold the cuneiform tablets, and priest-classes were formed to collect and interpret the records revealed by the skies.

The Saros period was still unknown, for the Saros predicts the pattern of five- and six-month eclipses and there would be no need to keep watch over a two-month interval. If an eclipse had been seen, then a watch could be kept in the next six-month interval; but if none was seen, then the possibility of a five-month interval had to be considered.

Eclipses—primarily lunar eclipses—were not neglected in the tablets. Even in Assyrian times, the expectation of an eclipse could be predicted in advance. This may have been because astrologers of the time perceived that one lunar eclipse is followed by another in either 41 or 47 months. Or, quite likely, they had noted that eclipses of the Moon repeat at six-month intervals for five or six times, followed by a gap before the sequence began again. It isn't a difficult pattern to find, for even a modestly dedicated amateur observer will begin to discern part of the pattern in his or her lifetime today, without recourse to tables or computer programs or even record-keeping, though we now have the advantage of knowing that one occurred, even if it wasn't visible from home or was clouded out.

Early accounts of eclipse prediction seem to have an element of surprise about them. From the accounts of the court astronomers of Nineveh we can read the predictions:

> *On the 14th of the month an eclipse will take place; misfortune for the lands of Elam and Syria, good fortune for the king; let the king be at ease. Venus will not be present, but I say to my lord, there shall be an eclipse.*

This is followed by:

> *To the king my lord I have written: an eclipse will take place. This eclipse has taken place; it did not fail. This is a sign of peace for the king my lord.* (Abetti 1952), Giorgio: The History of Astronomy, 1952, Henry Schumann, New York).

The tone of the message suggests the same wonder that we express when a weather forecast turns correct!

A famous tablet residing in the British Museum lists columns of nothing but years and months, two months for each year, from 373 to 277 BC. It is clear that the list is one of lunar eclipse months, and they are arranged in groups of 223 lunar months—a Saros cycle of 18 years. It is a clear example of Babylonian techniques, showing how the knowledge of a string of eclipses leads to the discovery of the pattern of repetition.

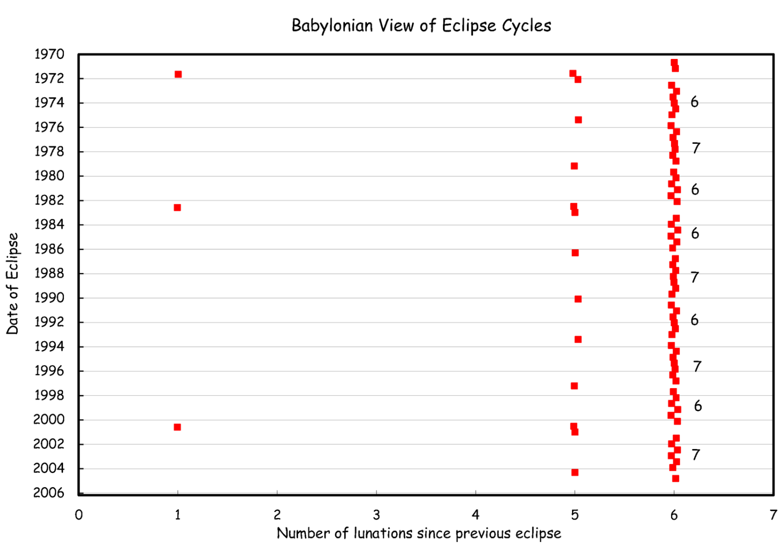


*Figure 3 — Eclipse intervals based on lunations rather than months, as the Babylonians would have seen them.*

While the cycle of lunar eclipses was largely deciphered by Babylon's astronomers, their success with solar eclipses was more limited. The frequency of eclipses of the Sun is only half that of the Moon, and not as readily detected, especially when only a small portion of the solar disk is affected. Occasionally the tablets tell of solar eclipses expected, but the basis for such a prediction is still a mystery. It is possible that the prediction was related to the lunar cycle, for an eclipse of the Sun is expected a half-month before or after an eclipse of the Moon (and sometimes both), and this pattern may have been discovered by the astronomers of Babylon. There is no firm evidence that the Babylonians were aware of the Saros cycle as it applied to the Sun, though there is some disagreement on this point.

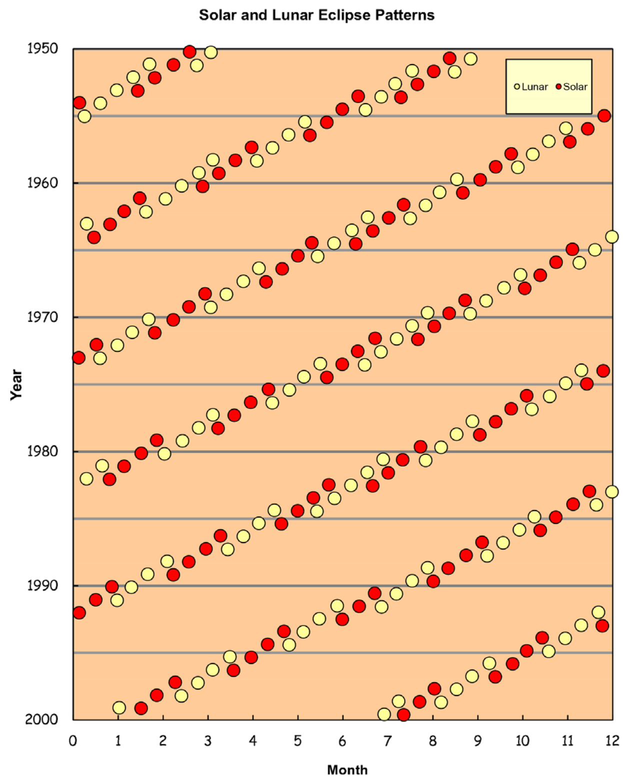


*Figure 4 — A diagram of the cycles of lunar and solar eclipses.*

Eventually, after two millennia of observation and study, an immense catalogue of astronomical positions and cycles was compiled. This knowledge was collected by Ashurbanipal in the 6th century BC and kept in order through the conquests of Alexander and the Seleucid era, in spite of the destruction of the library by the Medes in 621 BC. In time, Babylonian contributions gradually faded as the focus of trade and wealth moved from the Euphrates River to the Mediterranean Sea; the last of the clay tablets dates from about AD 75.

The knowledge gleaned from those tablets didn't disappear with Babylon, but instead passed to the Greeks who ruled after Alexander. Buried in its clay symbolism was the underpinning of another 2000 years of astronomy, until eventually being surpassed by Kepler and Newton. It was a fitting tribute, for those early numbers speak of intense dedication and ritual, of intelligent men lost to time, of unknown observing instruments and techniques, of countless hours under the stars, and the unending search for pattern and meaning—a treasure too precious to lose. ✶

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*Jay Anderson is Editor of the* Journal.

# Universe Starter Kit

*By Ken Backer, Unattached Member*
*(kbacker@iprimus.ca)*

# Stargazing in a Rush

*by Jesse Corbeil, Montreal Centre*
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> *3:30 a.m. Clear, frigid night sky. Jupiter is a point of ice hanging below the moon. This is what you miss when you keep reasonable hours.*

That was the entry in my stargazing journal (and subsequent Facebook update) from seven months ago as I walked home in the wee hours of a Saturday morning. My band had finished the first of two nights at Hurley's Irish Pub, and I'd eschewed the usual taxi, since I didn't have to bring 50 pounds of musical crap home. I do this often; it lets me stop and look up whenever the spirit moves me. Which is a lot—though truth be told, my life leaves me precious little astronomy time. It's not just the music; as the bewildered father of a fiery 10-month-old named Camille, I kind of have to take my stargazing where I can. The upshot? Though I joined the RASC in spring of 2011, as I write this sentence I still haven't met a single member. Or even figured out how to properly polar align the equatorial mount on the 8-inch Celestron I bought at the same time.

This doesn't mean that I'm ignoring the sky. I'm just not looking up the same way I would be if I were blessed with five extra hours every night. Instead, I try to locate something familiar—Jupiter, say—whenever I'm out and about after dark. The easy ones; those are all I can see from my light-polluted neighbourhood. Actually, I find Jupiter an especially compelling target, because the distance involved in turning that titanic globe into a point of light is so vast. When the numbers get that big, I may as well call it magic. Extrapolate outwards to the next star over or out to Andromeda, and I get buried by the wonder of it. I have no idea if I'd still see things the same way if I was a degree-carrying scientist, but that's not what's keeping me up nights.

> *A clear night! The vista above is breath-taking. I can just make out the dark "clouds" down the centre of the Milky Way, and a minute ago I watched a shooting star disintegrate above our hunt camp. I saw the meteor for the roiling fireball that it was, rather than the nondescript brushstroke on the sky it would have been back home.*

I try to enjoy the familiar and love the new. Whether I'm on my balcony, hauling through Eastern Canada with the band, or waiting for a moose to make a mistake in Gaspésie, it's the same sky above. But it doesn't *seem* like the same sky. Rather, the landscape, the surrounding light, the Moon's phase, the season, and even my mood can change the night's face; revealing all or closing the works up until all I can see is the Moon and maybe Orion. But I still try to find something to focus on even in the flat urban night. This past March? That's a no brainer: the slow dance of Jupiter and Venus. But as every amateur astronomer well knows, each season brings something fabulous to look at, even without the aid of binos or a telescope. Lunar eclipses, Perseids, the stately march of the planets… the list literally goes on.

> *Tonight I brought my new scope over to [my sister's] place. Faked a polar align using a tree branch near Polaris and spent a couple of hours looking at stuff: Mizar/Alcor, Vega, Arcturus. Saturn. We figured that Saturn was something worth getting [my niece] out of bed for, and we weren't wrong. The poor girl nearly blew a gasket when she saw it.*

And then there's my own personal outreach project: I am working in a low-level way to cultivate a love of the cosmos in my niece, and will do the same with Camille once she's old enough to peer through the telescope that I will surely have learned to align by then. The reason is simple: there is no reason why children can't be encouraged to fall for the sky, even if it's so much harder in our light-polluted age. Let's face it: a whole lot of kids only get to see the stars in movies. I can't see this helping to instil in them any real sense of wonder. So, if I can show up with a telescope I hardly know how to use and still blow a child's mind, then I think that's worthwhile. If it makes her think to look up some night and find excitement in the shapes of the constellations, then that's even better. Due to a lot of factors, it took me 30 years to get my first telescope. If Camille *does* at some point decide that she wants one of her own, she won't have to wait that long—but she'll still know how to enjoy the sights using nothing other than her own two eyes.

Would I rather have more time for getting the telescope out and spend the night looking up? Absolutely. But at least for the foreseeable future, that's just not in the cards. So, as I said, I look up whenever I can, whenever the weather and the Moon co-operate, and no matter how bright my surroundings are. Through showing the sky to kids, reading magazines, and just plain old looking up, I maintain my interest, even when my next date with the telescope is weeks off. I do this secure in the knowledge that, when I finally get around to an evening with the Celestron, the stars are still going to be up there, waiting. ✶

*Jesse Corbeil is a Montreal-based freelance writer who plays bass for Montreal- and Calgary-based Celtic/pop trio* Squidjigger.

*Figure 1 — The Lagoon Nebula (Messier 8 or M8) is one of the most-watched objects in the summer and fall sky—the archetype of warm-weather observing. Klaus Brasch collected the light for this composite from his observatory in Flagstaff, Arizona, using a C11 HD telescope at f/6.2. The image is a stack of several exposures totalling 16 minutes, along with separate exposures taken through filters to enhance the red Hα emission. The Lagoon spans an area of 90′ by 40′ in Sagittarius and is easily visible in binoculars—sometimes even by eye.*

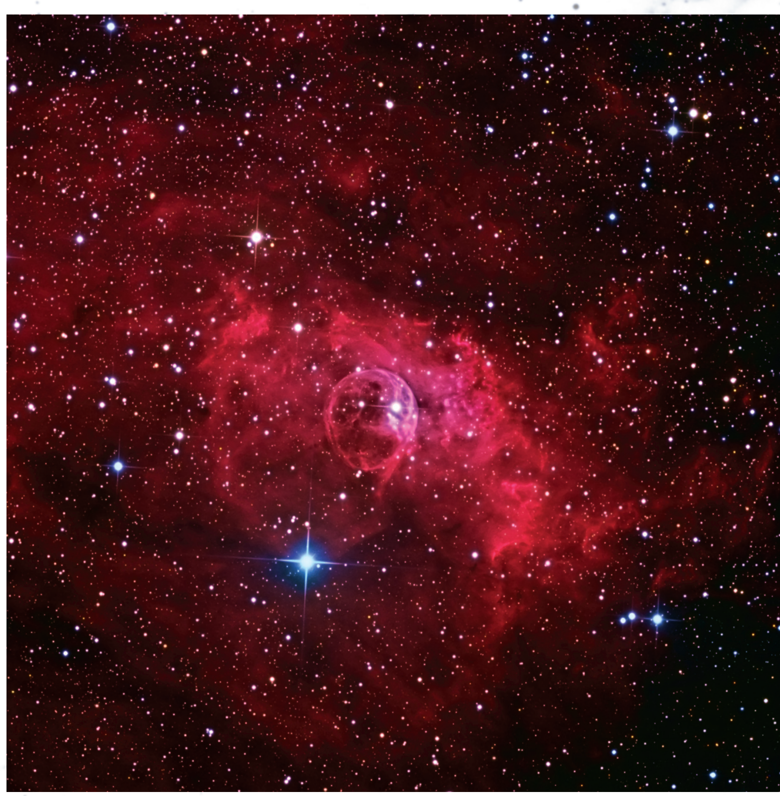

*Figure 2 — The Bubble Nebula, NGC 7635, is another popular fall object with* Journal *contributors. This one comes from Howard Trottier and is the result of approximately 12 hours of exposure, with about 300 minutes in luminance (unbinned), and about 100 minutes in each of R, G, B, and Hα (all with 2x2 binning). Ten-minute subframes were taken in all channels. Howard used a PlaneWave Instruments CDK17, operating with a focal reducer at f/4.5 and an SBIG STL-4020M camera. The Hα channel was blended into both the luminance and red channels in order to get as much depth as possible in the extensive emission nebula, while trying to maintain a "natural" colour. The Bubble is an HII emission region in Cassiopeia; the bubble shape is created by a stellar wind from the hot central star.*

*Figure 3 — Halifax Centre's Blair MacDonald, who advises us about image processing in each issue of the Journal, caught April's special moment when Venus passed the corner of the Pleiades star cluster. Venus's yellowish colour contrasts subtly with the cold blue tones of the cluster's stars in this 60-minute image, taken on the 3rd of the month. Exposure was a total of 60 minutes at various sub-exposures using a Canon 350D through both an f/9 APO refractor and an 8-inch f/5 Newtonian.*

*Figure 4 — The gas clouds, clusters, and dark nebulae around the bright red star Antares and the star fields of Ophiuchus provide one of the most scenic views in the night sky and Victoria Centre's John McDonald has done them justice in this exposure. The dark Pipe Nebula stretches into the photo from the left edge, above the bluish stars of the Butterfly Cluster. The globular cluster, M4, lies to the right of Antares. This image was captured from a site near Rodeo, New Mexico, using a modified Canon T3i with a 70-200-mm lens set at 70 mm and f/4; exposure was 7×240 s at ISO 1600.*

*Figure 5 — Kevin Black of the Winnipeg Centre captured March's highlight event in this image of the conjunction of Jupiter and Venus embedded in the Zodiacal glow over the Chiricahua Mountains. Kevin used a Canon 5D, a zoom lens set at 20 mm, and f/5.6 for this 122-second exposure from Portal, Arizona, on March 16.*

*Figure 6 — Comets display a spike-like antitail when passing through the plane of the Earth's orbit. The tail is made up of larger particles that spread out in a disk shape; the edge-on disk becomes visible ahead of the nucleus when the orbital geometry lines up. Editor Jay Anderson caught Comet Garradd on February 14, the day after its passage through the orbital plane. Exposure was 10×6m with a Canon 40D on a 130-mm TMB refractor at f/7.*

*Figure 7 — Kerry-Ann Lecky Hepburn brings us IC 342, a nearby spiral galaxy in Camelopardalis that usually doesn't attract much attention. Though large—bigger than the full Moon—it is partly obscured by dust in the Milky Way, giving it a visual magnitude of 9.1. Kerry-Ann used an Astro-Tech AT8RC telescope and a QHY-8 camera to collect 58 10-minute sub-exposures (totalling 9 hours 40 minutes) of this impressive galaxy.*

*Figure 8 — IC 1318 is well known to astrophotographers as the region around Gamma Cygni, but this view by Paul Mortfield shows it in more intimate colours. Paul used three narrow-band filters—SII (Sulphur-II); Hα; and OIII—with an Apogee U16M camera and an RCOS 16-inch telescope for a series of exposures totalling 9 hours. The colours are mapped according to the "Hubble palette" in which sulphur is assigned to red, hydrogen to green, and oxygen to blue.*

# CASTOR

*by Chris Gainor, Victoria Centre*
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A team of Canadian astronomers and contractors is preparing a proposal for a Canadian space telescope that could lead to an instrument comparable to the Canadarm and the *Hubble Space Telescope*.

The proposed *Cosmological Advanced Survey Telescope for Optical and UV Research (CASTOR)* mission is being designed to probe the formation of galaxies and the mysteries of dark energy, and could be used for other studies, including research on the outer reaches of our own Solar System. "The object is to design the most exciting mission we can. This would truly be a flagship Canadian mission," *CASTOR* Principal Investigator Patrick Côté said in an interview at his office at the Herzberg Institute of Astrophysics in Victoria, B.C.

*CASTOR*, which was known for a time as the *Canadian Space Telescope*, would be able to take stunning images that would appeal to the public and collect scientific data unavailable elsewhere, and as a result, Côté said, it could be a Canadian technological icon comparable to *Hubble* and the Canadarm.

The $250,000 study contract for *CASTOR* was among six awarded by the Canadian Space Agency last fall "in areas related to future space exploration ventures" that could become "Canada's next revolutionary technologies," according to the CSA announcement. COM DEV International was the prime contractor on the *CASTOR* study contract. Bristol Aerospace, and the Canadian branch of the international engineering company ABB that produces space optical instruments, also took part in the study contract, which was submitted to the space agency in March.

The concept of *CASTOR*—a space telescope providing both wide-field and high-definition imagery in the blue and ultraviolet part of the spectrum—arose out of a 2006 CSA workshop that brought together more than 100 Canadian astronomers. *CASTOR* became part of the 2010 Long Range Plan for the current decade of the Canadian Astronomical Society/Societe Canadienne d'Astronomie (CASCA).

Canadian astronomers have also showed interest in taking part in two other proposed spacecraft probing the mysteries of dark energy by imaging in the near infrared: the European Space Agency's *Euclid* mission, which is planned for launch in 2019, and NASA's *Joint Dark Energy Mission*, which is now not proceeding because some of its features will be incorporated into a similar orbiting space telescope proposal called the *Wide-Field Infrared Survey Telescope* (*WFIRST*).

*CASTOR* "is designed to be complementary" to *Euclid* and *WFIRST* by imaging distant galaxies in the blue and near-ultraviolet part of the spectrum, said Al Scott, project manager and technical lead for COM DEV on the contract. "This will give us more complete spectral characterization of distant galaxies."

"By combining infrared and red with blue and ultraviolet data, you can more accurately measure the distance of objects such as galaxies and stars," Côté said.

Denis Laurin, Space Astronomy Senior Program Scientist at CSA, explained that "There are a lot of telescopes in orbit now, but this type of telescope, operating in the optical and ultraviolet, is in an area that is not being filled right now."

The *James Webb Space Telescope*, which is planned to succeed *Hubble*, will operate in the infrared. Ground-based telescopes such as the Large Synoptic Survey Telescope, currently in the planning stage, are restricted to obtaining data in the optical spectrum, but ultraviolet data can be obtained only from space.

"We want to get back further in time and get a better idea of the evolution of our Universe," Scott said.

"This is the facility that would give us the deepest, widest, and sharpest view of the Universe in the blue end of the optical spectrum and the ultraviolet, and that is where young and intermediate-age stars can be studied most efficiently," Côté explained.

"This is a gaping hole in everyone's astronomy plans," said astronomer John Hutchings, the chair of CASCA's Long-Range Planning Implementation Committee. "It will be a unique and very powerful instrument."

Côté said CSA has suggested a budget of up to $200 million for *CASTOR*, including launch costs, and Hutchings pointed out that this price is similar to the $150 million Canada is spending for its part on the *James Webb Space Telescope*, the successor to *Hubble*.

*CASTOR* is being designed to obtain images with a resolution of 0.15 arcseconds, comparable to *Hubble* images and about five times the resolution of the best ground-based telescopes, noted Côté. The field of view of each rectangular image would cover about two-thirds of a square degree of sky.

One of *CASTOR*'s main goals would be to conduct a digital survey of a large portion of the sky. Côté said that *CASTOR* would also be useful for finding distant quasars, studying globular clusters, and even taking part in the search for bodies in the outer reaches of our own Solar System.

"This facility is going to be used as both a survey instrument and a guest observer instrument," he explained. "Imagine 5,000 square degrees at *Hubble* resolution. There's a lot of science you can do with that."

Hutchings added that *CASTOR* will be able to obtain spectra of all the objects it images, which "would add greatly to the scientific power of the facility."

*CASTOR* would follow in the footsteps of spacecraft such as the *Galaxy Evolution Explorer (GALEX)*, a telescope launched into orbit in 2003 that has surveyed the sky in ultraviolet but at a lower resolution than that planned for *CASTOR*. *GALEX* is now being shut down, and by the time *CASTOR* could fly, *Hubble* will also likely no longer be operational, which means that *CASTOR* could be the only telescope imaging in ultraviolet and blue wavelengths.

The telescope at the heart of *CASTOR* would have a primary mirror of about a metre in diameter enclosed inside a structure a few metres long and weighing about 500 kg. Scott said this size would make *CASTOR* a "smallsat," not a "microsat" like Canada's first space telescope, *MOST* (for *Microvariability and Oscillations of STars*), which was launched in 2003 and is equipped with a 15-cm-aperture telescope.

*CASTOR* would likely be launched on a Falcon 9 rocket or an Indian Polar Satellite Launch Vehicle into a near-polar Sun-synchronous orbit between 600 and 1000 km high for a mission lasting between 3 and 7 years. The telescope on *CASTOR* would be pointed away from the Sun, while solar panels on the other side of the spacecraft would provide power.

While *CASTOR* will utilize existing technologies as much as possible, Scott said it might drive the development of new and critical technologies. The study contract will also develop cost estimates for such a mission and seek to identify potential international partners. Côté said there is already a great deal of interest in *CASTOR* from both inside and outside Canada, but it is too early to see which countries will get involved in *CASTOR*.

In the press release announcing the study contracts for *CASTOR* and others for projects such as on-orbit servicing and orbital debris elimination, CSA President Steve MacLean said: "The space business is about turning science fiction into reality."

The reality of today's tight budget for space activities means that not every idea now being studied will make it into space. Hutchings acknowledged Canadian astronomers, having put a high priority on *CASTOR*, will "have to keep pushing to keep this going."

*Chris Gainor, a well-known author, has been recently nominated for the position of the Society's 2nd Vice-President.*

*This article has been previously published in* Space Quarterly.

### *SWEPT*

Along with the study contract for *CASTOR*, the Canadian Space Agency also granted a study contract to a group at the University of Alberta in Edmonton to examine the concept of the *Canadian Sweeping Energetic Particle Telescope (SWEPT)*, which would be attached to the exterior of the *International Space Station* to monitor high-energy radiation.

Team lead and engineering professor Robert Fedosejevs explained that all radiation monitors on the *ISS* are inside the station, and *SWEPT* is being designed to provide better information on what radiation is striking the station, because it will be placed outside.

And because the shoebox-sized *SWEPT* will be capable of being rotated, it will be able to tell researchers whether the source of the radiation is solar or cosmic. *SWEPT* is called a telescope because its detectors are highly directional, he added.

"Without knowing more about the primary sources of radiation, you can't design better shielding," Fedosejevs said. "We're trying to characterize the incident high-energy flux better than it has been done before."

U of A engineers will work with COM DEV to design the device, and U of A space physicists led by Ian Mann will look at models of the radiation environment in low-Earth orbit to help describe the radiation environment based on data from *SWEPT*. The physicists' work with *SWEPT* will build on an earlier concept study for a satellite designed to study the Earth's radiation belts. Due to tight budgets, CSA never funded the *Outer Radiation Belt Injection, Transport, Acceleration and Loss Satellite (ORBITALS)*.

"The average radiation dose rate on the *space station* is on the order of 300 millisieverts per year, which is about 100 times higher than the typical annual radiation dose of people on Earth," Fedosejevs explained.

By studying the radiation environment in low Earth orbit, Fedosejevs hopes to learn more about the radiation environment in deeper space. He said that high-energy protons generated as part of solar and cosmic radiation can turn into high-energy neutrons when they strike other atoms in the spacecraft or even in the human body. The body is much more sensitive to high-energy neutrons than to protons or electrons, and while high-energy neutrons have been studied extensively, more study is needed of high-energy protons—hence the need for *SWEPT*. ✶

# Stamp Pages from Rick Stankiewicz



*Rick Stankiewicz from the Peterborough Astronomical Association is a prolific photographer, but when skies are cloudy, he becomes an astronomical philatelist. Rick made these (and several others) for a regional stamp show—and we'll be showing more of them in future issues of the* Journal.

## Letter to the Editor

Dear Editor:

The February 2012 issue of the RASC *Journal* includes a news item headlined "Oldest planetarium in Canada closes and awaits new home" in reference to the closing of the Dow Planetarium in Montreal.

This headline is misleading. I was Director of Edmonton's Queen Elizabeth Planetarium from 1965-67 and another RASC member, Ian McLennan, was Director from 1960 to 1965. It was Canada's first public planetarium and, until the Dow opened in 1966, it was the only full-time, professionally-staffed, public planetarium in the country. In 1962, the RASC held its General Assembly in Edmonton, the first time this event had been staged outside of Central Canada. The Queen Elizabeth Planetarium was a key attraction for delegates that year and was a major reason why the GA came to Edmonton.

Many years later, and long after Ian and I had left, the Queen Elizabeth Planetarium was replaced by the spectacular Edmonton Space Science Centre, later to be known as the Telus World of Science. But the beautiful little Queen Elizabeth Planetarium, now a heritage building, remains intact in Coronation Park.

I think one could say that the Dow was longest continuously running planetarium in Canada (1966-2011), but not the oldest.

David A. Rodger,
RASC Life member, Vancouver Centre

# Flat Frames

*by Rick Saunders, Halifax Centre*
*(ozzzy@bell.net)*

*Figure 1 — A sample flat frame, showing vignetting in the corners of the optical system and the shadows of dust spots in the camera.*

Very seldom does an optical system assembled with parts from different sources work perfectly out of the box. Optical issues such as vignetting (light being blocked at the periphery of an image) or light fall-off in the corners due to the optical design are the bane of astrophotographers. In addition, contaminants such as dust particles or even stray hairs can create imperfections in the illumination of the sensor that will later show up in the final image. To mitigate these errors, astrophotographers shoot flat-field frames.

A flat-field frame is an exposure taken of a flat, featureless scene that will, in a perfect optical system, fully expose a sensor evenly from corner to corner. Any imperfections in illumination will show up in the flat frame. This "flat" is then digitally divided into the image frames, so that areas of the image that are under-illuminated are "boosted" to achieve an even background. A typical flat frame might look like that in Figure 1, which, when stretched, shows both fall-off at the corners and a few smudges of dust on the filter in front of the sensor. Once the images have been processed with the flat frame, these imperfections will be gone from the final product.

Flat frames should be taken with the equipment set up exactly as it would be to take the image (or light) frames. A new flat frame, or set of flat frames, should be taken each imaging session. Some imagers develop a library of flats, but these won't fix the effect of any stray dust that lands on the sensor between your nights out with the stars.

Flat frames are quite easy to take just after sunset, before an imaging session. I shoot mine while I set up my equipment at the dark site. Of course, the sky will be cloudless, which means that it will have no visible structure and will generate a flat field when photographed. To do this, point the telescope about 20 degrees from the zenith, exactly opposite the point of sunset, and shoot a series of pictures. Store these as your flat-field frame. The flat frames must be exposed correctly, which means neither burned out nor too dark. I've found that with my DSLR set at the ISO value at which I'll be shooting the target, I should adjust the shutter speed to give me exposures that are about 1/3 of the maximum range of the histogram (Figure 2). If you're using a CCD camera, expose for 1/3 of maximum value. With the stacking software I use (*DeepSkyStacker* or *IRIS*), this seems to give the best result.

Some photographers place a layer or two of white T-shirt material over the front of their telescope when shooting flat frames of the sky, but I have found that this really isn't needed.

In order to take flat frames at any time of day (or night), you can build a light box illuminated with an incandescent bulb or other light source. There are as many different designs for light boxes as there are people building them. A good representative example is shown in Figure 3. Greg Pyros, an imager from California, constructed this versatile unit. His light box has inserts or cutouts to allow it to be used with several telescopes and lenses. His Web site (www.gregpyros.com/html/light_box.html) has full plans and a bill of material.

If you don't want to build a light box, you can use your laptop or computer monitor. To do this, first set up a white background such as an empty word-processing page. Then place the telescope on a tripod or other stand so that the front can be placed flat against the screen with a layer or two of T-shirt material or paper between the telescope and the panel. When you are set up, take a series of flats—6 to 12 should

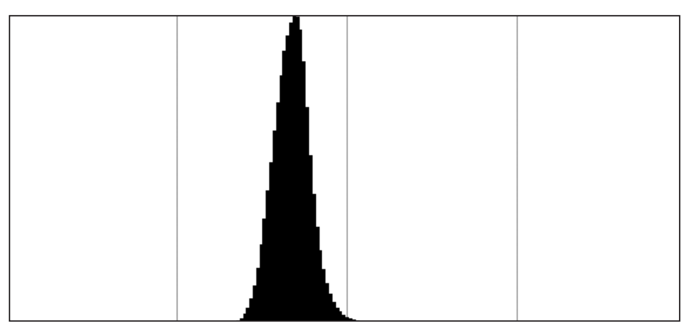


*Figure 2 — Histogram of a proper flat-frame exposure.*

Figure 3 — Examples of flat-frame boxes.

be enough—making sure that your exposure reaches the 1/3 mark on the histogram. A commercially available 12-volt electro-luminescent panel can be used as an illumination source in the same way. Figure 4 shows how a small refractor can be set up on a tripod to take flats using a laptop or computer monitor screen. A sheet of white plastic or paper between the screen and the telescope can act as a diffuser if so desired.

For larger telescopes or those permanently mounted, a simple diffuser can be fashioned using a suitably sized embroidery hoop holding two layers of T-shirt or sail material. Don't stretch the material tight and open up the weave; let it sit naturally in the hoop. This type of diffuser can be used to shoot flats during daylight hours.

Figure 4 — Shooting flat frames using a computer screen.

Shooting calibration frames such as flat-field frames and dark frames should be part of the ritual involved in collecting data for your astrophotos. If planned properly they don't take up any time in the field and will make your images that much better. ✶

*Rick Saunders became interested in astronomy after his father brought home a 50-mm refractor and showed him Saturn's rings. Previously a member of both Toronto and Edmonton Centres, he now belongs to the London Centre, and is mostly interested in DSLR astrophotography.*

# Cosmic Contemplations

## Make Your Own On-Axis Guider and 3-inch Monster Crayford Focuser

*by Jim Chung, Toronto Centre*
*(jim_chung@sunshine.net)*

A few months ago, I was introduced to yet another revolutionary new concept in guided imaging. A company by the name of Innovations Foresight (www.innovationsforesight.com) has introduced an *on-axis guider* (ONAG) that promises to address a number of shortcomings associated with other forms of autoguided astro-imaging.

Image exposures that are minutes long require corrections to the tracking of the telescope mount in order to keep the image sharp and the stars round. Tracking errors in the mount can be due to poor polar alignment, deficiencies in the gears of the motor-drive system, and sky seeing fluctuations over time. With increasing focal length, these can accumulate to the point where they become visually obvious. In the not-so-distant past, guiding corrections were made manually by the operator as he or she stared through an illuminated-reticule eyepiece and adjusted the mount with the hand controller to keep a guide star cemented between the crosshairs. Today, a guide camera's CCD watches the same guide star, and software issues the corrections to the mount automatically.

Most guide cameras[1] look through a smaller secondary guide scope and this system works well with short-focal-length imaging. It is difficult to rigidly mount the guide scope to the main telescope, and the two scopes may exhibit independent movement known as differential flexure. This movement may be near microscopic, but still be enough to introduce error in the guiding corrections. These errors become especially apparent under the high-focal-length imaging of distant planetary nebulae like the Eskimo or the Crab.

Even the most secure guidescope mount cannot eliminate one area of common differential flexure—the tendency of the large primary mirror in Schmidt Cassegrain telescopes (SCTs) to move slightly (*mirror flop*) due to weight shifts as the scope changes angulation while tracking throughout the night. The traditional solution has been to use a small pick-up prism in the optical train of the imaging camera to capture the guide star. Known as an off-axis guider (OAG), this is a compact and lightweight addition that eliminates all forms of differential flexure, since the guide camera shares the same view as the imaging camera. However the OAG's prism must be placed only in the periphery of the optical train to avoid casting a shadow on the image, and it can be challenging to find a bright-enough guide star in the severely limited field of view.

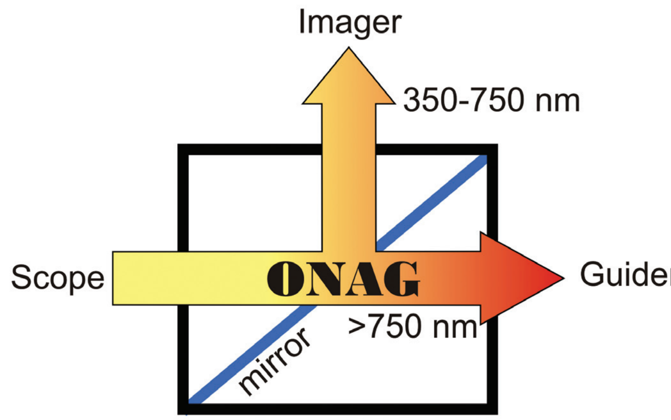



*Figure 1 — A schematic diagram of the Innovations Foresight On-Axis Guider.*

Innovations Foresight's ONAG provides a full central-axis field of view from which to select a guide star by using a mirror to split the beam and send an extended visible spectrum of light (370-750 nm) perpendicularly to the imaging camera, while passing near-infrared light straight through to the guide camera. More than 75% of main-sequence stars radiate infrared energy, and CCDs are well suited to seeing them, since quantum efficiency peaks in this region. Innovations Foresight also claims that not only are guide stars easier to find, but they are no longer subject to the peripheral aberrations of coma that is common in reflectors and SCTs, making guiding more accurate. I believe the centroid-computing algorithms used in autoguiding software cope as easily with coma-flared stars as with normal round stars, so this is likely a specious selling feature.

Being a budget-minded hobbyist, I wondered if it was possible to make my own version of this ONAG for considerably less than the market price of $1000. The critical component is clearly the dichroic beamsplitter mirror, and I began searching eBay for something suitable. I had acquired a very well made, second-hand, TrueTechnology flip mirror to use as housing, which had the all-important built-in 45° stop for the flip mirror. Most of the eBay mirrors were unable to fit the flip mirror and also transmit well within the red region. I wanted a mirror that would reflect both critical OIII and Hα wavelengths and transmit in the IR, and I was fortunate to find a Carl Zeiss FT660 DRLP (DichRoic Long Pass) mirror for $30. It is used for fluorescence microscopy, where a high-pressure mercury lamp provides incident energy to excite the fluorophores in a cell culture, and the longer-wavelength specimen emission is allowed to pass through the beamsplitter into the camera (Figure 2). The mirror reflected 95% at two peaks centred at 436 nm and 620 nm and transmitted 90% at 670 to 800+ nm. My QSI532 CCD can be seen in the imaging position and a Starlight Express Lodestar in the guide-camera position. My version lacks an XY mechanical stage, so I am unable to take full advantage of all the guide stars available on axis, but otherwise it appears to work well. The mild elongation of the star shapes is probably due to astigmatism that I introduced in not strictly verifying the 45° placement of the beamsplitter.

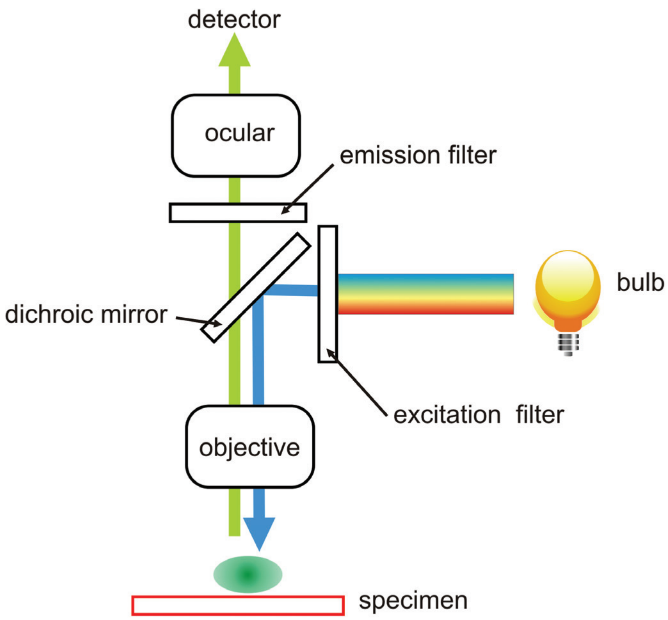



*Figure 2 — A schematic diagram of the optical layout of a fluorescence microscope.*

My laptop screenshot (Figure 3) displays a single, unprocessed 5-minute frame of the Eskimo Nebula using *Nebulosity* to control the QSI camera and *PHD Guiding* to control the Lodestar guide camera. The telescope is a Celestron 8-inch SCT operating at f/10. Bonus marks go to readers who can explain why it is white and not black, orange, or grey (and this is the original factory finish). The scope dates from the 1990s.

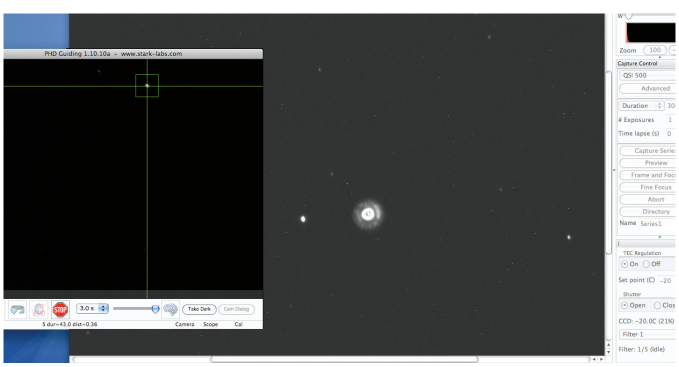


*Figure 3 — A capture of the author's computer screen showing the results of his home-built on-axis guider.*

## Revisiting the Schmidt Project

I'm briefly revisiting my Schimdt camera project (*JRASC* April 2011), as I wasn't satisfied with the quasi-helical focuser contrived from plastic plumbing components or the small CCD that I used for imaging (the Lodestar). I needed a larger focuser to accommodate a camera with a larger sensor. The Starlight Express (SX) HX916 is a long-defunct camera that preceded the very popular SVXH9 and has a similarly sized sensor (1300×1030). The best feature of Starlight Express cameras is their slim cylindrical profile and easy dismantling. I needed to be able to place the CCD sensor deep within the body of the Schmidt camera in order to achieve focus, and needed to disassemble the camera to place the plano-convex lens over the sensor to act as a field flattener.

*Figure 4 — Stages in the construction of the Schmidt camera's new focuser and camera mount.*

In 1971, John Wall introduced his invention known as the Crayford focuser to the world, and freely gifted it to all amateur astronomers by not taking out a patent for it. The focuser is delightfully simple in design; four bearings hold the focuser tube tightly against a cylindrical focusing shaft. I needed a 3-inch focuser to accommodate the SX camera and decided to make a Crayford design from hardwood (Figure 4). The aluminum pipe was purchased from a local Metal Supermarkets outlet (www.metalsupermarkets.com).

I spent those incredibly warm weeks in early March furiously imaging Venus, Mars, and Saturn, night after night, and I think I overdid it. I'm now waiting on next new Moon to try out the modified Schmidt camera. ✶

1 SBIG cameras have long offered a built-in self-guiding sensor option, but this method doesn't work for me, as I am primarily a city-based narrowband imager. In narrowband imaging, the guide camera must be able to work with unfiltered light.

*Jim Chung has degrees in biochemistry and dentistry and has developed a particular interest in astroimaging over the past four years. He is also an avid rider and restorer of vintage motorcycles, which conveniently parlayed into ATM projects. His dream is to spend a month imaging in New Mexico away from the demands of work and family.*

# On Another Wavelength

## Galaxy Groups in Leo

*by David Garner, Kitchener-Waterloo Centre*
*(jusloe1@wightman.ca)*

I always look forward to Leo as if I am flipping the calendar page and finding that spring is here and summer is nigh. Leo is a great constellation with lots of deep-sky objects to wonder about (Figure 1). Among its brighter stars are Regulus (α Leonis), Denebola (β Leonis), the lion's tail, and Algieba (γ Leonis), the mane of Leo.

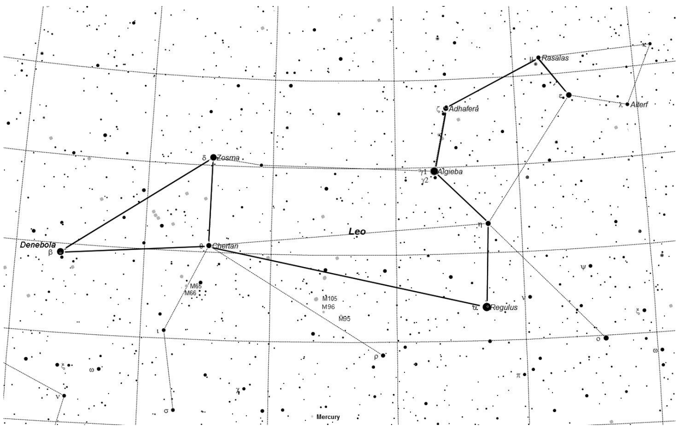



*Figure 1 — A map of the constellation Leo.*

Regulus, a blue-white class B7 star with an apparent magnitude of +1.35, is the brightest star in the constellation and is one of the brightest stars in the night sky. It is actually part of a multiple-star system composed of four stars organized into two pairs. Regulus lies very close to the ecliptic and is occasionally occulted by the Moon. You might want to mark your calendar for 2014 March 20, when Regulus is predicted to be occulted by the asteroid 163 Erigone. The path of occultation will extend from New York City to North Bay, Ontario.

Denebola is the second-brightest star in Leo. It is considerably more luminous than the Sun and only 36 light-years away, giving it an apparent magnitude of +2.1, easily visible to the naked eye. The third-brightest star, Algieba, is actually a binary star system comprised of a bright orange K0 star and a yellow-green G7 partner. The pair can be split with an 8-inch telescope. The star Wolf 359, south of Leo, and only 7.8 light-years distant, is one of the nearest stars to Earth (compare to Proxima Centauri at 4.2 light-years). However, with an apparent magnitude of only +13.5, this interesting star may be difficult to find.

Leo also contains several bright galaxies: M65, M66, NGC 3628, M95, M96, and M105. The first three make up the

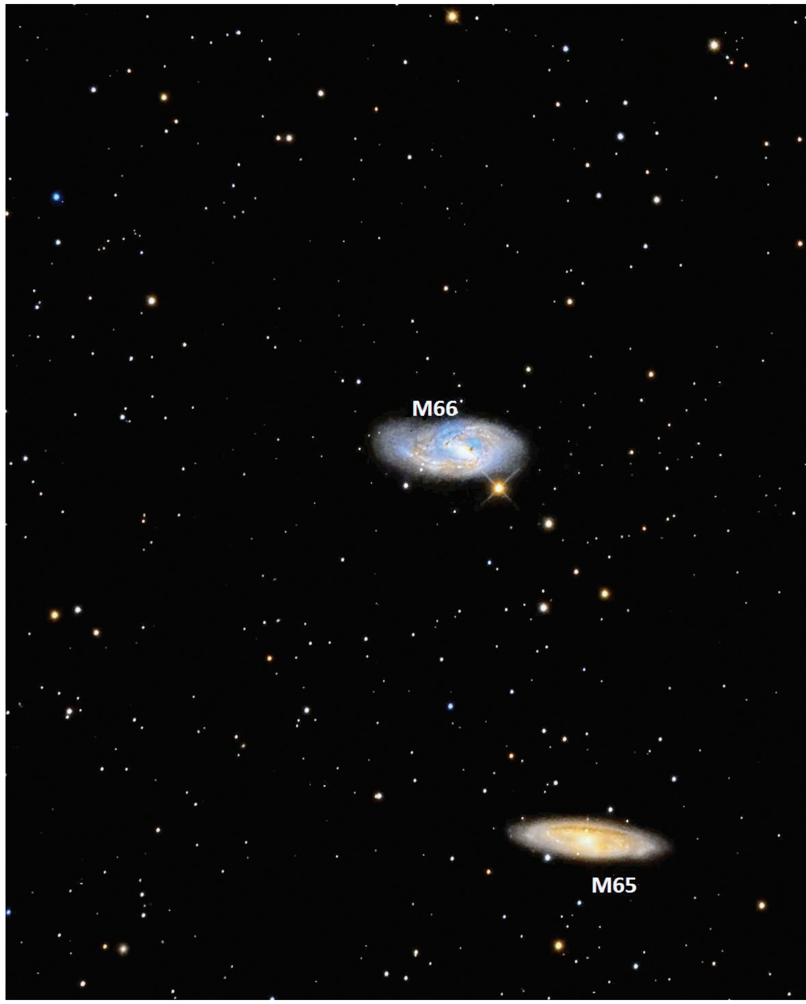
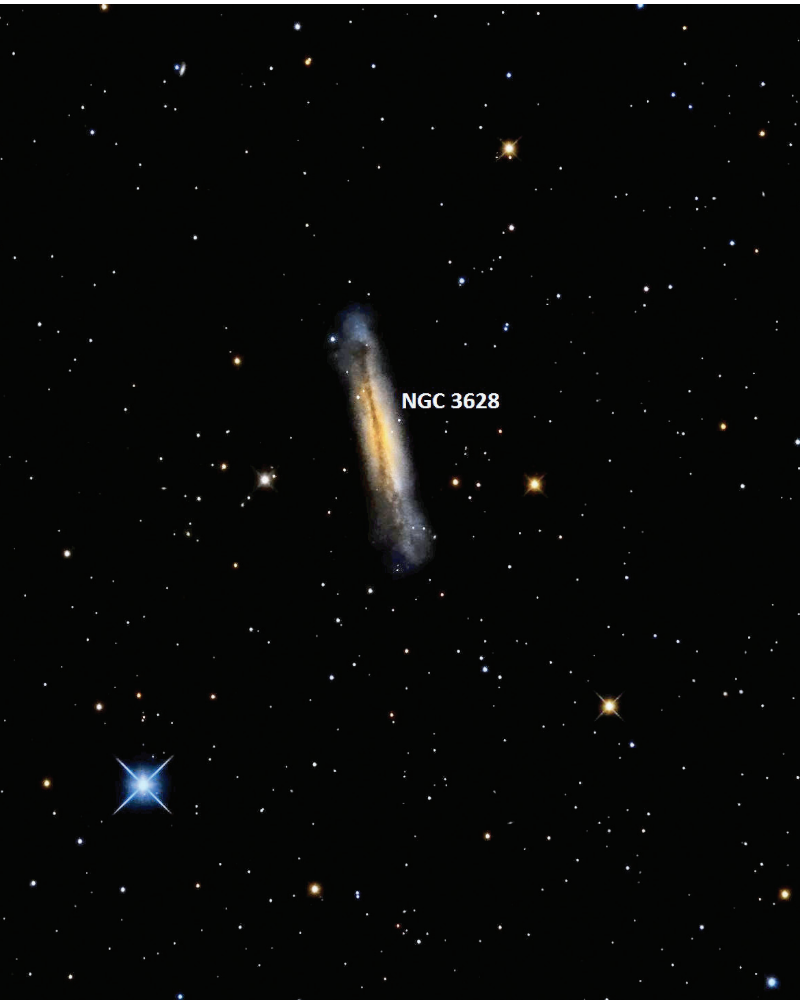



*Figure 2 — The Leo Triplet: M65, M66, and NGC 3628. Courtesy of Ron Brecher, K-W Centre. The image was shot from his SkyShed POD in Guelph, Ontario. It was acquired over about 4 or 5 clear nights using SBIG STL-11000M camera, Baader LRGB filters, and a 10-inch f/3.6 ASA astrograph on an MI-250 mount. Acquistion, guiding, calibration, registration, and integration were all done using* Maxim DL.

well-known Leo Triplet (Figure 2), also known as the M66 Group. M65 is a relatively large galaxy with an apparent magnitude of +10.2, approximately 8′×2′ in extent and elongated in the north-south direction. M65's disk appears slightly warped, which may have been caused by some external disturbance. It has been suggested that M65 may have interacted with the two other galaxies in the Leo Triplet about 800 million years ago.

M66 is brighter than M65 with an apparent magnitude of +8.9, even though it is smaller than the latter at 6′×3′. The fact that it is the brightest of the Leo Triplet is the reason for naming them the "M66 Group." An interesting YouTube video will let you travel to M66 and take a closer look at the striking dust lanes and bright star clusters along sweeping spiral arms (www.youtube.com/watch?v=LTzaJKGIGCA).

NGC 3628 is the largest of the trio at 10′×2′, but is fainter with an apparent magnitude of +9.5. Messier did not find this




object in his searches, and thus the discovery of NGC 3628 was left to William Herschel in 1784. In Figure 2, NGC 3628 is seen edge-on, showing the dark dust clouds that form a broad equatorial band, obscuring the galaxy's bright central region. The dust band is distorted and deformed in the outer regions of the galaxy due to the gravitational interaction with its two neighbors, M65 and M66.

M96 is the brightest (apparent magnitude +9.2) of several galaxies within the M96 Group. This group also includes the Messier objects M95, M105, and several other faint galaxies. M96 and M95 were actually discovered by Pierre Méchain in 1781, and catalogued by Charles Messier shortly afterward. If the outermost spiral arms of M96 are taken into account, the galaxy spans 100,000 light-years. Take a look at the image in Figure 3; you can see the dust lanes in the spiral arms.

M95 is an interesting barred spiral galaxy about 38 million light-years away with an apparent visual magnitude of +9.7. Looking at the image of M95, you can see a distinctive ring-shaped star-forming region with plenty of hot, blue stars around the centre of the galaxy.

The galaxy that we call M105 (apparent magnitude +9.3) was also discovered by Pierre Méchain in 1781 but was not


*Figure 3 — M96. Image credit: Adam Block/NOAO/AURA/NSF. M95. Image Credit: Michael and Michael McGuiggan/Adam Block/NOAO/AURA/NSF. M105, Image Credit: NASA/ESA*

included in the original Messier Catalogue compiled by Charles Messier. M105 was added to the catalogue much later, after Helen Sawyer Hogg found a letter by Méchain describing a galaxy known today as NGC 3379. Figure 3 includes an image of M105 that reveals striking detail of a bright elliptical galaxy with a point-like nucleus crossed by a dark band of dust and gas. The rapid motion of stars observed around the centre strongly suggests a massive black hole that is estimated to contain 50 million solar masses.

Now that summer is approaching, and the weather is warming, it's time to go out and have a look. ✶

*Dave Garner teaches astronomy at Conestoga College in Kitchener, Ontario, and is a Past President of the K-W Centre of the RASC. He enjoys observing both deep-sky and Solar System objects, and especially trying to understand their inner workings.*

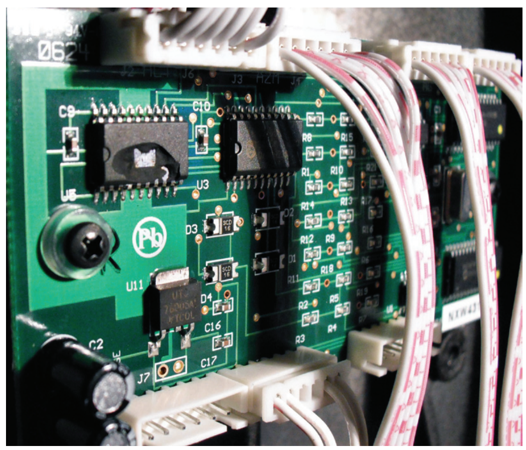
# Through My Eyepiece

## Telescope Troubles

*by Geoff Gaherty, Toronto Centre*
*(geoff@foxmead.ca)*

My telescope troubles began last August. I was working in my office one evening during a thunderstorm, when there was a huge bang from the other end of the house where my observatory is located, and the lights went out. Lightning had struck! A few nights later, I went to use my telescope and found that it wasn't working.

My primary telescope these days is a Celestron CPC 1100: an 11-inch telescope housed in my SkyShed POD observatory in my SkyShed POD observatory. It's a cosy fit, but very convenient. Oh, to decipher the alphabet soup, CPC = Celestron Professional Computerized, and POD = Personal Observing Dome.



At first, I thought that the power supply was fried. I replaced it with another power supply, and the hand control lit up, so I thought all was well. Not so fast: the GPS (Global Positioning System) was working fine, but neither the altitude or azimuth motor would run.

This was getting beyond my tinkering abilities. Normally I would take the telescope to my dealer and let him handle it. Unfortunately, because of the recent economic woes, the dealer I'd bought the scope from had just gone out of business. I've always been a tinkerer with telescopes, ever since I got my first scope when I was 16 years old, when anything that came into my hands was fair game for disassembly and (hopefully!) reassembly.

I'd already partially disassembled the mount in the past while investigating problems with the azimuth drive, so I wasn't intimidated. I disassembled one side of the fork mount and could see no problems. I filed a problem ticket with Celestron Tech Support, and they said I would have to return the whole telescope to California. I would have to pay the shipping both ways, which came pretty close to the cost of a new mount.

Luckily, I got a line on a brand new Celestron CGEM (= Celestron German Equatorial Mount) mount for a reasonable price, so I bought this and soon had it installed in my POD. After some further surgery on the CPC mount, I was able to separate the optical tube from the mount and, with the addition of a dovetail mounting plate, soon had the optical tube up and running on the CGEM.

I really love the CGEM mount. Finally, after 55 years in observing locations with Polaris blocked from sight, I have an equatorial mount that doesn't need to see Polaris in order to do a polar alignment. Its computer will do a polar alignment on any star. It works like a charm, and the mount is quiet and friendly.

Only one problem: remember how I said how the CPC 1100 was a cosy fit in the POD? Well, put the 11-inch on a German equatorial, with its need to swing on both sides of the polar axis, and "cosy" became "impossible."

Meanwhile, I had this half-disassembled CPC mount sitting in my workroom. I decided to entrust it to my friend Blake Nancarrow of the Toronto Centre. Blake had previously done a wonderful piece of electronic surgery on my Vixen Great Polaris mount, so I asked him to take a look at the CPC.

Blake disassembled the other arm of the mount and right away discovered the source of the problem. One of the chips on the motor control board was blown, literally. Simple solution: order a replacement board from Celestron and install it.

New problem: Blake and I are in Canada, and Celestron won't ship parts to Canada. In fact, they won't even let Canadians *look* at parts. Their Web site is programmed to block Canadian IP addresses from even seeing the parts catalogue, let alone ordering from it.

Luckily we were able to draw upon our good friend Terry Trees, another member of the Toronto Centre, who just happens to live in Pittsburgh, Pennsylvania. Terry was quite happy to order the part and then ship it to Blake, who installed it in the mount. Instantly the motors were purring happily again.

Last Sunday, I had a visit from four of my friends in the Toronto Centre, including Blake, and they presented me with my refurbished CPC mount. It's now reassembled and about to be moved back into its POD.

So, once again I've learned what a wonderful resource our RASC is, and what a wonderful bunch of RASCals you all are, but especially Blake and Terry! ✶

*Geoff Gaherty received the Toronto Centre's Ostrander-Ramsay Award for excellence in writing, specifically for his* JRASC *column,* Through My Eyepiece. *Despite cold in the winter and mosquitoes in the summer, he still manages to pursue a variety of observations, particularly of Jupiter and variable stars. Besides this column, he contributes regularly to the* Starry Night Times *and writes a weekly article on the Space.com web site.*

## Rising Stars

# Paul-Emile Legault Never Stops Learning or Teaching

*by John Crossen, Buckhorn Observatory*
*(johnstargazer@xplornet.com.)*

The Manitoulin fog crept up from the nearby beach, where a cluster of telescopes awaited a clear break. Our campfire's glow wrapped around us like a warm blanket. Little did we know at the time, but we were about to get an astronomy lesson from one of the masters of the storytelling art.

The tale he wove was far older than the tree branches we had pulled together as makeshift benches. It was from and about Canada's First People. Like all early civilizations, they painted their lives, their history, and their spiritual beliefs across the oldest canvas in the Universe—the night sky.

Our storyteller was Paul-Emile Legault, a remarkable man who has carved out a niche in the rocky terrain that Laurentian University calls home. The night we shared was just another mile marker on one of the more unusual career paths one could encounter in astronomy.

If you are familiar with the story of how Milton Humason rose from being a mule skinner during the construction of the Mount Wilson Observatory to become one of the facility's celebrated astronomers, you have a hint of where we're headed. While not receiving the public recognition that Humason did, there are some parallels between the Humason and Legault stories.

For Paul-Emile Legault, astronomy began with a rocket blast in 1957. The Russians had launched *Sputnik*, and the world was startled, amazed, and perhaps a little frightened. At the time, Paul-Emile was a high-school student and amateur radio enthusiast. One night he tuned his radio in to the beep, beep, beep, of *Sputnik* as it arced over Canada. The idea of space travel had always intrigued him, but with that first beep, it captured his imagination. From that moment on he followed every Soviet and NASA space mission with youthful excitement.

While astronomy was an extremely fascinating hobby, electronics held the promise of long-term employment. So Paul-Emile moved to Toronto to study what he thought would be a more viable career path. After graduation, he worked for a year at Motorola in Montreal. Then he decided to return to school and further his electronics education. This led him to Tri-State University in Angola, Indiana, where he majored in electrical engineering. But a turning point came about during his summer break, a consequence of his temporary job back in Sudbury.

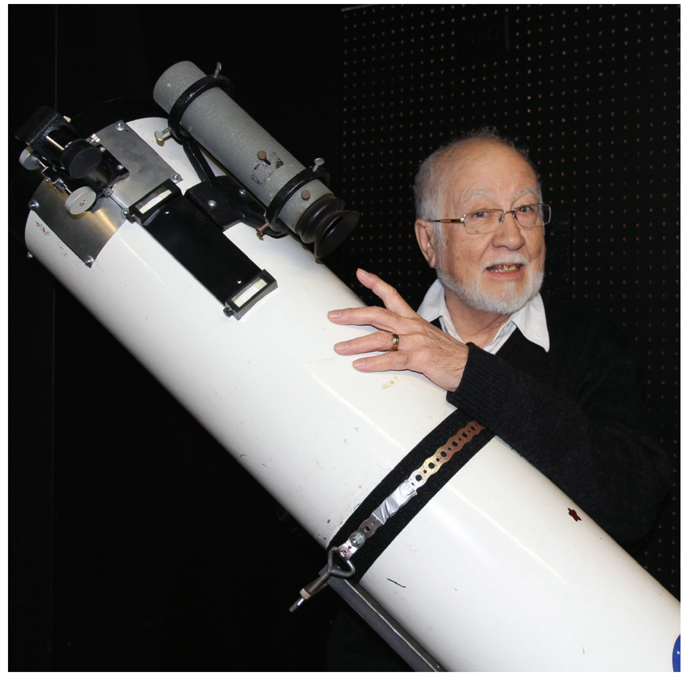


*Figure 1 — Paul-Emile Legault*

Laurentian University was in its infancy. The different departments were scattered across town, and Paul-Emile's summer job found him sweeping the floors of the Physics Department. One day, he met Dr. Roger Leclaire who was not only an astronomer and head of the Physics Department, but also had an interest in amateur radio. The two struck up a friendship.

Later, in 1968, Laurentian was growing rapidly, and on a whim, Paul-Emile decided to look up Dr. Leclaire who was then Director of the Institute of Astronomy at the University. The Institute had a contract with the National Research Council to work on an adaptive-optics project and another contract with NASA tracking the *Geos B* satellite. Dr. Leclaire was looking for a qualified electronic engineer and hired Paul-Emile on the spot. To quote a smiling Paul-Emile, "I had just stumbled onto my dream job." With that fortuitous incident, telescopes also became a part of his life. He still recalls his first look at Jupiter.

"My first time at a telescope, I saw Jupiter's Medicean stars. My head began to spin; there I was with Galileo looking at those points of light in orbit around Jupiter. It was an event that changed the history of Astronomy. Copernicus was right, and Galileo had proof."

Paul-Emile has been with Laurentian University ever since. In 1983, he taught his first astronomy course. It was a one-year six-credit course designed for non-science students, who were required to take one science elective.

"They dread taking a science course," said Paul-Emile, "I changed the course format to make it fun and interesting." Judging by past enrolment and current success, the students seem to agree with him.

When Doran Planetarium was reopened as a public outreach facility in 1994, Paul-Emile became its Director. He also expanded his teaching capabilities by designing an Internet course. As a prerequisite to teaching the course, he wrote a handbook in French and English. The handbook is a series of 19 written lectures that the course follows. To help keep him in touch with his students and to allow them to interact with each other, he uses the *D2L* (Desire to Learn) from the Department of Continuing Education.

Along the way Paul-Emile acquired yet another interest—astronomy related, of course. "My interest in Native American lore began in 1996, when I was asked to give a talk at a science camp for the Mnidoo Mnising Area Management board." Since then he has given many talks on Native Peoples' folk lore at the Great Manitoulin Star Party. While he has also incorporated Greek and Roman legend into his planetarium talks, he is especially proud of his talk based on First Nations lore. Supposedly retired in 2006, he is still the Director of the Doran Planetarium and very active in the University's astronomy program as well as the local astronomy club.

Over the past 44 years, Paul-Emile Legault has taught thousands to understand the magic and mysteries of the night sky. For many it is their first and only encounter with science, so he feels obligated to ensure that it is a good one. Let's let Paul-Emile have the last word:

> *I believe that we must do everything that we can to encourage our younger generation to study sciences. Scientists are pictured as nerds and science as difficult and not cool. Since astronomy easily captures a young student's attention, I use it to stir their imagination. An interest in rocks becomes comparative planetology, bugs become exobiology, electronics becomes satellites, toy rockets become interstellar space ships, planting flowers becomes terraforming, love of travel becomes an interplanetary journey to Mars. It may not be important to present research, but who will continue that research if we fail to prepare this generation?* ✶

*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.*



# Imager's Corner

## Fixing Trailed Stars

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

This edition continues a group of Imager's Corner articles focussing on a few techniques that are useful in processing astrophotos. Over the next several columns, I'll attempt to give a guide to image stretching, background correction, SMI processing, and any other technique that I happen to find useful. All the techniques discussed will be useable with nothing more than a standard image processor that supports layers and masks. No special astro-image processor is required.

This column will deal with fixing those images with **slightly** trailed stars. You know the ones, the deep-sky object isn't bad at all, but the stars have a slight trail that ruins an otherwise great shot. Now please note the emphasis of the word "slight." This technique can fix up stars that are trailed about two to three times their width. Although it can be used to work on longer trails, it will start to impact the background and mess up the deep-sky object as well.

Figure 1 — The original image with trailed stars

First let's take a look at the kind of image I'm talking about.

This image is a single sub from an imaging session a couple of years ago and, as you can see, the stars are slightly trailed toward the top of the frame. The first step is to select the stars in the image. Now here there are a number of ways to go about this including simply clicking on the stars with the magic wand selection tool. The issue with this approach is that it misses a lot of the stars outside the brightness range set in the tool. One of my favourite ways around this is to use a layered approach to select the stars in the image.

First duplicate the image twice and slightly blur the upper layer. The amount of blurring is determined through a little experimentation, but generally a Gaussian filter with a radius of two or three pixels will do the job. Next set the combine mode on the upper, blurred layer to difference. This gives the following layer stack (Figure 2):

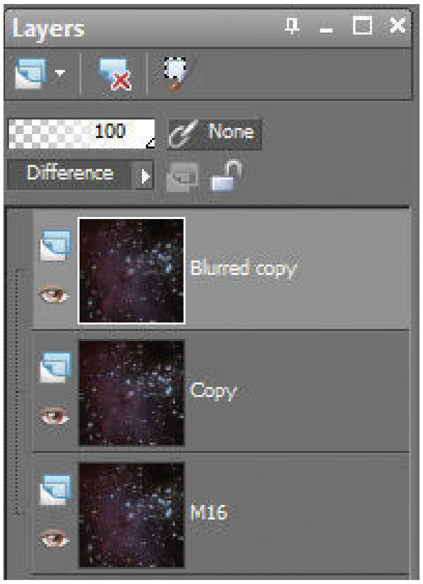



Figure 2 — Layer stack

What happens is that the blur slightly dims the stars because of their small size. The deep-sky object brightness is left virtually unchanged because of its size. Merge the top two layers. This removes the nebula leaving the smaller stars and outlines of the larger ones as shown in Figure 3a.

Next, use the threshold function to produce a high-contrast version. You can do this with a curves adjustment as well, but it's not as simple as using the threshold function. Play with the threshold level to produce an image with the stars standing out and the noise minimized as shown in Figure 3b.

Apply a slight blur—again a two-pixel Gaussian is about right—to remove the small noise dots introduced by the thresholding, and then threshold again to produce the image in Figure 3c.

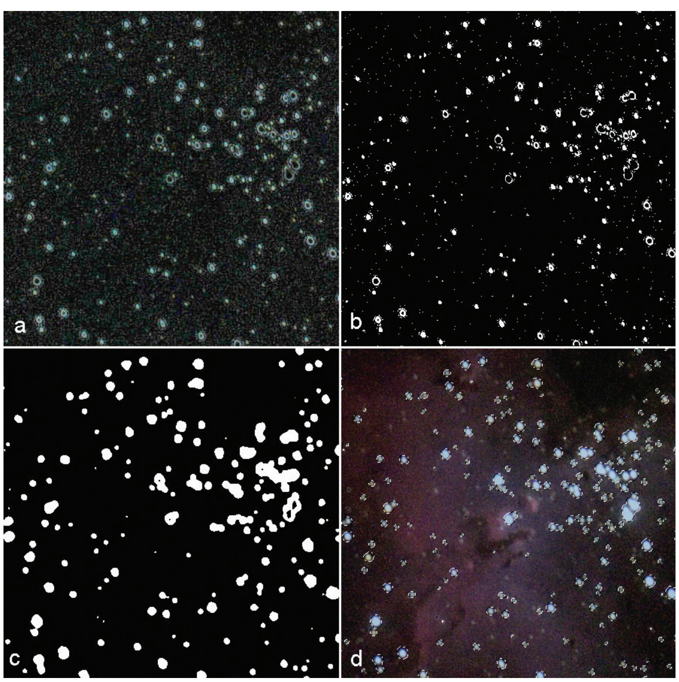



Figure 3 — a: the difference layer; b: after thresholding; c: the final thresholded selection layer; d: star selection on the original image.

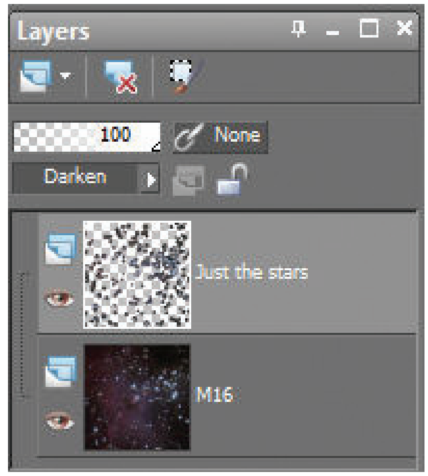



Figure 4 — The final layer stack

Now use the magic wand, and select the black background with continuous mode turned on; then, invert the selection. Presto, you have a selection of the stars in the original image (Figure 3d). Delete or hide the top layer and see the selection on the original image.

Now enlarge the selection by about the number of pixels that the stars have trailed; in this image, that is four pixels. Copy the selection to a new layer, and you have a layer of just the stars in the image. Turn off the selection, and set the combine mode on the new layer to darken. This gives the image stack in Figure 4.

Now make the top layer active, and use the move tool to nudge it around while looking at the image. As you move it down in the direction of the trail, the stars will become rounder.

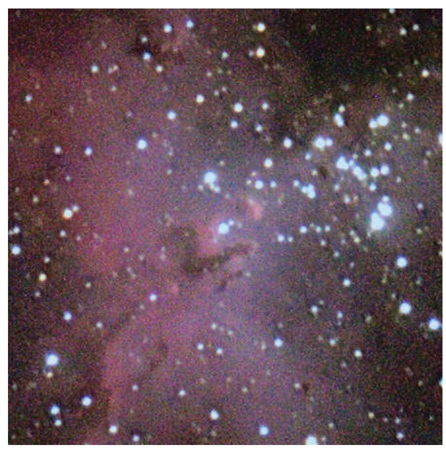


Figure 5 — The final image, with rounder stars.

What happens is that the "darken combine" replaces the brighter sections of the bottom layer with the darker sections of the upper star-only layer.

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.*

## Second Light

# A "New" Asteroid Belt as a Source of Giant Impacts on Earth until 1.8 Million Years Ago

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

The inner Solar System, particularly Earth and Moon, was pummelled with asteroids during a period from about 3.7-4 billion years ago in what is called the Late Heavy Bombardment. The traditional method of sorting out the history of impacts is counting craters. We know that the record of impacts on Earth is seriously incomplete because of erosion and plate tectonics, and that the Moon's record is plagued with uncertainties, partly because of "crater saturation" in some parts—newer impacts erase the signature of older ones—but also because we lack age constraints for the most ancient lunar terrains. This has left most evidence of energetic impacts on Earth to the youngest terrains (for example, the Chicxulub impact that ended the age of dinosaurs). To get around this problem, Brandon Johnson and Jay Melosh of Purdue University decided to try a different method of studying ancient impacts—they use the presence of "spherule beds" in old rock formations on Earth to determine that big impacts occurred on Earth throughout an early period of Earth's history (see the 2012 May 3 issue of *Nature*). They find that the rate of impacts declined much more gradually than previously thought.

As big asteroids hit Earth, they vapourize an amount of rock roughly equivalent to the asteroid's mass. The vapour expands and cools into droplets called spherules, which are distributed far from the point of impact. If the body is bigger than about 10 km in diameter, enough spherules are deposited over the Earth that their traces can still found in found in ancient terrains where conditions were ideal for preservation. Johnson and Melosh worked out a relationship between the energy of the impact and the thickness of the spherule bed (along with some complicating factors) and found that, although the number of impacts in recent (geological) times is less than it was >3.5 billion years ago (billion years ago, hereafter shortened to Ga), the decrease was rather gradual, with at least seven impacts in the range of 3.23-3.47 Ga, four of 2.49-2.63 Ga, and one of 1.7-2.1 Ga.

The discovery of exoplanets very close to their parent stars (the "hot Jupiters") forced theorists to explore the consequences of planets interacting with disks of dust and gas out of which the planets (and star) form, as well as what happens to more evolved systems placed in initially unstable configurations. They found that planets often migrate substantial distances early in the history of the planetary system. One popular model (the "Nice model"—so named because one of the leading proponents is based in Nice, France) for explaining the Late Heavy Bombardment is that it was triggered by Jupiter's and Saturn's migration outward about 500 million years after the Solar System was formed. In that model, the giant planets went through a late stage of migration, as the planets interacted with a large disk of comet-like objects located beyond the original orbit of Neptune. One consequence of this was that a lot of asteroids were sent into the inner Solar System over a period of hundreds of millions to perhaps billions of years. If there was no sharp end to the Late Heavy Bombardment, however, and impactors kept hitting Earth, where did most come from?

Bill Bottke of the Southwest Research Institute in Boulder, CO, and his colleagues, think they have the answer. The late impactors came from an extension of the asteroid belt that started just beyond the orbit of Mars—a region they dub the "E belt." This belt is now largely extinct, as it was destabilized by the migration of Jupiter and Saturn, though some remnants appear to exist in the high-inclination Hungaria asteroids (see the 2012 May 3 issue of *Nature*). They ran extensive numerical simulations to see how such a belt would evolve with time.

The inner edge of the main asteroid belt is now about 2.1 AU from the Sun—asteroids near the edge today are unstable, and are rapidly pushed onto orbits that cross those of the inner Solar System planets (in < 1 million years). The position of the inner edge and the size of the unstable region are mainly set by the orbits of Jupiter and Saturn. But, if Jupiter and Saturn were originally on different orbits, the inner edge might have been closer to the Sun than it is now. So Bottke and his colleagues wondered what would happen if the asteroid belt had been populated much farther in, to just 1.7 AU from the Sun. The working assumption is that when the giant planets moved to their current locations, a destabilizing "resonance" swept across the asteroid belt before finally stopping at 2.1 AU. The net effect was to destabilize the E-belt asteroids, sending most onto planet-crossing orbits. As the asteroids migrated into these orbits, many passed through or near the Hungaria region. This is the closest (fairly) stable region to the terrestrial planets.

Curiously, at least to me, this picture leads to most of the biggest impacts (the ones that created basins on the Moon) coming from the E belt, with only about 20 percent coming from what is now the main belt. It turns out that although the E belt did not contain much mass, objects in it were about ten times more likely to hit the terrestrial planets (and the Moon) than typical main-belt asteroids. The other effect is to begin the late heavy bombardment period at 4.1-4.2 Ga, rather than at 3.9-4.0 Ga as has historically been assumed. This would help to explain some puzzling shock-degassing ages of various meteorites.

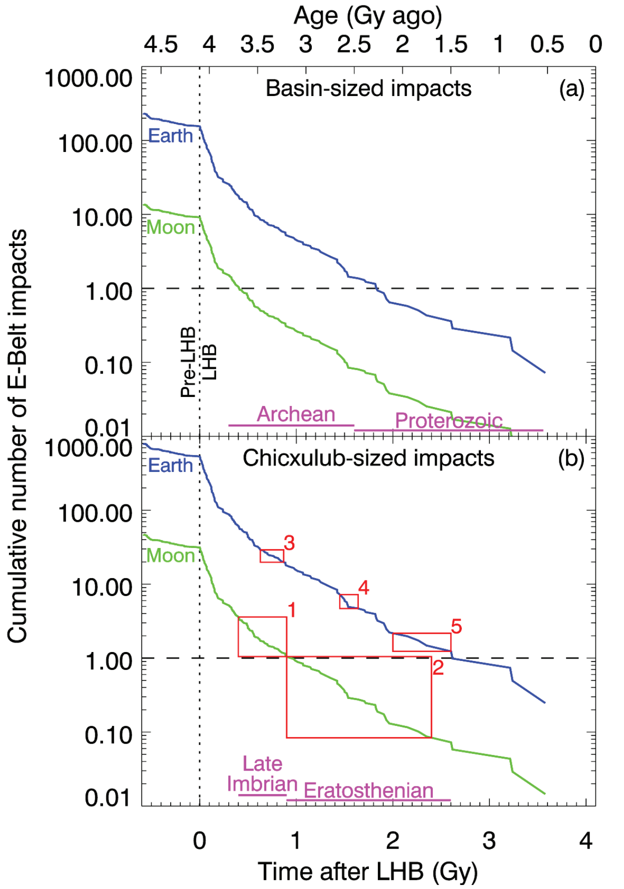



*Figure 1 — The upper panel shows the number of basin-sized impacts on Earth and the Moon, based upon the simulated evolution of the asteroid belt, including the E Belt. The lower panel shows the evolution of Chicxulub-sized impacts. Image courtesy of Bill Bottke and* Nature.

In Bottke's models, the E belt declines gradually, such that it produces enough large impacts to explain the known spherule beds described by Brandon Johnson and Jay Melosh . About nine Chicxulub-sized impacts are predicted to have occurred just after the end of the heavy bombardment period (3.23-3.47 Ga), tapering down to one in range of 0.6-1.7 Ga. What is quite disconcerting to contemplate, though, is that between 2.5-3.7 Ga, Earth was hit by about 15 impacts of the size that formed the lunar basins, which are far more energetic and destructive than Chicxulub!

Bottke and colleagues only mention in passing that all these impacts would be expected to have some effect on the evolution of life on Earth. I find it very interesting indeed that the Cambrian explosion of life happened about 0.54 Ga—perhaps the large impacts before then kept re-setting the evolutionary clock back to zero (or near zero). Or perhaps the impacts helped trigger the development of life. This is entirely speculative at the present time.

Of course the simulations come with assumptions and limitations, and the statistical arguments only capture probabilities, but the whole story hangs together in a rather Nice way. ✶

*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.*

# Society News

*by James Edgar, Regina Centre*
*(jamesedgar@sasktel.net)*

Since last issue, we've had a couple of things happen at National Office, some good, some not so good.

The good news is that we have settled on a new insurance broker, who will provide group coverage at the same or better level than before at a lower rate, plus the opportunity exists to obtain household and auto insurance through the same broker.

The not-so-good news is that our Membership and Publications Co-ordinator, Emily Cornford left for a job at a different firm. This means we will again be searching the job market to replace her—that's the royal "we," since most or all of the grunt work falls on our Executive Director, Deborah Thompson and President Mary Lou Whitehorne. We will miss Emily; she is an energetic and capable worker! Late-breaking news... We've hired Julia Melnikova as of April 27.

Moving on, we have some exciting events coming up in the not-too-distant future with eclipses, transits, solar activity bumping up, and star parties galore. This is the best time for education and public outreach, so get out there and do some of your own! ✶

*The Royal Astronomical Society of Canada is dedicated to the advancement of astronomy and its related sciences; the Journal espouses the scientific method, and supports dissemination of information, discoveries, and theories based on that well-tested method.*

# Edmonton welcomes you!

## 53rd General Assembly of the Royal Astronomical Society of Canada
## 2012, June 28 – July 1

Enjoy Canada's festival city this summer while attending the 2012 General Assembly (GA) of the RASC. It's an excellent opportunity to mix and mingle with fellow astronomers. We've put together an amazing program of exciting speakers for you together with some outstanding social events. We have lined up some great tours for you and your family, including an opportunity to meet a dinosaur face-to-face and a chance to hunt for a meteorite.

The GA will take place at the **University of Alberta** main campus, located in the heart of Edmonton next to the North Saskatchewan River valley—the largest urban greenbelt in North America.

The principal venue will be the **Centennial Centre for Interdisciplinary Science** (CCIS)—the newest building on campus and a vibrant environment for learning and discovery.

## Lodging

Lodging will be available at the Lister Centre, which has easy access to campus and offers three styles of accommodation—hotel style, residence style with private washroom, and dormitory style with shared washrooms. We have block booked 80 rooms—some of each style.

The University of Alberta does **not** offer on-line bookings for these facilities, but a form is available on the Web site that can be faxed or emailed.

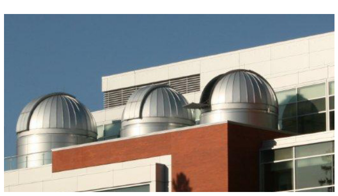
A **hospitality suite** has been reserved for the duration of the GA.

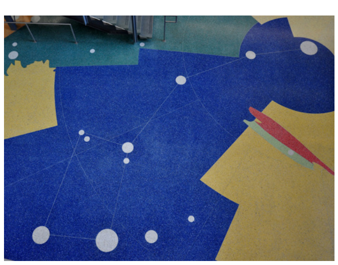
## Featured Events

### National Council BBQ

We are continuing the fine tradition started in Fredericton by hosting a BBQ for National Council delegates and their guests. The menu will consist of a choice of steak, chicken, or fish entrée* barbecued to your liking. Pre-registration is required. [Thu June 28]

### Wine & Cheese Reception





This will be a great opportunity to relax and mingle in the astronomy-themed West Atrium of the CCIS. Admire the stellar terrazzo floor and the Solar System mobile, tour the observatories on the roof, participate in Murphy Night. This reception will be kicked off with an invited talk by **Dr. Martin Connors**. [Fri June 29]

### Helen Sawyer Hogg Public Lecture

This public lecture will be presented by **Dame Jocelyn Bell Burnell**, best known as the discoverer of pulsars. A reception will follow. [Sat June 30]

### Closing Banquet

The closing banquet in the Maple Leaf Room at Lister Centre will feature a choice of beef tenderloin, stuffed chicken, or glazed salmon for the entrée*. The featured speaker at the banquet will be **Dr. Chris Herd**. [Sun July 1]

### Catered Meals

- National Council BBQ [Thu June 28]
- Wine & Cheese [Fri June 29]
- Catered Lunch [Sat June 30]
- BBQ before Hogg Lecture [Sat June 30]
- Closing Banquet [Sun July 1]

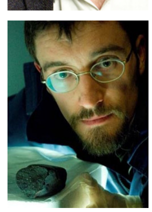
** Vegetarian options available upon request for all catered meals.*

## Other Invited Speakers

**Dr. Martin Connors**
Athabasca University

*Invited Talk*

"Earth's Trojan Asteroid: A Space Odyssey to a Space Oddity"



**Dr. Christopher Herd**
University of Alberta

*Banquet Speaker*

"When the Sky Falls: Meteorites as Probes of Other Planetary Bodies"

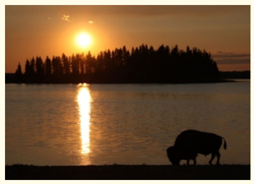
## Tours

Our tours are designed to offer fun for the whole family. Choose among three full-day tours and four half-day tours. See the Web site http://edmontonrasc.com/2012ga/ga_registration.html for details.

### Whitecourt Meteorite Crater

About 1,100 years ago, a space rock the size of a big tree stump slammed into western Canada. This is your chance to go on a guided tour of the impact crater. Hunt for your very own meteorite specimen!

### Elk Island National Park & Beaver Hills Dark-Sky Preserve



Explore this beautiful oasis, home to herds of free-roaming plains bison, wood bison, moose, deer, and elk. Be it for wildlife viewing, hiking, golfing, picnicking, or camping, there is something for everyone at Elk Island National Park.

### Fort Edmonton Park

At Canada's largest living history museum, explore Edmonton's progress from a fur-trade post in the vast Northwest to a booming metropolitan centre after the First World War.

### Enjoy Centre


More than a garden centre, the Enjoy Centre is built on the central conviction that consumers want more than products and services. They want an experience. Always inspiring. Always evolving. Always inviting.

### Jurassic Forest

A new interactive dinosaur park, featuring Tyrannosaurus rex, one of 40 life-sized, pre-historic robotic beasts. Take a guided tour or walk by yourself.

### Muttart Conservatory

A year-round escape into the beauty of the world's plant life. Vibrant, colourful, tranquil and inspirational, the pyramids' display gardens are a welcome oasis for all.

### TELUS World of Science—Edmonton

There's nothing quite like the TELUS World of Science. Kids love it. Adults think it's great. Experience science like never before. Explore an exhibit or two, catch the latest IMAX film, immerse yourself in cool Full-Dome shows in the Margaret Zeidler Star Theatre, or be dazzled by an array of Science Demonstrations.

## Display Competition

We will have three display competitions, open as follows:

- Project displays (adult RASC members)
- Project displays (students—open)
- Photography and Visual Displays (open)

See the Web site
http://edmontonrasc.com/2012ga/ga_displays.html for details.

## Call for Papers

We will have two sessions of papers where delegates can share their astronomical experiences, data, and insights. Submissions are due by 2012 April 1. See the Web site http://edmontonrasc.com/2012ga/ga_papers.html for details.

## Registration

Registration is now open! Registration fees are:

$110/person by March 31,
$135/person by May 31,
$150/person June 1, onwards

Online registration
http://edmontonrasc.com/2012ga/ga_registration.html
closes June 18.

## Transportation

We are offering complimentary transportation between the Edmonton International Airport, VIA Rail Terminal, or bus terminals and Lister Centre *(or wherever you may be staying, if possible).*

See the Web site
http://edmontonrasc.com/2012ga/ga_registration.html for details.
Parking is available at Lister Centre for those who wish it.

## Contact Us

**GA Chair**
Howard Gibbins, 2012ga@edmontonrasc.com

**Papers & Posters**
Doug Hube, papers2012ga@edmontonrasc.com

**Registrations & Accommodations**
Ross Sinclair, register2012ga@edmontonrasc.com

**Transportation**
Geoff Robertson, transport2012ga@edmontonrasc.com

## Web site

edmontonrasc.com/2012ga

Follow us on Twitter: @RASC2012GA

# Great Images

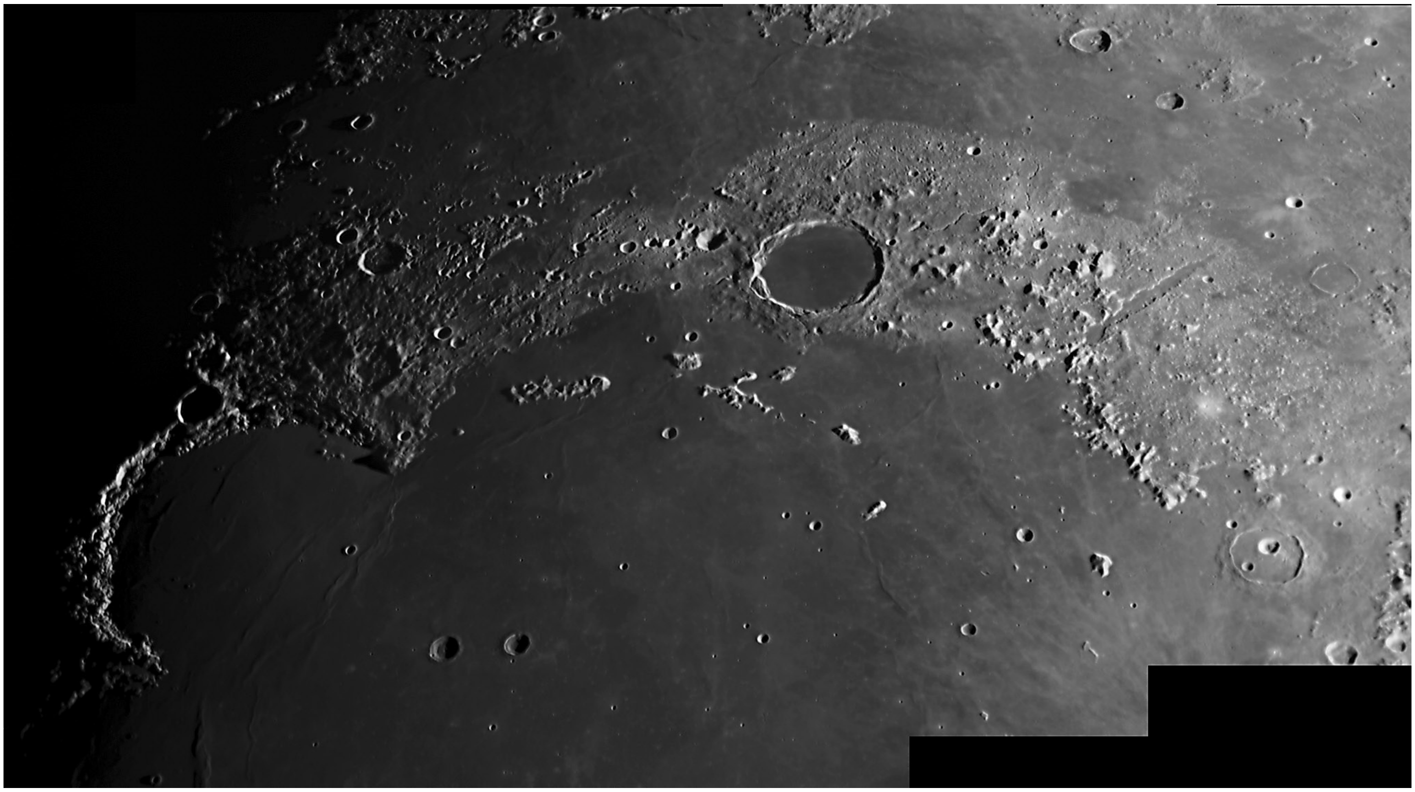


Figure 1 — Stephen McIntyre of the Ottawa Centre took this composite image of Plato, Vallis Alpes, Mare Imbrium, and Sinus Iridum on April 1 when the Moon was 10.5 days old. Stephen used a Celestron Edge HD11 telescope at 2800 mm focal length, giving a resolution of 0.28″ per pixel on a Cameleon video camera. The pixel scale represents a resolution of 1 km at the distance of the Moon, allowing the rille in Vallis Alpes, which is 700 m to 1 km wide, to be visible in the northeast part of the valley.

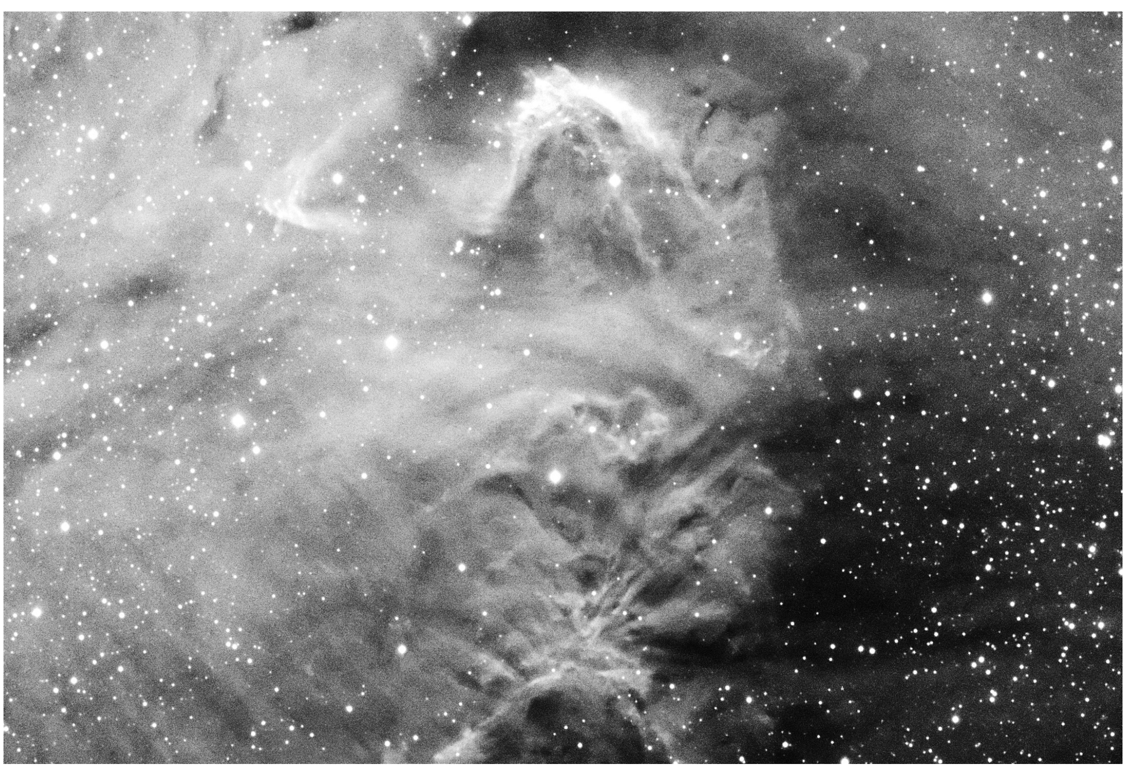


Figure 2 — Serge Theberge used five hours (20×15 min) of exposure through an Astrodon 6-nm H$\alpha$ filter and a Takahashi FS152 f/8 telescope to capture this view of the SH2-273 nebula on the outskirts of the complex that contains the Cone and Fox Fur Nebulae. Serge made the exposures in mid-February from Theberge Remote Observatory near Orangeville, Ontario, using an SBIG ST-10XME camera.

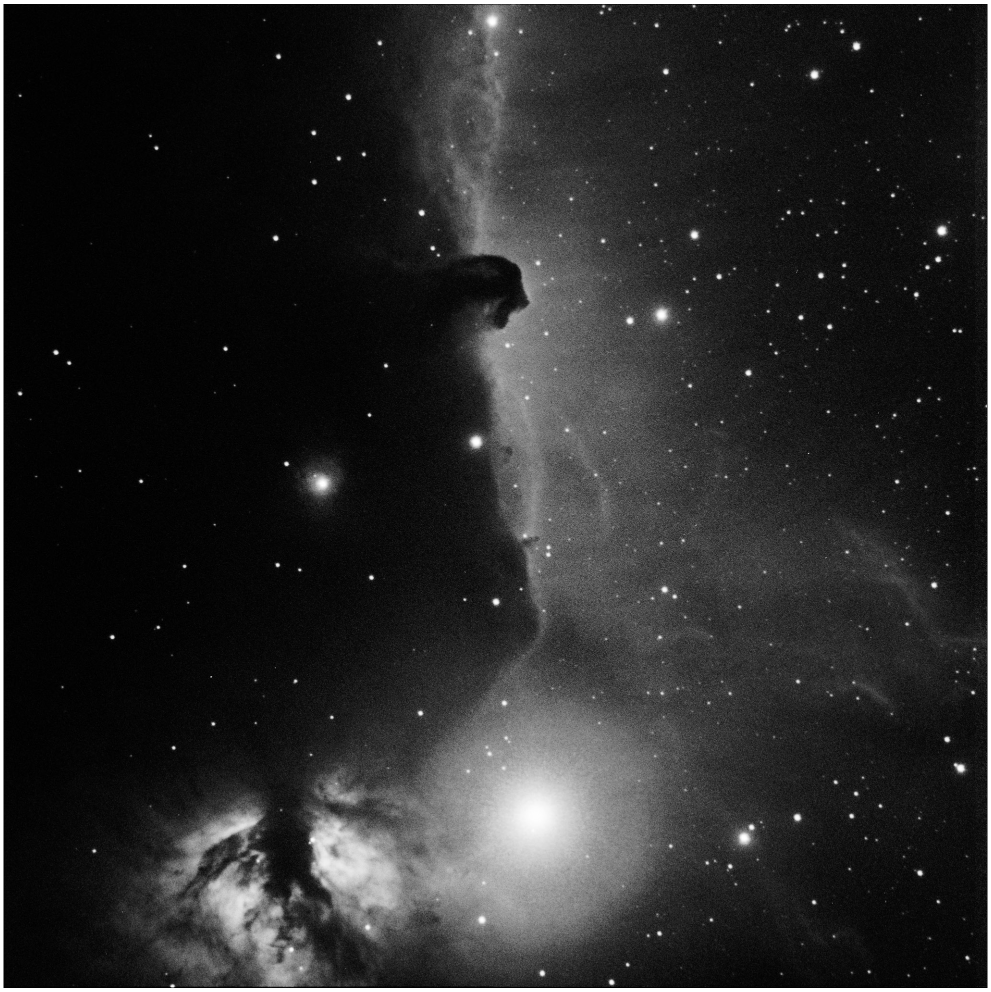
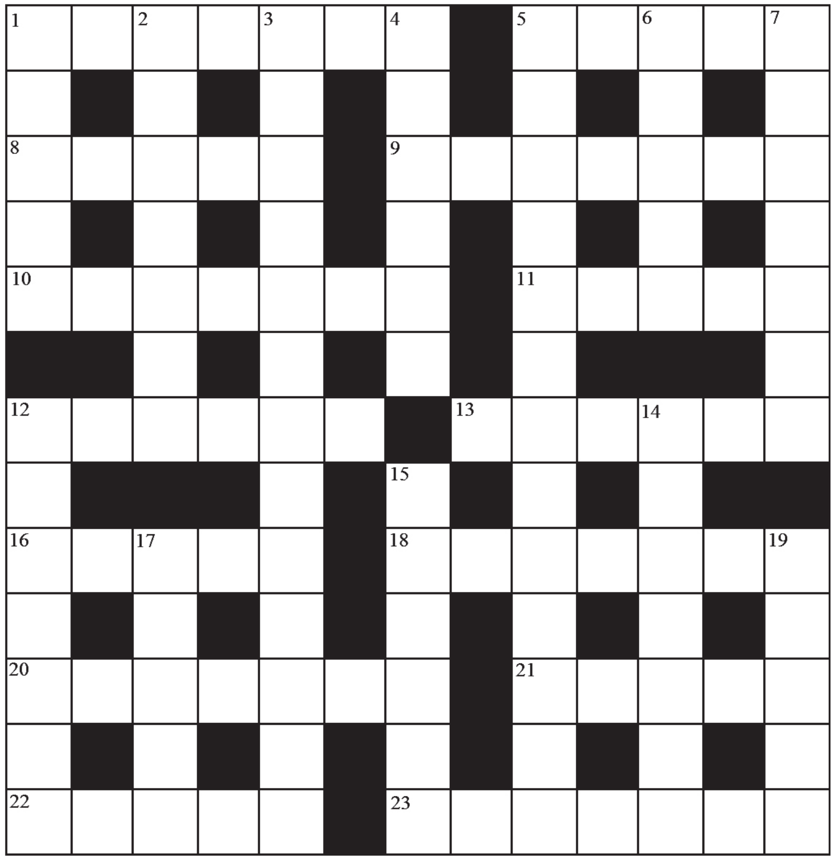


*Figure 3 — Dalton Wilson turned his telescope and camera to a familiar winter object in Orion to capture this view of the Horsehead Nebula in Hα emission. Dalton used a 900-mm f/l Equinox 120 telescope with a QSI540 camera for this 30-minute (3×600 s) exposure from Didsbury, Alberta. The opacity of the Horsehead is caused mostly by thick dust; bright spots in the Horsehead's base are young stars just in the process of forming. The change in density of stars from one side to the other of the ribbon of nebulosity that contains the horse-head shape is an indication that an obscuring region of dust lies in the region.*

*Figure 4 — Joel Parks captured the Flaming Star Nebula (IC 405) in Auriga with a 4-hour exposure through an Hα filter using a Takahashi 130 telescope and an SBIG STL 11000 camera. The nebula encompasses the star AE Aurigae, giving an impression that the star is burning—thus the name. AE Aur is an erratic variable and runaway star whose motion can be traced back to the Orion Belt area. The nebula lies about 1500 light-years distant and spans a diameter of about 5 light-years.*

# Astrocryptic

*by Curt Nason*



ACROSS

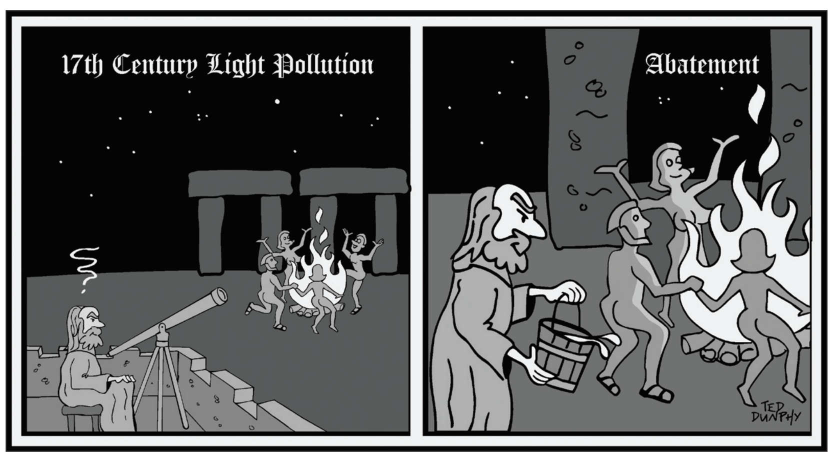
1. Tin star moving across the face of one (7)
5. Old solar astronomer but not by name (5)
8. Herschel's career field was total back before the Index Catalogue (5)
9. Steel turns into rock and ice around Saturn (7)
10. Astronomy is one found oddly in such iced nuclei (7)
11. Ultimate Greek character is around game changer (5)
12. Inspect without a heart, like Musca (6)
13. See Zorro knock out friend who was a Czech astronomer (1,5)
16. I hear a flying machine on Elysium or Utopia (5)
18. Run coin around a star map to find Monoceros (7)
20. Tiered wall inside broken crater to the east of the Moon (7)
21. Outreach effort with electronic outlet (5)
22. New school board epitomized by Einstein (5)
23. Star and Sun blend for outreach highlight with rings (7)

DOWN

1. Sidereal and solar ones let me sit back around (5)
2. Hussies make HA comet images like Lovejoy and McNaught (7)
3. Scot accent Don arranged at time of total immersion (6,7)
4. Patrick Moore and his books have them (6)
5. Somehow tell fine wonky folks our best place to watch the ToV (11,2)
6. A sure change bears north in the sky (5)
7. Get sick feeling about nothing stretched in our magnetosphere (7)
12. Iapetus provides the driving force with AM conversion (7)
14. Space probe series had one in dock (7)
15. It sure is variable in Carina (6)
17. Star that leads a triangle in two ways (5)
19. Herschel made them with pen and oboe (5)

# It's Not All Sirius—Cartoon

*by Ted Dunphy*



# THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

## Executive committee and appointed officers for 2012/Comité exécutif et membres attitrés pour 2012

| | |
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| **President** | Mary Lou Whitehorne, Halifax |
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| **Editor of The Beginner's Observing Guide** | Mary Lou Whitehorne, Halifax |
| **Editor of Observer's Calendar** | Dave Lane, Halifax |
| **Executive Director** | Deborah Thompson, CAE, Toronto |

## Centre addresses/Adresses des centres

The most current contact information and Web site addresses for all Centres are available at the Society's Web site: www.rasc.ca

**Belleville Centre**
c/o Greg Lisk, 11 Robert Dr
Trenton ON  K8V 6P2

**Calgary Centre**
c/o Telus World of Science, PO Box 2100
Stn M Location 73
Calgary AB  T2P 2M5

**Charlottetown Centre**
c/o Brian Gorveatt,
316 N Queen Elizabeth Dr
Charlottetown PE  C1A 3B5

**Edmonton Centre**
c/o Telus World of Science
11211 142 St
Edmonton AB  T5M 4A1

**Halifax Centre**
PO Box 31011, Halifax NS  B3K 5T9

**Hamilton Centre**
c/o Mr. A. Blanchard, 2266 Lakeshore Rd W
Oakville ON  L6L 1G8

**Kingston Centre**
PO Box 1793, Kingston ON  K7L 5J6

**Kitchener-Waterloo Centre**
305 - 20 St George St, Kitchener ON  N2G 2S7

**London Centre**
c/o Peter Jedicke, 82 Barrydale Cres
London ON  N6G 2X4

**Mississauga Centre**
PO Box 98011, 2126 Burnhamthorpe Rd W
Mississauga ON  L5L 5V4

**Centre francophone de Montréal**
C P 206, Station St-Michel
Montréal QC  H2A 3L9

**Montréal Centre**
18455 Meloche St
Pierrefonds QC  H9K 1N6

**New Brunswick Centre**
c/o Paul Gray, 1068 Kingsley Rd
Birdton NB  E3A 6G4

**Niagara Centre**
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Niagara Falls ON  L2E 6A2

**Okanagan Centre**
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Kelowna BC  V1Y 9H2

**Ottawa Centre**
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**Prince George Centre**
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Prince George BC  V2N 6S2

**Québec Centre**
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Québec QC  G1J 5E7

**Regina Centre**
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Regina SK  S4P 4J7

**St. John's Centre**
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St. John's NL  A1E 5H9

**Sarnia Centre**
c/o Marty Cogswell, 6723 Pheasant Ln
Camlachie ON  N0N 1E0

**Saskatoon Centre**
PO Box 317 RPO University
Saskatoon SK  S7N 4J8

**Sunshine Coast Centre**
5711 Nickerson Rd
Sechelt BC  V0N3A7

**Thunder Bay Centre**
286 Trinity Cres
Thunder Bay ON  P7C 5V6

**Toronto Centre**
c/o Ontario Science Centre
770 Don Mills Rd
Toronto ON  M3C 1T3

**Vancouver Centre**
1100 Chestnut St
Vancouver BC  V6J 3J9

**Victoria Centre**
3836 Pitcombe Pl
Victoria BC  V8N 4B9

**Windsor Centre**
c/o Greg Mockler
1508 Greenwood Rd
Kingsville ON  N9V 2V7

**Winnipeg Centre**
PO Box 2694
Winnipeg MB  R3C 4B3

Journal

## Great Images

*Lynn Hilborn contributed another spectacular sky portrait to the* Journal*'s back cover with this detailed image of the galaxies M106 and NGC 4217. The image was acquired at his Whistlestop Observatory near Grafton, Ontario, over five days in March. Exposure was a total of 20.5 hours using a TEC 140 telescope and an FLI ML8300 camera: 9 hours Hα; 5.5 hours luminance, and 2 hours each in R, G, and B. High-energy jets emanating from the supermassive black hole in the centre of M106 create a shock wave that excites material in the galaxy's halo, seen here in the ionized light emitted by hydrogen atoms.*