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Journal

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PROMOTING ASTRONOMY IN CANADA

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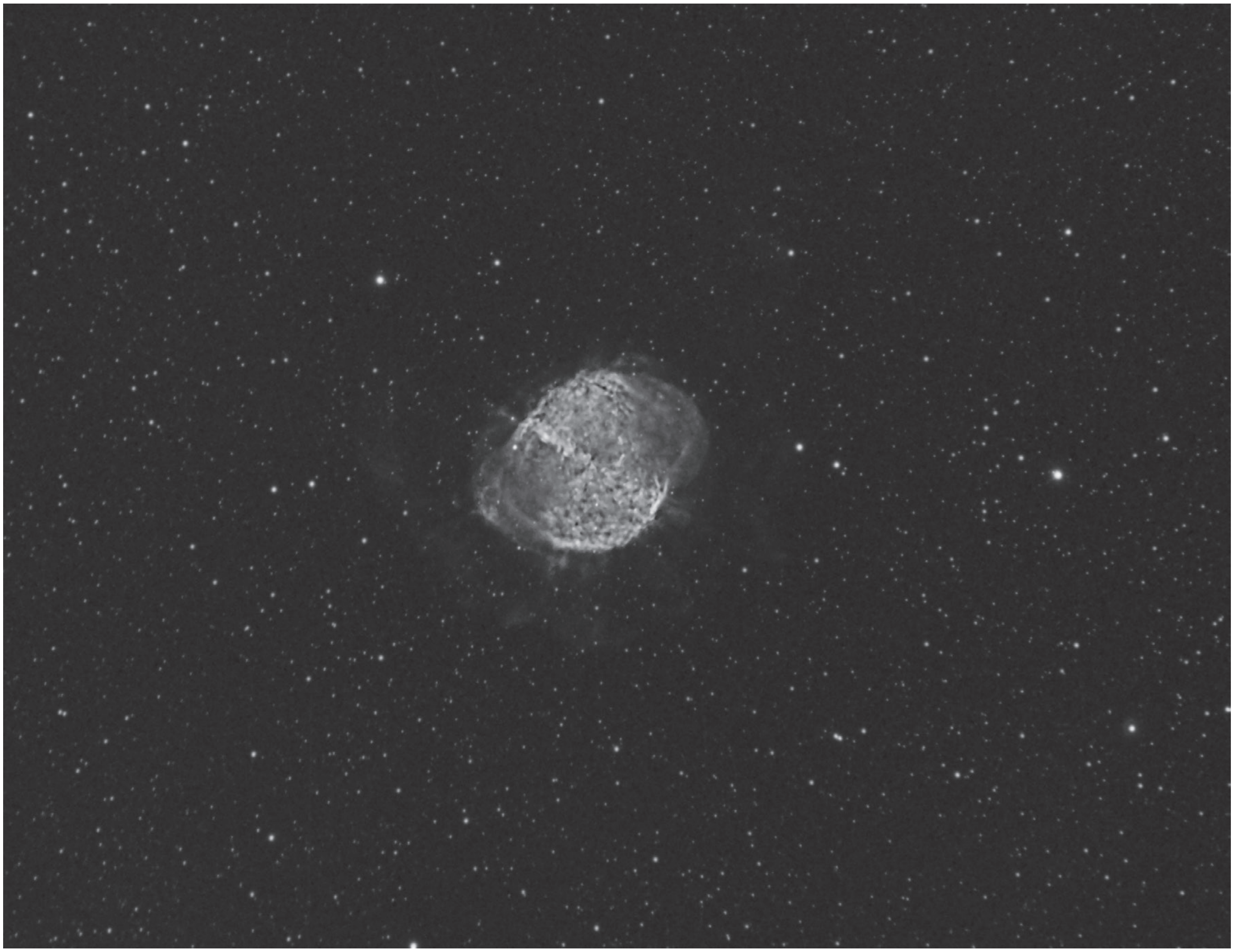
Dark Knight

The Best of Monochrome.

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



This Hα image of Messier 27, otherwise known as the Dumbbell Nebula, was captured by Dan Meek from Calgary, Alberta. The 3-hour image was taken on 2015 August 11 with a Tele Vue 127is telescope with a 2× Powermate and a QSI583wsg CCD camera.

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contents / table des matières

Feature Articles/ Articles de fond

Columns / Rubriques

Departments / Départements

Drew Patterson captured the Horsehead Nebula and the Flame Nebula from Horseshoe Valley, Ontario, in March 2015 using an Orion ED80 and an SBIG STF 8300c. The image is a total of 13 900-second exposures and was processed in PixInsight.

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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Canada

President's Corner

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

Last month I wrote "There's a certain feeling in the air that BIG things are about to happen." And, as I said, BIG things—the RASC bought *SkyNews* magazine! How much bigger does it get? See Randy Attwood's article further on. This begins an exciting venture for both the RASC and *SkyNews*. It means the publication will carry on with an unbroken record of 20 years of generating good, old, home-grown astronomy articles and information for astronomers of all ages and levels, from rank amateur to seasoned professional.

At the Board of Directors election in July at the General Assembly, I was re-elected as your President, and I pledge to continue my efforts toward a better RASC. We're not alone in this, as there are numerous other people on the Board and the National Council (note that we're no longer calling it the "Advisory Council"—too exclusive), people with many talents and valuable experience and knowledge, who guide everything we do in the Society. We try to adhere to our long-range Strategic Plan, and I believe we are actually accomplishing what we set out to do.

Part of that Strategic Plan is to "Improve the Society's Centre Support Programs." One of those targets is to create a National Speaker's Bureau; another is to develop astronomical research through specific projects. Let me tell you about the new and improved website. By the time you get this, the new site will be up and running, including the Speaker's Bureau, thanks to much hard work from Denis Grey, and a new Special Projects Program, initiated in September, with Barbara Wright (Victoria), Katrina Ince-Lum (Toronto), and Dr. Howard Trottier (Vancouver) as Trustees. If you have a project in mind, make sure to apply for a grant, and keep applying, even if you don't succeed at first.

By the way, if you were at the Halifax General Assembly, be sure to tell your fellow astronomers about the good times you enjoyed. If you weren't there, you missed out on a great opportunity to "recharge your batteries," as David Levy famously said.

This is the first issue of the *Journal* for Nicole Mortillaro, incoming Editor-in-Chief. We will ensure she has all the support she needs to continue in Jay Anderson's very large footsteps.

Clear skies! ✶

Editor's Note

Nicole Mortillaro, Toronto Centre
(editor@rasc.ca)

Just a few short years ago, upon a chance meeting with Paul Mortfield, now the Toronto Centre president, I joined the RASC. I had been hesitant at first, intimidated by what I perceived to be the wealth of knowledge I didn't yet possess.

But now, not only am I a proud member of RASC, I am proud to take the helm of our prestigious *Journal*, 109 years after its inception.

Our *Journal* is a well-respected source of astronomical information, from what is popular to scientific advances.

But a lot has changed since 1907.

Cars are a major form of transportation, as are airplanes. Then there's television. We started a space program. We have sent 12 people to walk on our Moon. We have, on average, 6 people who travel around our planet once every 90 minutes in a space laboratory. Not only have we discovered what was once considered our ninth planet, Pluto, but we've sent spacecraft there, to the outer reaches of our Solar System. We understand that we only see just roughly 5 percent of our Universe. We know that almost every star supports planets, and we've even mapped out clouds on these distant worlds.

And that means that we, as the *Journal*, have also grown. That we continue to change along with what we've learned and how society has changed.

We need to change with it.

While we may think that the youth of today aren't interested in science, you only need to look around to see that that's not true.

News articles follow the *Rosetta* spacecraft as it tags along with Comet 67P/Churyumov-Geramisenko. People are excited to see the Aurora Borealis and want to know when they will get the chance to see it for themselves. There are social-media events like Tweetups that our youth soak up and in which they eagerly participate.

Figure 1 — The love of astronomy is healthy. Here, your intrepid Editor-in-Chief—with much enthusiasm—along with hundreds of others at Johns Hopkins University in Laurel, Maryland, witnesses history as NASA's New Horizons *spacecraft reaches its closest flyby of Pluto on 2015 July 14.*

And, most recently, people cheered and cried to see Pluto for the very first time up close and personal.

We, as an organization, need to take up arms and bring these people into our fold. While we may be reticent to change, we need to show them the enthusiasm we feel. We need to make our organization a welcoming place from which the public knows it can gain further knowledge. We need to bring them the latest scientific breakthroughs and theories. But we need to make the information palatable and accessible.

Our *Journal* is a magnificent forum where we can do this.

Our members can help us make our *Journal* change along with the fast-paced world.

My door is always open. Please: feel free to let me know what you want to see more of (or less of) in our publication. Let me know how we can continue the prestigious tradition of our beloved *Journal*.

So, it is with great humility that I take the reins from Jay Anderson, who has helped make the *Journal* what it is today. And I am thrilled to work with James Edgar, RASC President and production manager of the *Journal*. He has always been encouraging and supportive of my role. And, as president, I know he is always looking for ways to improve our organization, from encouraging more youth involvement to ensuring that there is more equal representation of gender.

Now, I turn to you, RASC members. Let us bring the love of our Universe to the public, especially those who may be intimidated, as I once was. They may be able to offer our Society a great deal more than we ever thought. ✶

Nicole Mortillaro, Editor-in-Chief

News Notes / En manchettes

Compiled by Andrew I. Oakes

Giant planet distorts circumstellar debris disk around young star

Beta Pictoris, a 20-million-year-old star located 63 light-years from Earth, is known to have a large, edge-on, gas-and-dust disk encircling it. Embedded within that disk is a giant planet, discovered in 2009. The planet's estimated orbital period is between 18 and 22 years, a comparatively short period, permitting astronomers to see large motions in only a few years, and to study how the Beta Pictoris disk itself is distorted by the presence of a massive planet.

NASA's *Hubble Space Telescope* secured two comparison photographs 15 years apart—one in 1997 and the other in 2012. According to information provided by NASA, the newer visible-light *Hubble* image traces the disk in closer to within about 1 billion kilometres of the star. The new images reveal the inner disk and confirm a complicated structure for the inner disk due to the gravitational pull by the short-period giant planet. *Hubble*'s Imaging Spectrograph took both images in visible light, incorporating the instrument's coronagraphic imaging mode that blocked out the glare of the central star so that the disk could be seen.

Astronomers have concluded that the disk's dust distribution has barely changed over 15 years despite the fact that the entire structure is orbiting the star "like a carousel." This suggests the disk's structure is smoothly continuous in the direction of its rotation on the time scale of about the accompanying planet's orbital period. The disk is easily seen because it is tilted edge-on and is especially bright due to a very large amount of starlight-scattering dust.

Hubble has not been the only instrument imaging the system, as ground-based telescopes have joined in to study the structure. For example, six years ago, the European Southern Observatory's Very Large Telescope directly imaged the gas-giant planet in the Beta Pictoris system in infrared light. For comparison purposes, scientists have calculated that within our Solar System, the planet would be located inside the radius of Saturn's orbit about the Sun.

To date, *Hubble* has viewed nearly all of the approximately two-dozen known light-scattering circumstellar disks. Scientists note that Beta Pictoris is the first and best example of what a young planetary system looks like. It remains the only directly imaged debris disk that has a giant planet.

Beta Pictoris was the first star discovered in 1984 to host a bright disk of light-scattering circumstellar dust and debris. Interestingly, *Hubble*'s spectroscopic observations in 1991 found evidence for extrasolar comets frequently falling into the star.

Potential mission to reveal atmospheric secrets of selected exoplanets

One of three proposed European Space Agency (ESA) science missions will investigate the atmospheres of several hundred planets orbiting distant stars if it is selected as the top project.

ARIEL (Atmospheric Remote-Sensing Infrared Exoplanet Large-survey) is due for launch in 2026, provided it beats out the two other candidate proposals. The *ARIEL* mission represents a concept developed by a consortium of more than 50 institutes from 12 European countries—UK, France, Italy, Germany, the Netherlands, Poland, Spain, Belgium, Austria, Denmark, Ireland, and Portugal.

According to mission planners, *ARIEL* will seek answers to such fundamental questions about how planetary systems form and evolve. The planned 3.5-year mission will observe over 500 exoplanets, ranging from Jupiter- and Neptune-size down to super-Earths, in a wide variety of environments with the main focus being exotic, hot planets in orbits very close to their star.

Scientists understand that hot exoplanets are "a natural laboratory" in which to study the chemistry and formation of exoplanets. In comparison, cooler planets result in different gases separating out through condensation and sinking to form distinct cloud layers. Most significantly, a hot exoplanet's scorching heat overrides these processes and keeps all molecular species circulating throughout the atmosphere.

As of July 2015, astronomers have identified nearly 2000 exoplanets. However, so far no discernible pattern has been recognized linking the presence, size, or orbital parameters of a planet to what its parent star is like. The answers to how either the chemistry of a planet is linked to the environment in which it forms, or its birth and evolution is driven by its host star, require researchers to study a large sample of exoplanets, a task that *ARIEL* will be well equipped to do.

The European spacecraft will feature a metre-class mirror collecting infrared light from distant star systems. This light will be focused to a spectrometer that will allow scientists to extract the chemical fingerprints of gases in the planets' atmospheres when target planets pass in front of or behind their parent star. The spacecraft's specifications include the following:

- Elliptical primary mirror: 1.1 × 0.7 metres
- Spectrometer: Covering the band from 1.95 to 7.8 microns and photometric bands in the visible and in the near-IR
- Mission lifetime: 3.5 years
- Payload mass: ~300 kg
- Dry mass: ~950 kg
- Launch mass: ~1200kg
- Destination: Lagrange Point 2 (L2 – a gravitational balance point beyond Earth's orbit)

- Cost: <450 million Euros
- Launch vehicle: Ariane 6-2
- Expected Launch if project selected: 2026

With an orbit at L2, the spacecraft will be shielded from the bright Sun. It will offer a clear view of the whole night sky, which will maximize *ARIEL*'s options for observing previously discovered exoplanets.

The other two candidate proposals recommended by a peer review committee for further evaluation include *Thor* (the *Turbulence Heating ObserveR*) and *Xipe* (the *X-ray Imaging Polarimetry Explorer*). The goals of these competing proposals are:

- *THOR*—Address a fundamental problem in space plasma physics concerned with the heating of plasma and the subsequent dissipation of energy. The spacecraft would orbit Earth with one of its objectives of studying the interaction of the solar wind with Earth's magnetic field. This information would shed light on the underlying physical mechanisms of plasma behaviour under turbulent conditions. It would lead to an understanding of a key interaction between planets and their host stars.
- *XIPE*—This mission would study X-ray emissions from high-energy sources such as supernovae, galaxy jets, black holes, and neutron stars. The objective would be to find out more about the behaviour of matter under extreme conditions. Able to make high-resolution measurements of the polarization sources, the mission would open a new window into the high-energy Universe.

A total of 27 proposals were submitted last year in response to the ESA's mission call for specific space-research programs. Whichever of the three short-listed candidate missions is selected, the winner will fill the fourth medium-class (M4) opportunity in ESA's *Cosmic Vision 2015–2025 Plan*. Current medium-class missions already selected are *Solar Orbiter*, *Euclid*, and *PLATO*. These are scheduled for launch in 2018, 2020, and 2024 respectively.

Sinkholes source of some dust jets

Comet 67P/Churyumov–Gerasimenko has given *Rosetta* mission scientists a glimpse of the comet's chaotic and diverse interior. According to a study reported in the science journal, *Nature*, some of the dust jets emerging from the comet the *Rosetta* spacecraft is currently orbiting can be traced back to active pits or "sinkholes" likely formed by a sudden collapse of surface areas.

From a distance of a few hundred kilometres, *Rosetta* has been monitoring the comet's activity robotically for over a year, seeing the halo of dust and gas grow with the comet moving ever closer to the Sun along its orbit. The comet has produced an intricate pattern of dust jets released from its nucleus spilling out into space.

Thanks to high-resolution images taken last year by *Rosetta*'s OSIRIS (Optical, Spectroscopic and Infrared Remote Imaging System) camera from distances of just 10–30 km from the comet centre, at least some of the dust jets have been traced back to specific locations on the surface. Scientists have identified 18 quasi-circular pits in the northern hemisphere of the comet, some of which continue to be the source of activity. According to estimates, the pits are a few tens to a few hundreds of metres in diameter and extend up to 210 metres below the surface to a smooth dust-covered floor.

Mission specialists have seen jets rising from the fractured areas of the walls inside the pits. They conclude that trapped volatiles under the surface are warmed more easily, and then escape into space. Images have led scientists to suggest that the pits are formed when the ceiling of a subsurface cavity becomes too thin to support its own weight and collapses as a sinkhole. The exposed interior now allows the previously hidden material to sublimate.

The comet's orbit is approximately 6.5 years. At its furthest, the comet can be located just beyond the orbit of Jupiter. At its closest, it is found between the orbits of Earth and Mars.

Rosetta originally rendezvoused with the comet on 2014 August 6, around 540 million km from the Sun after a 10-year journey. On 2015 August 13, the comet was at perihelion—its closest point to the Sun, some 186 million km from it—with the orbiter in tow and accompanying the comet back to deep space until the mission ends in September 2016.

The mission, a Planetary Cornerstone Mission in ESA's long-term space science program, consists of two spacecraft—the orbiter (*Rosetta*) and the lander (Philae) that successfully settled on the comet on 2014 November 12. The ESA mission has contributions from its member states and NASA. Meanwhile, *Rosetta*'s Philae lander involves a consortium led by DLR (the national funding agencies of Germany), MPS (Max Planck Institute for Solar System Research), CNES (France), and ASI (Italy). Canada participated in the construction of ESA's first 35-m-diameter Deep Space Antenna in Australia, built for *Rosetta*.

The overall mission takes its name from the *Rosetta Stone*, an incomplete stela of black basalt incised with three scripts—Egyptian Hieroglyphs, Egyptian Demotic, and Greek—that provided the key to deciphering Egyptian hieroglyphs. The lander is named after an island in the Nile River. Here archaeologists found an inscription on an obelisk that confirmed their interpretation of the *Rosetta Stone* texts, a major breakthrough in Egyptology.

Solar System scientists expect major breakthroughs in understanding the cometary domain.

Planetary science scores a major accomplishment

American ingenuity and determination secured a major scientific triumph with the visit of what was until recently the ninth Solar System planetary body now designated a dwarf planet. The successful flyby of the *New Horizons* spacecraft on 2015 July 14 finally rewarded professional and amateur astronomers with the long-anticipated close-up views of the Pluto system, and specifically Pluto itself. The NASA spacecraft also observed the smaller members of the Pluto system—its four other moons: Nix, Hydra, Styx, and Kerberos.

As a mission of exploration, the flyby revealed immediate discoveries of icy mountains on Pluto and a crisp view of its largest moon, Charon. In addition to identifying flowing ice across Pluto—revealing signs of recent geologic activity—mission scientists were also surprised by exotic surface chemistry, and an extended haze, which all point to a diversity of planetary geology.

Seven hours after *New Horizons*' closest approach, the spacecraft's LOng Range Reconnaissance Imager (LORRI) pointed back at Pluto and captured sunlight streaming through its atmosphere. This image revealed hazes as high as 130 kilometres above Pluto's surface, with two distinct layers of haze—one about 80 kms above the surface and the other at an altitude of about 50 kms. Previous calculations had predicted that temperatures would be too warm for hazes to form at altitudes higher than 30 kms above Pluto's surface (see back cover image).

The LORRI image represents the first photograph of an alien atmosphere in the Kuiper Belt. It will provide clues as to what is happening below on the dwarf planet. For scientists, the detected hazes denote a key element in creating the complex hydrocarbon compounds that give Pluto's surface its reddish hue.

More discoveries will follow as the data collected by the *New Horizons* probe, which will take 16 months to download back to Earth, are studied.

According to preliminary assessments, NASA also reported that the close-up image of an equatorial region near the base of Pluto's bright heart-shaped feature shows a mountain range with peaks jutting as high as 3 500 metres above the surface of the icy body. The mountains may be composed of Pluto's water-ice "bedrock."

Scientists estimate these mountains likely formed no more than 100 million years ago, which suggests the close-up region (covering about one percent of Pluto's surface), may still be geologically active even today with currently unknown processes generating the mountainous landscapes. In comparison, our Solar System is estimated at being 4.56 billion years old.

As for the moon Charon, mission scientists have described the new images revealing a youthful and varied terrain with a surprising apparent lack of craters. They have identified a swath of cliffs and troughs stretching about 1 000 kms. This situation suggests widespread fracturing of Charon's crust, due likely to internal geological processes. A canyon running 7 to 9 kms deep has also been imaged.

Known as a Kuiper Belt object, Pluto is the first to be visited by a mission from Earth. The *New Horizons* spacecraft is continuing deeper into the Kuiper Belt, searching for more clues as to how our Solar System formed.

The Johns Hopkins University Applied Physics Laboratory in Laurel, Maryland, designed, built and operates the *New Horizons* spacecraft and manages the mission for NASA's Science Mission Directorate.

Kepler-452b: First near-Earth-size planet in habitable zone

Planetary science experienced a major extra-solar milestone in late July 2015 when NASA's *Kepler* space mission confirmed the first near-Earth-size planet in the "habitable zone" around a Sun-like star.

Kepler-452b is the smallest planet to date discovered orbiting in the habitable zone of a G2-type star, like the Earth's Sun.

The zone is an area around a star where liquid water could pool on the surface of an orbiting planet.

Mission scientists have calculated that Kepler-452b is 60 percent larger in diameter than Earth and is considered a super-Earth-size planet. Previous research suggests that planets the size of Kepler-452b have a good chance of being rocky.

Kepler-452b orbits its star in 385 days, some 5 percent longer than our Earth orbits the Sun. Also, the planet is 5 percent farther from its parent star Kepler-452 than Earth is from our Sun. The newly identified planet is 6 billion years old (1.5 billion years older than our Sun), has the same temperature, is 20 percent brighter, and presents a diameter 10 percent larger.

Scientists collaborated with ground-based observatories to help confirm their findings and to better determine the properties of the Kepler-452 star system. The team's research paper reporting its findings will be published in an upcoming issue of *The Astronomical Journal*.

Ground-based observations were conducted at the University of Texas at Austin's McDonald Observatory, the Fred Lawrence Whipple Observatory on Mt. Hopkins, Arizona, and the W.M. Keck Observatory atop Mauna Kea in Hawaii. Measurements obtained were key for researchers to confirm the planetary nature of Kepler-452b, to refine the size and brightness of its host star, and to better pin down the size of the planet and its orbit.

The Kepler-452 system, located 1 400 light-years away, is in the constellation Cygnus. ✶

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

Featured Articles / Articles de fond

Starlight and Semiconductors

Art Cole, Halifax Centre (art.cole@gmail.com)

Did you know that your astrophotos are three-dimensional? It may be a bit hard to believe, but it's true. They're not 3-D in the sense that you can put on a pair of red-and-blue glasses and see stars and planets popping out of your computer screen, though—the third dimension in your images is a little more subtle. But once you understand what this third dimension is and how to visualize it, it becomes much easier to manipulate your images to get better-looking results.

Let's begin with the first two dimensions of your astrophotos—namely, the width and height of your images. All computer images are made up of a grid of tiny dots, called pixels, that collectively make up an image. When you look up an image's properties on your computer and it says that your image is 1024×512, that means your image is 1024 pixels wide and 512 pixels high (and thus contains 524,288 pixels).

So what is this magical third dimension? It's brightness! Every single pixel in an image has its own brightness value, commonly called its intensity, and it's the pixel intensities in an image that give it information and make it interesting (okay, there's colour, too, but let's save that for another day). A photo

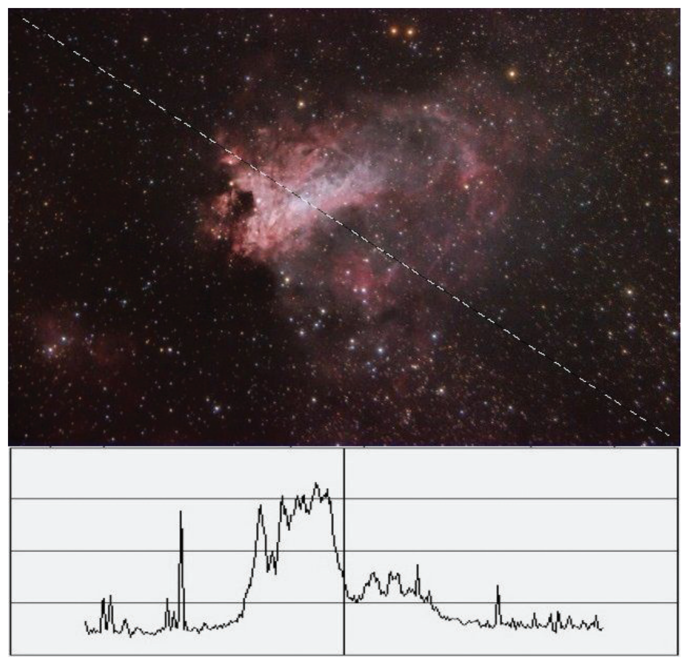

Figure 1 — The line profile of an M17 image displays the nebula as a "mountain" that rises above a low sky background, with stars appearing as tall, thin spikes.

of a bright, daytime beach scene would mostly contain pixels with high-intensity values, while a nighttime photo would mostly contain pixels with low-intensity values.

But trying to visualize this third dimension for the first time can be a bit difficult. I usually explain it to people like this: Imagine you could peel your image off the computer screen, make it bigger, and then lay it on the floor like a big tapestry. Then, with a wave of your magic wand, the image would lift

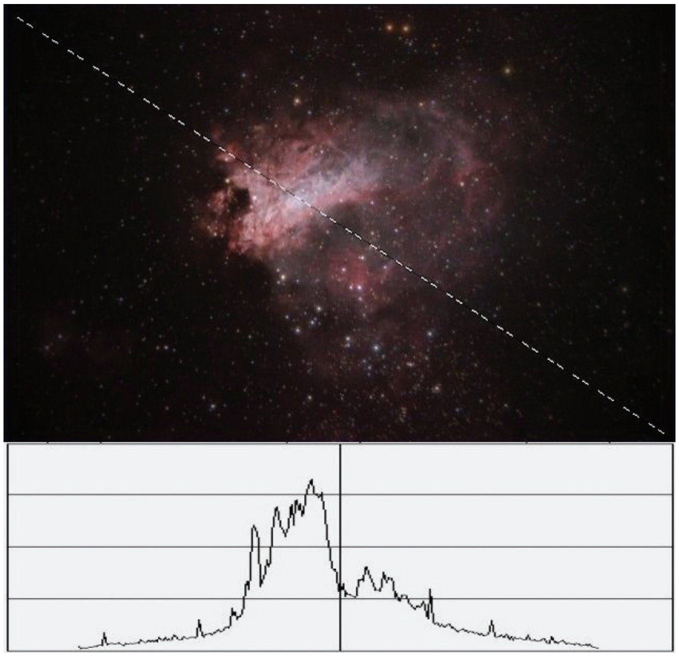

Figure 2 — With the unwanted effects of vignetting, the M17 image has a high brightness in the centre and a low brightness at the edge.

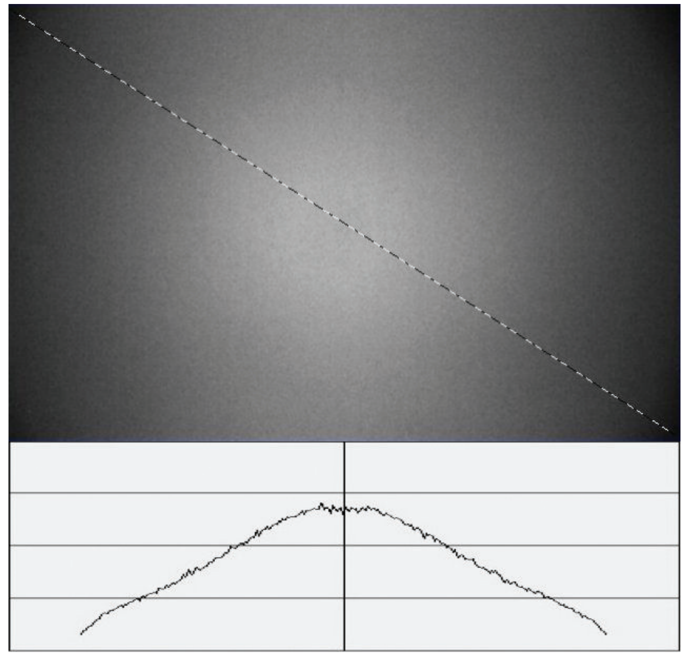

Figure 3 — The line profile of a "flat" calibration image shows that its 3-D intensity peaks in the centre and decreases towards the edges.

up off the floor, with bright areas of the image rising almost up to the ceiling, and dark areas staying low. Your previously flat-looking image is now three-dimensional, with stars looking like tall, thin spikes, galaxies and nebulae looking like hills and mountains, and the sky background being a low, flat, fuzzy layer. And there are limits—the floor is as low as you can get (zero brightness, or black) and the ceiling is as high as you can get (maximum brightness, or white).

In order to show this visually, I took one of my images of the Swan Nebula (M17), drew a line through it, and plotted the brightness of the image along that line (Figure 1). If you look at that line profile and imagine that the bottom of the plot is the floor, and the top is the ceiling, then the 3-D shape of the image becomes apparent. The image background is low and flat (being dark, but not completely black), the stars are tall, thin spikes, and M17 appears as a big "mountain" in the room, with two distinct height regions representing areas of two different intensities.

Now that we know how to visualize an image in 3-D, we can put this to work for us. Have you ever heard astrophotographers talk about "flat" frames? These are used to solve an optical problem called vignetting. Vignetting is an undesirable artefact produced by optical systems where the image captured by the camera appears darker in the corners than in the middle. Figure 2 shows the same view of M17, but with vignetting present. The corners of this image are very dark, making it impossible to see what's there. If you look at the line profile, you can see that the 3-D shape of the image has been fundamentally altered—the areas of the image away from the nebula "mountain" now slope away from it, making the sky background uneven. To fix this, astrophotographers use special images called "flats" to remove this distortion. Figure 3 shows a typical flat image, along with its line profile. In 3-D, this image would look like someone plopped a volcano in your room, with a tall central peak that slopes down to the corners. So how does the flat allow us to reduce vignetting? This is done by dividing each pixel's value in the sky image by the value of its corresponding pixel in the flat image. Since the pixels in the corners of the flat image have lower intensities than those in the middle, dividing by those lower pixel values will boost the brightness in the corners of the original image (as we're dividing by smaller numbers) and flatten the image background, getting us back to the "flat" image in Figure 1. In essence, what we've done is we've lifted up the perimeter of our outward-slanting image from Figure 2 until the background is flat and has a nice, even brightness, just like how the sky actually looks.

We can also apply this visualization technique to better understand the bane of astronomers everywhere: light pollution. If you could plot an image of pure light pollution in 3-D in your magic room (refer to Figure 4) it would look something like a level, opaque layer, with its height above the floor representing how bright the light pollution is at your location. This layer would be almost down on the floor for an image taken at a very dark location, and it would be near the ceiling for an image taken in the centre of a large city. Unlike with vignetting, which merely distorts your image,

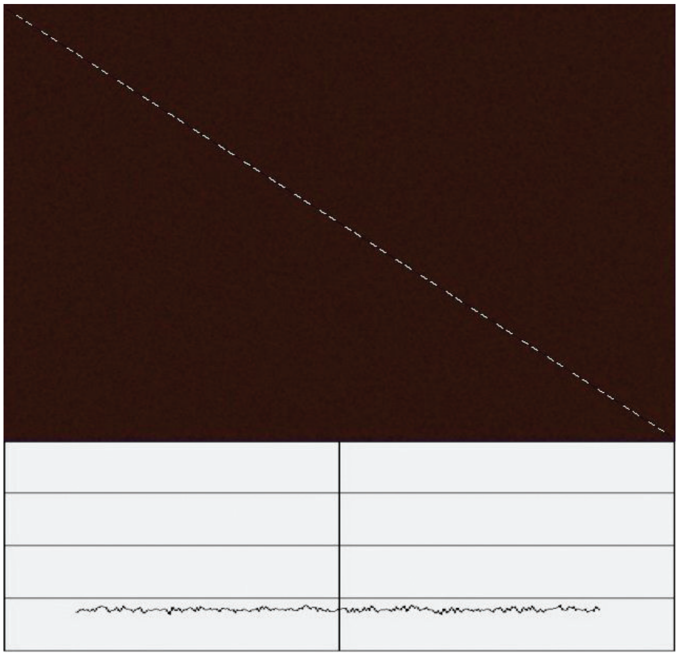

Figure 4 — The line profile of a light-pollution-only image shows that the intensity is "flat" across the image.

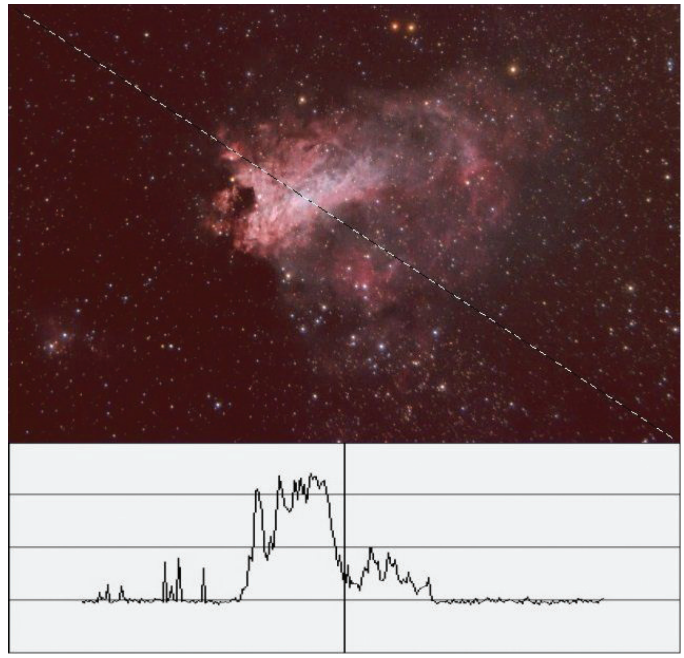

Figure 5 — With the addition of the light-pollution layer on top of the original M17 image, the darker portions of the image disappear.

light pollution sets the lower bound on what you can see—it actually removes desired information from your image. So going back to our visualisation exercise from Figure 1 (with our dark sky background near the floor and the hills and valleys of M17 rising up to eye level), imagine laying our light-pollution layer on top at knee height (Figure 5). Now we can only see features that rise above the light-pollution layer, such as the bright centre of the nebula and the brighter stars. All of the dimmer areas of the nebula are now gone, as are the dim stars. By visualizing light pollution in your image in 3-D, it becomes immediately obvious that the only way to mitigate its effect is to reduce it before it hits your camera, whether it's done by using light-pollution filters or simply going to a dark location for imaging—there's no digital quick fix for light pollution.

Astrophotographers use countless techniques for improving the quality of their images and for eliminating unwanted information such as camera noise and sky gradients. For a beginning astrophotographer it can be a bit daunting to fully understand these techniques and understand how they work (spoken from experience!), and even for an experienced astrophotographer it can sometimes be a complex mental exercise to apply the right techniques in the right order. But no matter what your skill level is, visualizing your images in three dimensions is an invaluable aid in improving your understanding of digital astroimage processing and achieving better results. ✶

Any questions? Contact me at art.cole@gmail.com.

Geoffrey W. Bell (1899-1982) Canadian Amateur Astronomer

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For well over a century, The Royal Astronomical Society of Canada has been an active organization in Canadian astronomy. During that time, its members have made substantial contributions to astronomy. One such example was small-town dentist Geoffrey Bell.

Geoffrey Bell (b.1899) was born and raised in Paris, Ontario. In 1921, Bell graduated from the University of Toronto studying dentistry and music. After graduation, he returned to his hometown to open a dental practice. It was during this time that his passion for music led to friendships through the popular Adeney Music Studio located in Paris. He met his future wife Kathleen, a student at the studio, and the couple eventually married in 1937. Soon the newlyweds moved to nearby Drumbo, but Geoffrey would continue to work at his practice in Paris until his retirement at age 80.

Bell's interests and talents were far-reaching. Aside from his professional work, Bell accomplished a great deal in other fields including music, poetry, and astronomy. Geoffrey was an accomplished cellist. His wife Kathleen was a professional musician who taught piano and violin until she was 99 years of age. For several years, the couple performed in symphony orchestras in Brantford and in Kitchener in southwestern Ontario. Kathleen celebrated her 100th birthday in 2011.

The Bell name is well known within the RASC Hamilton Centre since the donation of his 125-mm refractor by his widow Kathleen in 1987. The Hamilton Centre regularly hosts public star parties at the Westfield Heritage Village where visitors can look through his classic Victorian-era telescope.

Later, Bell's son, R. Dennis Bell, donated another of his telescopes to a modest museum in Drumbo. The Drumbo and District Museum predominantly displays the telescope along with a few other accessories including a well-crafted wooden storage box. The origin of the 95-mm ~*f*/13 refractor is not known but is obviously of high standard.

In 2014, the Kitchener-Waterloo Centre also received a wonderful contribution from Bell's family. His daughter, Nuala Freund, donated his personal logbook displaying methodical sketches of the position of the planets relative to the Sun. Starting in January 1926, Bell sketched the Solar System on a monthly basis, putting the Sun at the centre of the page and plotting the planets accordingly. The zodiacal constellations (including Ophiuchus) are displayed on an outer ring. These curious schematics continued through to June 1931. Within these pages are a few observational notes and other sketches. Highlights include a sketch of Saturn and a noteworthy series of drawings showing the position of comet Pons-Wennecke over a course of several days in late June 1927.[1]

Bell's interest in astronomy is further evident in select articles that have appeared in the *Journal* over many years. Some of his poetry and wonderful anecdotes of visual observing are featured in these pages. Among his observational experiences includes a trip to Québec to witness a total solar eclipse in 1963.

Perhaps his most lasting astronomical work is preserved in his solar sketches. Meticulous observations of the Sun covering more than 50 years are archived and highlighted in a graph that shows the solar cycle highs and lows during that span. So impressive were these observations that a former director of the Meudon Observatory in France had requested a copy for their records. The Hamilton Centre also retains these observations currently stored at their club observatory.

Figure 1 — Geoffrey Bell's 95-mm refractor is displayed in the Drumbo and District Heritage Museum in Drumbo, Ontario. Photo by Clark Muir

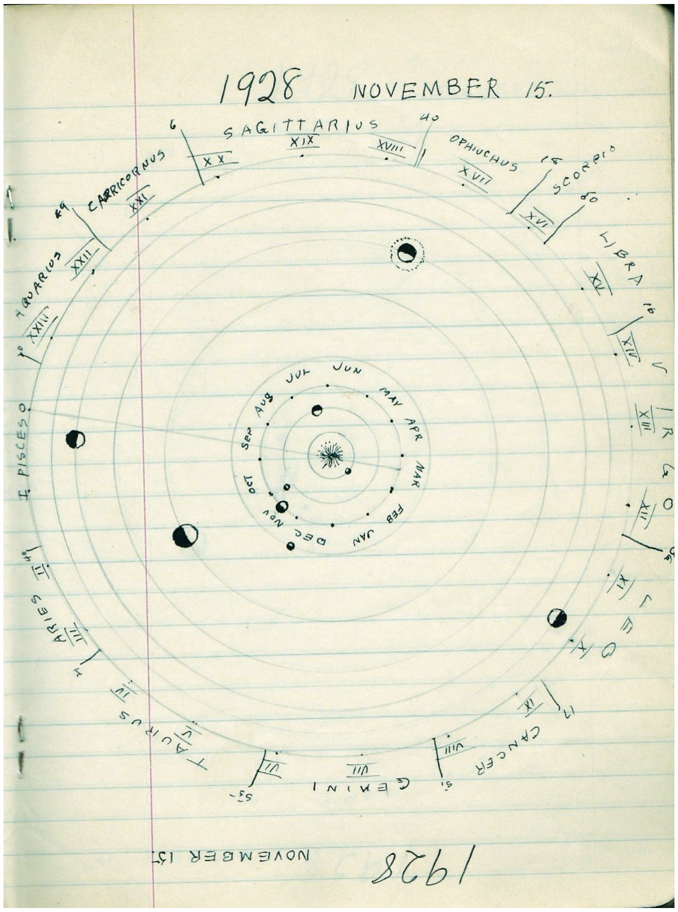


Figure 2 — A page contained in Bell's logbook shows a model of the Solar System with the planet positions accurately placed around the Sun. Scan by Jim Goetz

RASC is privileged to have acquired many of Bell's fine collection of astronomical artefacts. They preserve his memory and the substantial contribution he made to Canada's amateur astronomy community. ✶

Acknowledgements

The author wishes to thank Nuala Freund of Kitchener, Ontario for the latest donation by her family to the Kitchener-Waterloo Centre and for sharing the memory of her late father.

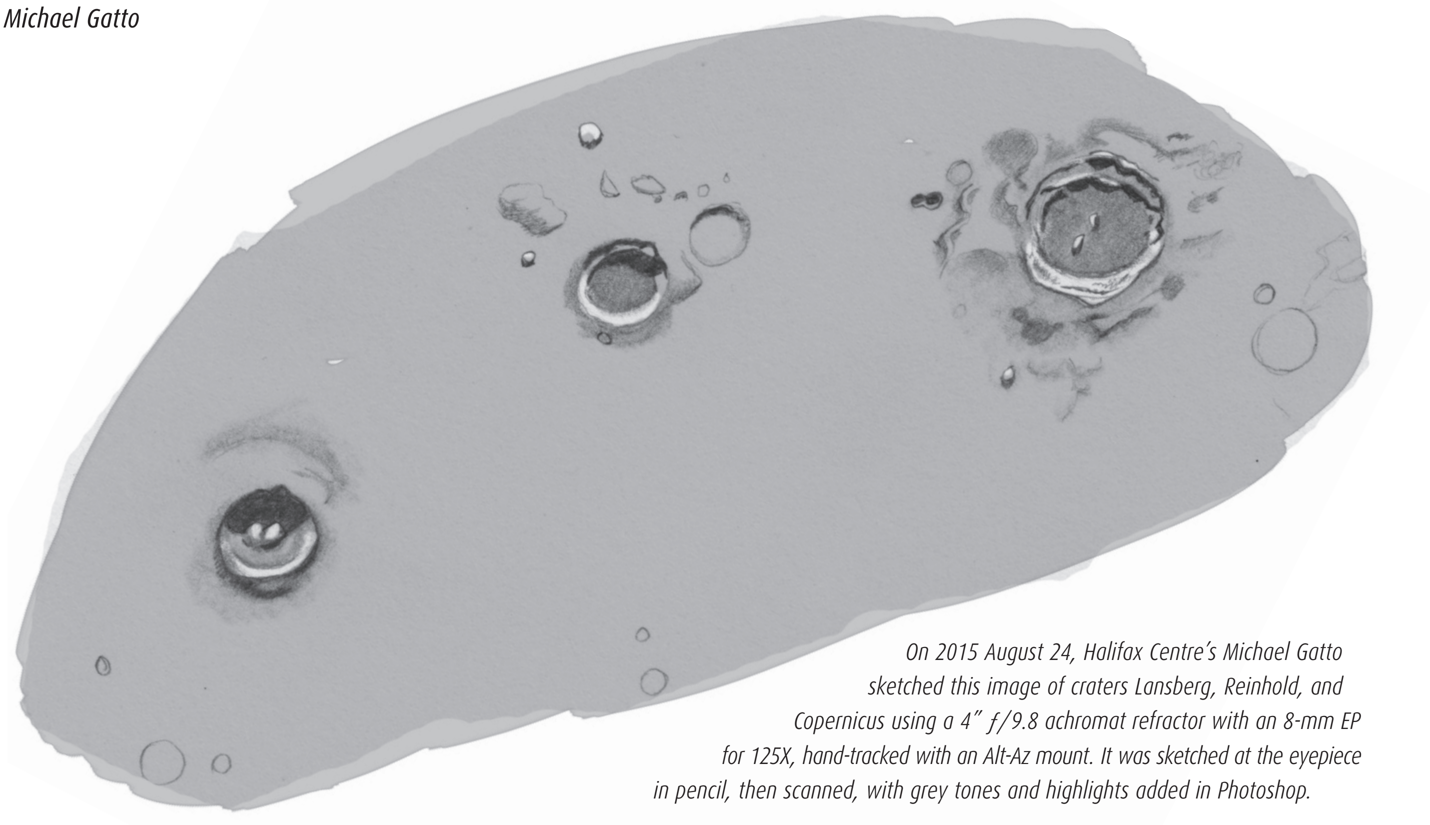
The author also expresses appreciation for the co-operation of The Drumbo and District Heritage Society in Drumbo, Ontario.

Endnotes

1 The June 1927 apparition of comet Pons-Wennicke was one of the closest to Earth by any comet in history.

Great Images

Michael Gatto



On 2015 August 24, Halifax Centre's Michael Gatto sketched this image of craters Lansberg, Reinhold, and Copernicus using a 4″ ƒ/9.8 achromat refractor with an 8-mm EP for 125X, hand-tracked with an Alt-Az mount. It was sketched at the eyepiece in pencil, then scanned, with grey tones and highlights added in Photoshop.

Ambrose Bierce, and RASC Honorary Members Barnard, Burnham, and Holden: Trouble in High Places

by R.A. Rosenfeld, RASC Archivist
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Abstract

Ambrose Bierce was an outstanding literary figure of America's "Gilded Age," and "Progressive Era." It is now not widely known that he was astronomically knowledgeable. Among his literary remains are two mordant satirical interventions in the power struggle between the first director of Lick Observatory, E.S. Holden, and two of his best observers, S.W. Burnham, and E.E. Barnard. Bierce's satires have not hitherto been cited in the modern literature concerned with the Holden affair.

The Devil's Lexicographer

"*Prattle*[,] the most wickedly clever, the most audaciously personal and the most eagerly devoured column of causerie that probably ever was printed in this country" (Millard 1915, 653). Such are the interesting words with which a memorialist graces the start of a favourable account of Ambrose Gwinnett Bierce (1842-1914?). Bierce was nothing if not interesting. The choice of words tells us much about the subject's reputation in the aftermath of his vanishing—literally— from the historical record. A century has passed since the "obituary" was written, yet the Bierce of *Prattle* is the Bierce popularly remembered today. It is not an unjust remembrance, merely an incomplete one.

"Bitter Bierce," the author of the unforgettably titled *The Devil's Dictionary* (1906), a mine of epigrammatic art for the discerning cynic, had earlier refined the satirist's craft in the trade of journalism (Sheller 1945).[1] He was apparently good at it. Writing for the less-than-scrupulous William Randolph Hearst (1863-1951) in the *San Francisco Examiner* (as well as other proprietors' media), his work could matter on the national political scene, it did not avoid controversy where it could, and it was never designed to ingratiate. People were influenced, but friends were not readily made.

It is also worth Bierce's service on the Union side in the American Civil War, his active engagement in some of the bloodiest engagements, and his surviving a serious head wound. It is venturing little to say that some of Bierce's bitterness was forged in that crucible.

There was indeed more to the textual Bierce than is now commonly remembered. He made lasting contributions to the literature of war through the tellingly applied realism of his Civil War fiction, to supernatural fiction through the sparely deft gothic of his ghost tales, and to letters through his unsparing but never dull criticism (Rubens 1976; Morris, 1999; Owens 2001). (His verse somehow seems lesser. It was doubtless written primarily to score immediate ends, rather than endure monumentally through the ages). And, among those texts, are references and pieces that attest to an author who was not confused in the least by the science of astronomy.

Bierce and astronomy

Bierce may have been among the best informed, and most capable American literary figures with an interest in astronomy.[2] His contributions could be by turns serious and playful.

A sardonic entry from *The Devil's Dictionary* illustrates those qualities: "OBSERVATORY, *n*. A place where astronomers conjecture away the guesses of their predecessors" (232).[3] This is Bierce at his epigrammatic best, memorable, succinct, and timeless, with a saying as applicable today as when it was first uttered. It says nothing about the carefully planned research programs, fruitful collaborations, continual improvements to and innovations in equipment and software, meticulous data collection, thorough data reduction, and peer-reviewed publication of results, marking work in the best observatories then and now, but it does highlight an aspect of nearly every media announcement now heralding the release of a "significant" research discovery (speculation is, after all, part of science).

Another piece is a work of criticism, namely criticism of his fellow authors for their ignorance of the course of the Moon visible to the naked eye. Of the authors targeted in "The Moon in Letters" (1911, originally published in 1903), only H. Rider Haggard is popularly remembered today. Bierce's comments are not misplaced, but the targets are easy.[4]

Astronomical personalities could also be a quarry. He took aim at Camille Flammarion several times. One instance concerned the sage of Juvisy's parapsychic views:

> *"The famous and popular Frenchman, Professor of Spectacular Astronomy, Camille Flammarion … M. Flammarion is a learned, if somewhat theatrical astronomer. He has a tremendous imagination, which naturally is more at home in the marvelous [sic] and catastrophic than in the orderly regions of familiar phenomena. To him the heavens are an immense pyrotechnicon and he is master of the show and sets off the fireworks. But he knows nothing of logic, which is the science of straight thinking, and his views of things have therefore no value; they are nebulous" (Bierce 1912, 248, 250).*

It is hard to see Bierce's comments on Flammarion's spiritualism as unjust, but that is from the perspective of the present. There was an almost respectable market for such things in the late 19th, and early 20th century.[5]

How did Bierce become astronomically knowledgeable?

The question is simple, the answer is not. Part of the problem lies in the paucity of independent sources from which to piece together Bierce's early background, his reluctance to indulge in direct and voluminous autobiography, and the measure of control of his self-crafted public persona (not always consistent).

Bierce did attend the Kentucky Military Institute at Franklin Springs, although only for a year (1859-1860). According to Roy Morris, the school "became one of the South's most prestigious military schools...with supplemental courses in... mathematics....It was here, presumably, that Bierce acquired... the useful skills of draftsmanship and cartography...." (Morris 1999, 18). In the Civil War, after ascending to officer rank, Bierce functioned as a military cartographer ("acting topographical engineer"). His surviving hand-drawn maps from that period are of high graphic quality, and have proved topographically accurate when compared against modern sources (Fatout 1954; Owens 2001, 221, 222, 234, 239, 244).[6] It is helpful to recall that cartography had intimate technical ties with 19th-century positional astronomy, that the art and science of surveying entailed a considerable amount of practical astronomy, and cartography was an "observatory science" (to employ the currently fashionable term; Schiavon 2010; Widmalm 2010). This would hardly be the first time surveying made an astronomer; the first two holders of the post of Chief Astronomer of the Dominion of Canada, Dr. William Frederick King (1854-1916), CMG, and Dr. Otto Klotz (1852-1923), both owed the beginning of their scientific careers to surveying (Jarrell 2014a; 2014b).

It seems, then, that Bierce's astronomy may have been a product of education, interest, and application.

Trouble on the mountain

Lick Observatory was the first of the monumental research observatories founded in the mountains of California (first light 1888 June 1), setting the example for what was eventually to be seen as "Big Science" in astronomical garb in the first half of the 20th century. Much was expected of the then largest refractor in the world, and, indeed, thanks to the site and the excellence of some of its complement of scientific staff, such as Sherburne Wesley Burnham (1838-1921), Edward Emerson Barnard (1857-1923), and James Edward Keeler (1857-1900), good work was accomplished (Barnard 1921, 313-314; Sheehan 2007, 122-222; Osterbrock 2002, 62-103). But all was not well on Mount Hamilton. The problem was the director.

Edward Singleton Holden (1846-1914) came equipped with a good education for the time (Washington University in St. Louis, and Westpoint), astronomical family connections (the Bonds of Harvard, and Chauvenet, the celestial mechanician), fine credentials (he was recommended by Newcomb), and excellent prospects. He was not a great or motivated observer, a meticulous astrophotographer, or an innovative theorist (Osterbrock 1984, 82-84). He was at his best as a writer of "review" articles, not an ignoble activity, which can serve as a means to advance science.[7] It might not have mattered that many on his staff were better astronomers than their director, if he had done his best to actively further their work, and was seen to do so. To the lack of managerial ability was married an ineluctable skill in antagonizing men of all sorts and conditions (Bill Sheehan has characterized it admirably; 2007, 122). The combination proved in the end fatal to his directorship of Lick, and his astronomical career.

Holden had also alienated powerful members of the Californian press, including the influential *San Francisco Examiner*. His scientific staff and the people of California were painted time and again as the aggrieved, and Holden as the oppressor. The press seemed remarkably well informed about what was happening atop Mount Hamilton. They reporters had help from the staff, and other members of the Californian scientific community not well pleased with Holden. Unfortunately for Holden, one of the *Examiner's* best writers was Ambrose Bierce.

The satires

It is clear from the texts of the two satires that Bierce was clearly of the anti-Holden camp. Both pieces centre around Holden and the Moon. The surface insult is that the Moon, the single easiest object to locate in the night sky, is all Holden is capable of finding with the great refractor at Lick. He is unable to recognize new astronomical phenomena, unlike those under him, Burnham with his hundreds of double-star discoveries, Barnard with his comet, Jovian Mmoon, and nebular discoveries, and Keeler with his epochal spectroscopic findings. But the insult has more layers, and bites deeper; it is an exquisite insult by a master. As director, Holden enjoyed mandated time at the great 36-inch, which he is reported to have squandered by leaving the dome early on good nights (reflected in the lines "...Years and years,/ Retiring early, rising with the sun,"), and by not ever implementing let alone developing his own meaningful observing programs. Barnard, meanwhile, widely recognized as a premiere observer and astrophotographer, was assigned the 12-inch, and for most of his tenure at Lick, enjoyed no regularly assigned time with the 36-inch. One of Holden's few "achievements" with the 36-inch was the beginning of a photographic lunar atlas, of which only 19 sheets ever appeared (1896-1897). Their quality was poor, particularly when compared against the excellent *Observatoire de Paris* lunar atlas of Loewy & Puiseux (1896-1910).

The tale of the literary astronomer, as well as containing the insults about Holden and the Moon, also refers to his reputation for charging exorbitant rates for his articles sent to the papers (Sheehan 2007, 197).

One can well imagine Burnham delighting in Bierce's anti-Holden satires, given his own well-developed sense of humour, and thorough dislike of the director. One wonders if Barnard would have let himself enjoy the skewering of Holden as much as his colleague might have. And was Bierce merely doing his duty in reflecting the editorial stance of the *Examiner*, or was there a more personally informed aspect to the satires? Was Bierce personally acquainted with Burnham and Barnard? Were the satires part of a primed effort, and was the astronomical background that made the satires so effective solely Bierce's work? Is it possible to discern Bierce's stylistic hand in any of the other anti-Holden press materials from the time which remain unattributed? (The tenor of these is nicely sampled in Sheehan 2007, accessible through the index under "Holden, newspaper criticisms of".)

Bierce's satires add a dimension of literary flair to the Holden affair, and while they have escaped notice in the generality of treatments (e.g. Wright 1987; Osterbrock et al. 1988), they add a skilful devilry to an already memorable story. What more could one ask for?

At The Observatory

Mahatma Holden, Autocrat of Stars,
Fixed to the telescope his curious eye
And waited for some great phenomenon
To seek his field of vision. Years and years,
Retiring early, rising with the sun,
With patience proof against defeat, he still
Had sought some grand discovery; and still,
Dogging the footsteps of endeavor, came
Grim disappointment and in mockery
Derided him. But now, even as he gazed,
A great white light crept up the sky, and lo!
Into the telescope's illumined ken
Swam with a stately grace a noble orb,
And paused in mid-field of the mighty tube!

Mahatma Holden, Autocrat of Stars,
Was found next morn beneath the instrument,
Senseless and motionless as one that's dead.
"By some emotion overcome," said one
(Sometime physician to the Ghug of Smat)
Who with sharp stimulants and kindly words
Strove to revive him. Scarcely had the fresh
And wholesome air saluted both his lungs
Than, "Paper!" cried he "paper, pen and ink!
Quick, ere the glorious memory fades ! Ah, friends,
Not all in vain my vigils and my skill
To read the secrets of the upper deep:
At last I'm famous and my name shall ring
Adown the centuries unlinked with theirs,
My menials, Burnham, Bar----"
he faltered then,
Yet with a mighty effort peaced himself,
Mastered his spirit, calmly gazed about
And, with angelic dignity, explained:
"I've found the Moon!" And it was even so.[8]

The Literary Astronomer

The Director of an Observatory, who, with a 36-inch refractor, had discovered the Moon, hastened to an Editor, with a four-column account of the event.
"How much?" said the Editor, sententiously, without looking up from his essay on the circularity of the political horizon.
"One hundred and sixty dollars," replied the man who had discovered the Moon.
"Not half enough," was the Editor's comment.
"Generous man!" cried the Astronomer, glowing with warm and elevated sentiments, "pay me, then, what you will."
"Great and good friend," said the Editor, blandly, looking up from his work, "we are far asunder, it seems. The paying is to be done by you."
The Director of the Observatory gathered up the manuscript and went away, explaining that it needed correction; he had neglected to dot an m.[9] ✶

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Endnotes

1 Bierce's best modern biographer speculates "Bitter Bierce" was coined by Bierce's occasional drinking companion of his English sojourn, the American *roué* James Mortimer; Morris 1999, 141.

2 Bierce's interest in astronomy is not well known in astronomical circles. Someone at the ESO several decades ago helpfully gathered some of Bierce's astronomical passages for distribution in the *Messenger*; Anonymous 1986.

3 "The Devil's Dictionary" started life as a column in the *Wasp* in 1881; an antecedent was Bierce's "The Demon's Dictionary" in *News Letter*, and *Fun*; Morris 1999, 182-185. The Dictionary appeared in book form in 1906 as *The Cynic's Word Book*, with a much fuller edition in 1911 under the more familiar title, *The Devil's Dictionary*. The "observatory" entry is missing from the 1906 edition the author examined, but is present in the 1911 edition.

4 Largely ignored in the literature dealing of astronomy in literature, Bierce's essay is cited by Berman 1970, 6.

5 Simon Newcomb, while not a believer, did spend some time investigating spiritualist claims, and even became the (sceptical) President of the American Society for Psychical Research; Moyer, 1992, 166-182. Other experts in the hard physical sciences were also members. As with things Arean, Flammarion's "methodology" would not appeal to those who preferred a cool, rational, fact-based approach. For a more sympathetic view of Flammarion, see Cotardière & Fuentes 1994.

6 Owens' doctoral thesis is used here; it has since appeared (2006) in monograph form as *The Devil's Topographer: Ambrose Bierce and the American War Story*, published by the University of Tennessee Press, Knoxville.

7 Joe Ashbrook writes with considerable respect of Holden's "monumental" review monograph on M42; Ashbrook 1984, 387-388. Ashbrook is of the opinion that the increasing effectives of nebular photography greatly curtailed any scientific role the 1876 monograph might have played.

8 Bierce, 1911, At the Observatory.

9 Bierce, 1899, The Literary Astronomer.

Gaius Sulpicius Galus: Soldier Astronomer

by Phil Mozel, Mississauga Centre
(dunnfore@gmail.com)

Rome

Quickly, name as many scientists from antiquity as you can. Now, how many were Roman? Probably few, if any. While Rome is known for its architecture and army, its gladiators and gods, it does not generally come to mind when discussing science.

And yet science will be paramount on 168 June 22 BC. Roman soldiers are bivouacked near Pydna, Greece, north of Mount Olympus, facing King Perseus of Macedon. The outcome of the following day's battle is, of course, unpredictable but a man in the Roman camp has knowledge, not military, but scientific, with which he hopes to stack the odds in Rome's favour.

At this time, Rome was not yet an empire; that would come later, in 27 BC, with the conquests of Augustus. And in its earliest incarnation, from the traditional founding to the expulsion of the king in 509 BC, Rome was a monarchy. At the time of Pydna, Rome was a republic and generally led by a pair of elected consuls with broad administrative, judicial, religious, and military powers.

Throughout much of this history, Rome was expanding. The extent of its conquests was so great that it eventually encompassed the entire Mediterranean Sea. One key factor in this expansion was the highly trained legionary army. Clad in metal armor and supplied with shield, spears, dagger, and short sword (gladius), a Roman soldier was generally superior to any other when fighting in legionary formation.

The legions were repeatedly put to the test including during a series of wars with Macedon in the third and second centuries BC. In particular, during the Third Macedonian War (172–168 BC), Rome's legions battled Perseus whose armies fought using the phalanx. Using this tactic, soldiers formed up in ranks, locked shields with the men to either side, and

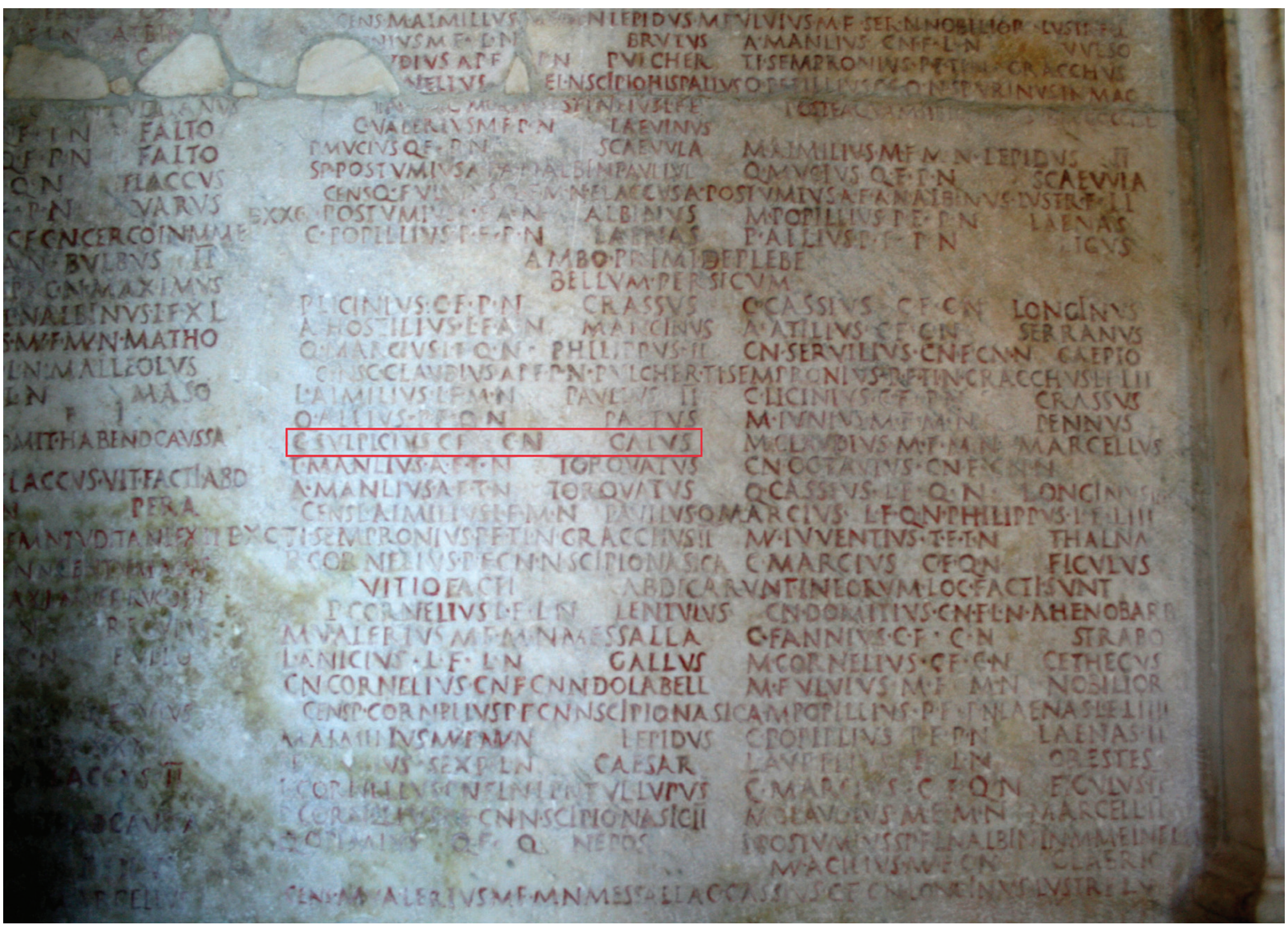

Figure 1 — The name of Galus from the Consular List displayed in the Capitoline Museum, Rome: "C SVLPICIVS CF CN GALVS" i.e. "Gaius Sulpicius, son of Gaius, grandson of Gaius, Galus". Photo courtesy of Kevin Dicus.

advanced with spears, of between two and three metres in length, protruding to the front. In 168 BC, a Roman legionary army of some 29,000 men, led by the consul Lucius Aemilius Paullus, faced Perseus's 40,000-strong phalanx on a level plain near Pydna.

Galus and the Portent

On the eve of battle a portent appeared in the heavens: a total lunar eclipse. What did it foretell? Not much, according to a legionary officer at Pydna, Gaius Sulpicius Galus, who knew it was a natural phenomenon. According to Quintilian (c. AD 35– c. AD 100), the Roman author, orator, rhetorician, and educator,

> *…Sulpicius Galus discoursed on the eclipse of the moon to the army of Lucius Paullus to prevent soldiers being seized with terror at what they regarded as a portent sent by heaven….If Nicias had known this when he commanded in Sicily, he would not have shared the terror of his men nor lost the finest army that Athens ever placed in the field (Quintilian).*

The Nicias referred to was the Athenian general who led a massive military force against the city of Syracuse in 413 BC. His entire command was wiped out due, in part, to a lack of understanding of lunar eclipses (Mozel 1995). Clearly, this harsh lesson had not been completely forgotten five centuries later.

According to Paullus's son, Scipio,

> *I had myself a great affection for this Galus, and I know he stood very high in the estimation of my father Paullus. I recollect in my early youth, when my father, as consul, commanded in Macedonia, and we were in the camp, our army was seized with a pious terror, because that suddenly, in a clear night, the bright and full moon became eclipsed. Galus, who was then our lieutenant, the year before that in which he was declared consul, hesitated not, next morning, to state in the camp that it was no prodigy, and that the phenomenon which had then appeared would always appear at certain periods, when the sun was so placed that he could not affect the moon with his light (Cicero).*

Other ancient authors go further and say that not only did Galus understand the cause of eclipses but knew when they would occur. According to the historian Livy (c. 64 BC–AD 12), Galus "…collected the soldiers in assembly, and gave them notice, lest they should any of them consider the matter as a prodigy, that, 'on the following night, the moon would be eclipsed…'" Galus further pointed out that, just as the men did not wonder at the rising and setting of the Sun and Moon, neither should they consider an eclipse anything but natural (Livy).

Sextus Julius Frontinus (c. AD 40–AD 103), author, general and consul, says that "Gaius Sulpicius Galus not only announced an approaching eclipse of the moon, in order to prevent the soldiers from taking it as a prodigy, but also gave the reasons and causes of the eclipse" (Frontinus). Pliny (AD 23–AD 79), author of Natural History, not only agrees that Galus, whom he refers to as a philosopher, had the ability to foretell eclipses but that he was "The first Roman that published the true reason of both eclipses" and that "…presently after [the battle] he compiled a book of the same" (Pliny). While the causes of eclipses had been known for some time, it is, however, questionable whether Galus had the ability to predict them (Thibodeau 2004). Nonetheless, Galus was knowledgeable about eclipses and their natural causes and was also able to convince rank and file soldiers of the same, thus calming their fears that a calamity was about to befall them.

Paullus was apparently also familiar with eclipses, "however, since he was very devout and given to sacrifices and divination, as soon as he saw the moon beginning to emerge from the shadow, he sacrificed eleven heifers to her" (Plutarch).

Cicero (106–43 BC) goes on at length in the *De re publica* about the abilities of Galus as an astronomer, calling him "a man of profound learning". He describes an occasion when Galus had brought out before him a celestial globe or planetarium, war booty from the Roman sack of Syracuse in 212 BC. This device had possibly belonged to, or had even been fashioned by, Archimedes (287–212 BC), who was killed in the fighting. Galus discussed its use, explaining that, while a simple globe was not sufficient to represent the motions of the Sun, Moon and planets, this Archimedean machine was different. Cicero tells of Galus explaining that,

> *…the invention of Archimedes was admirable, because he had calculated how a single revolution should maintain unequal and diversified progressions in dissimilar motions. In fact, when Galus moved this sphere or planetarium, we observed the moon distanced the sun as many degrees by a turn of the wheel in the machine, as she does in so many days in the heavens (Cicero).*

That such devices were available so long ago should not be surprising as evidenced by the remarkable Antikythera mechanism, a multi-geared analogue computer dating to c. 100 BC that could be used to locate planetary positions far into the past or future.

Valerius Maximus (early 1st century AD) confirms these abilities of Galus and offers something of an explanation for them in that "…it was Galus's knowledge of the liberal arts that paved the way to the famous victory of Paullus, because if Galus had not vanquished the panic of our soldiers, our general could not have vanquished our enemies" (Maximus).

What is a soldier doing with this kind of knowledge? What might have been his educational background? Early in the republic, education was left to the parents. From around 250 BC, with the availability of educated Greek slaves

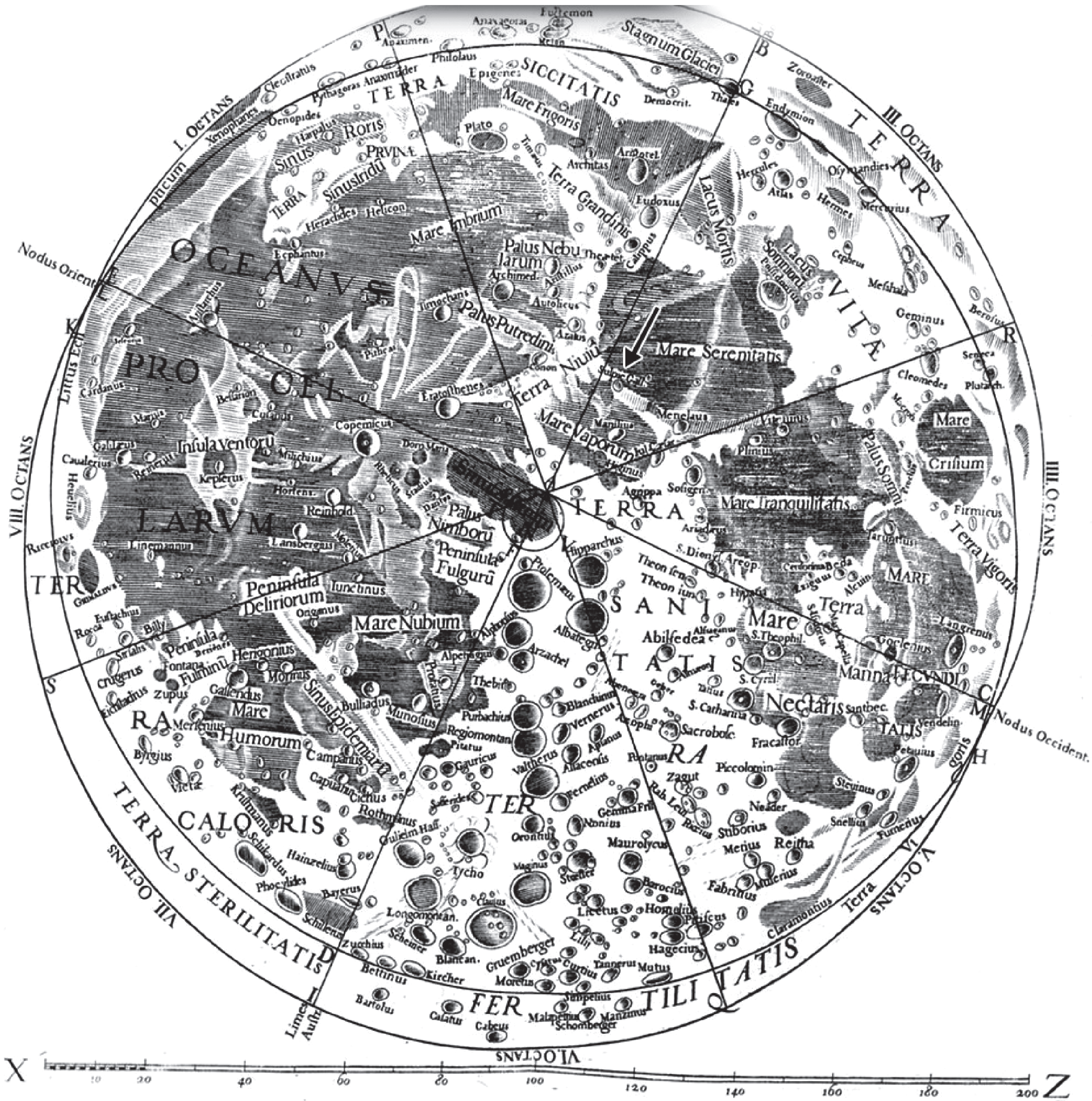

Figure 2 — Moon map of Riccioli and Grimaldi, 1651. Galus's crater is labelled "Sulpic. Gall." In keeping with the Consular List, this article uses a single L for the cognomen. (www.sciencephoto.com/media/364355/view).

due to Roman territorial expansion, quality tutors became available. In the late republic, primary schools at which the three "R"s were taught were available. Advanced education at grammar schools was available to those showing promise possibly followed by training in oratory. One might also study abroad, in Greece, for example (The Romans; Ancient Roman Education). However, it was practical knowledge, as opposed to the "merely" theoretical or scientific, that was held in high regard in Rome (Walker 1996). Scientists were far from numerous as compared to, say, Greece but the upper levels of Roman society were, nonetheless, well educated and well informed. Where and how Galus acquired his education is not known, but he certainly demonstrated the practicality of turning astronomy to military use!

And what of the battle? It started badly for the Romans who were pushed backward by the Macedonians. Too far, as it turned out, for the fighting left the level plain and moved onto more uneven ground, terrain less suited for effective use of the phalanx. As the phalanx maneuvered forward, its originally straight battle lines became ragged; openings began to appear.

These gaps were exploited by the more flexible legions who broke through and fought on the Macedonians' exposed flanks. With 25,000 casualties compared to just over 1,000 for Rome, Perseus was utterly defeated. The combination of Roman superiority in troops, tactics, leadership, and astronomical knowledge proved lethal. Given their ignorance of eclipses, (Goldstein and Bowen, 1995) "…the Macedonians were shocked, as at a dismal prodigy, foreboding the fall of their kingdom and the ruin of their nation; nor did their soothsayers explain it otherwise" (Livy). (The relative merits of the Roman and Macedonian educational systems is left to the reader to judge!) Now, with the end of the Third Macedonian War, Rome was master of Greece, Perseus was displayed in Paullus's Roman triumph and Galus went on to a career in politics, becoming consul in 166 BC (Figure 1).

On the Moon

With the invention of the telescope, astronomers began to seriously map the Moon. An early map of importance was that of the Jesuit astronomers Giovanni Riccioli (1598–1671) and Francesco Grimaldi (1618–1663). Many of the named features we are familiar with today trace their origins to their lunar map of 1651 (Figure 2). Nestled on the southwest shore of their Sea of Serenity is a crater they named for Galus.

Other lunar maps appeared over the centuries, but there was little consistency in their nomenclature. In 1913, Mary Blagg published the *Collated List of Lunar Formations* to bring order to the naming chaos (Blagg). This formed the basis for Blagg and Karl Muller's *Named Lunar Formations* of 1935 which was the first such work to be accepted by the International Astronomical Union. The accompanying map was published by Blagg and W.H. Wesley (Blagg and Wesley) and includes the crater Gallus. It may be seen to advantage when adjacent to the terminator around the Moon's first-quarter (sunrise terminator) or last-quarter (sunset terminator) phases. Interestingly, not far south of Gallus is another crater named for a Roman who, about a century later, also took an interest in astronomy: Julius Caesar.

What, then, are we to make of Galus? How did he fit into Roman society? Perhaps he may be viewed as being to Roman science what the Antikythera mechanism surely was to Greek technology. Each may have been a rarity but surely not a lone example. It is impossible to believe that the Greek computer existed in a vacuum, that it had no theoretical underpinnings and that there was absolutely no other advanced technology available. The same might be said for Galus. He learned from someone. He spoke with other like-minded thinkers. Some must have been, however few in numbers, other Roman "scientists" of whom we have no knowledge. Galus was soldier, politician, author, and, by all accounts, competent scientist; a renaissance man come early. How good a scientist was he? What did his writings consist of? We may never know. ✶

Phil Mozel is a Life Member of the Society and a past National Librarian. He tends to write on cloudy nights and observe variable stars when the sky is clear.

Acknowledgements

Many thanks to Meg Morden for helpful comments on a draft of this article and to Kevin Dicus, Visiting Assistant Professor, Department of Classics, Case Western Reserve University, for the photograph of the Consular List.

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The December *Journal* deadline for submissions is 2015 October 1.

See the published schedule at
www.rasc.ca/sites/default/files/jrascschedule2015.pdf

What do we do at the Society Office?

by Randy Attwood, Executive Director

The RASC is made up of 28 Centres that form the central core of activity of the Society—the astronomy, the public outreach, and the various member programs. Without the Centres, there wouldn't be an RASC.

A large organization such as ours requires some sort of central base—an office with staff. Currently the RASC office is in western Toronto, just north of the Islington subway station. There are three employees:

- Renata Koziol is the Office Administrator.
- Julia Neeser is the Membership and Marketing Coordinator.
- Randy Attwood is the Executive Director.

Renata is responsible for the running of the Society Office. She manages membership support and financial activities. Julia is responsible for the day-to-day marketing and administration. Randy oversees the employees and activities in the office and provides general leadership and direction in the Society.

Over the summer, we have had a fourth person in the office. Joseph Astelliro has been working on contract for modifications to the RASC website.

The office serves as a base for the Society's operations, stores the Society's archive and historical collection, acts as a mailroom, and is a source of information and support for members.

When did the Society first hire employees? According to the Society historian Randall Rosenfeld: "the RASC (then the Astronomical & Physical Society of Toronto) established a part-time paid position in 1894, at roughly the same time that the Society started to rent "office" space (1893), but that the first full-time Executive Secretary position was created in the mid-1950s, at roughly the same time that we acquired our own property at 252 College St. in 1956."

The functions of the RASC staff are primarily supporting the membership, handling finances and selling our products.

Membership Handling

The RASC is a member-based organization with just under 5,000 people who pay membership dues annually. The office staff maintains the membership on a computer database where they process new and renewing memberships (online, by mail, and via phone calls). Since the membership year is floating, renewal notices need to be sent out every month. Members receive renewal notices via email and, as a last resort, a phone call as memberships near expiry.

Figure 1 — Office staff at Peggy's Cove, during the 2015 General Assembly.

Continues on page 217

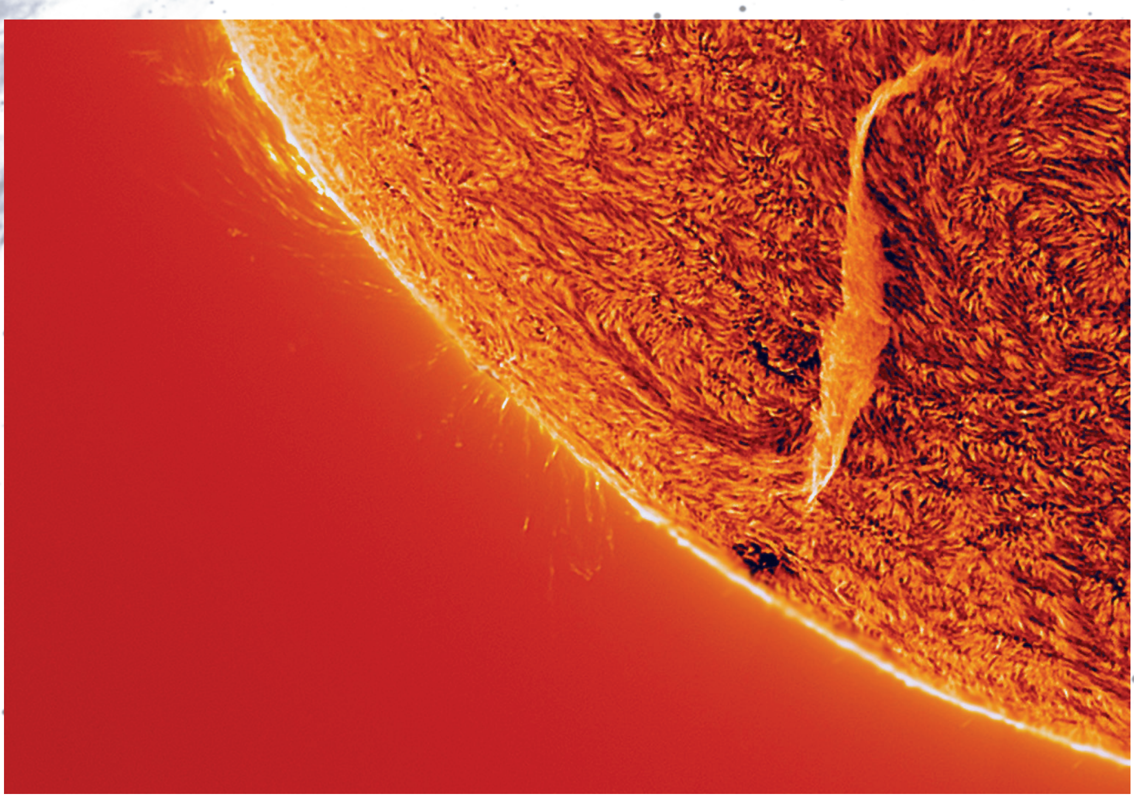

Figure 1 — Heather Campbell took this stunning image of the aurora borealis from Yellowknife, Northwest Territories, on 2015 March 21 with star trails using her Canon 6D with her Rokinon 14mm lens. The photograph is a composite of 65 images, each a 30-second exposure at ISO 1600 ƒ/2.8. She processed them using Lightroom and stacked them using Star Stax and then combined them using Photoshop.

Figure 2 — This incredibly detailed image of the Sun and its filament was taken by Gary Palmer of the Royal Astronomical Society on 2012 August 31. Palmer used a Coronado Solarmax 90-mm solar telescope with a DMK 31 camera.

Figure 3 — Dwarf spiral Galaxy NGC 6503 lies utterly alone about 17 million light-years from us. Not only is it not gravitationally associated with any other galaxy, but it lies at the edge of the Local Void, a vast, virtually empty region of space that may be as big as 150 million × 250 million light-years. Ron Brecher (astrodoc.ca) from the Kitchener-Waterloo Centre acquired this 14hr 40m LRGB exposure from his SkyShed in Guelph, Ontario, using an SBIG STL-11000 camera and a 10″ f/6.8 reflector. The image was processed in PixInsight.

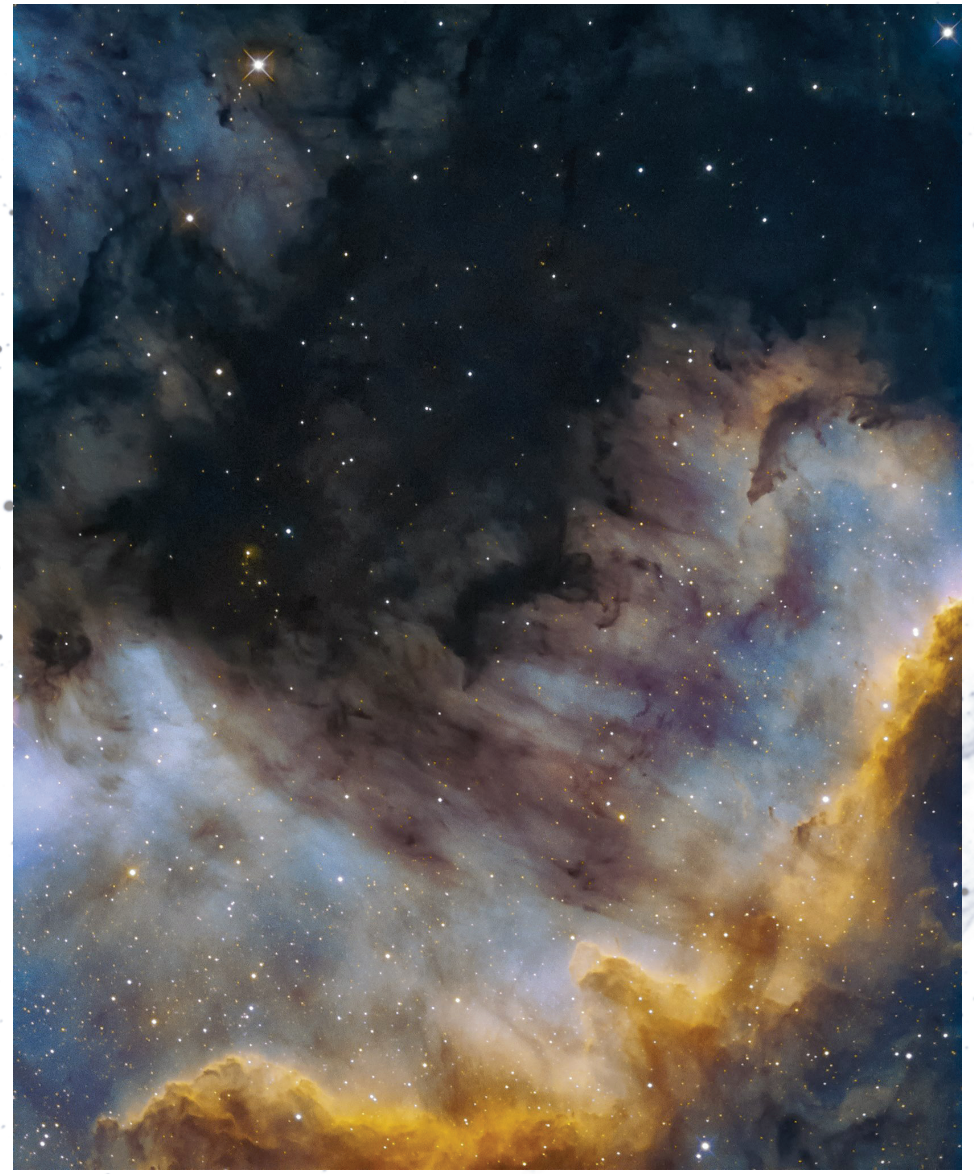

Figure 4 — "The Wall" of the North America Nebula in Cygnus in full narrow-band colours. This was Toronto Centre member Kerry-Ann Lecky Hepburn's first real attempt at tricolour narrowband processing. Using Hα, OIII, and SII filters. With 20 exposures 600 seconds long for each channel, Kerry-Ann used an SBIG 8300, AT8RC, EQ6 mount. Though she initially started with the classic Hubble *palette with the assignment of Green to Hα, Blue to OIII, and Red to SII, she eventually found a balance better to her liking by mapping Red to Hα, Cyan to OIII and Yellow to SII. Taken from Grimsby, Ontario.*

Figure 6 — Ian Wheelband of Toronto captured this beautiful image of Messier 101 on 2015 July 22. Known as the Pinwheel Galaxy, this beautiful example of a spiral galaxy is one of the last entries in Charles Messier's catalogue. This galaxy is enormous, about twice that of our own Milky Way, with a diameter of 170,000 light-years.

Figure 7 — Toronto Centre member Bill Longo took this image of the Algonquin Radio Observatory in Algonquin Park, Ontario, during the 2015 Perseid meteor shower. He was lucky enough to capture an eruption of the Aurora Borealis as well.

General Assembly 2015

Terry Dickinson, Society Office Staff, and Board of Directors (missing Karen Finstad)

2015 Award Winners

Seabrook sisters from Toronto, Emma and Melanie

Julia Neeser and Renata Koziol

Mi'kmaw Women Of The Shore Drummers

James Edgar introduces Anne Archibald, 2015 Plaskett lecturer

Presenters at the 2015 GA

Observer's Handbook Editors.

The first RASC Fellows (missing Peter Broughton)

James Edgar and Michael Gatto

Eight Past Presidents, in order of office, L to R..

Continued from 212.

We respond to member enquiries (online and by phone). Enquiries include, for example, requests for publications that never arrived or the resetting of user accounts for the RASC website.

We remind members of the benefits that are available to them as members of the Society. We also provide other benefits—such as the movie passes last autumn—which are made available from time to time.

For each mailing of the *Observer's Handbook*, *SkyNews,* and the *Journal*, mailing lists are generated. For large mailings, we use a mailing house. For small mailings such as single *Observer's Calendars*, *Observer's Handbooks*, or promotional materials, we ship out of this office.

We support the Awards Committee by ordering the various awards to be handed out at the General Assembly Awards Banquet. The staff administer the observing certificate program by preparing certificates and mailing them to the successful observers.

We also support the General Assembly by handling registrations and the associated finances.

Finances

Much of Society Office activities revolve around finances. The Society has an income of $450,000 per year—and much, if not all, of it is spent.

We receive and deposit all membership dues and product payments. Financial information is kept up to date in iMIS—our finance and membership handling software program. This information is imported into Quickbooks, a computer accounting program and is balanced to the bank ledger.

Every month, Centres are paid their portions of membership fees. Society bills, such as office rent, utilities, employee payroll, and computer software licencing are paid.

We provide the Finance Committee with up-to-date statements.

Donations to the Society are processed and charitable receipts issued. We run campaigns to solicit donations from the membership from time to time.

Every year starting in January, we work with the auditor to prepare the audit and then we work with the Treasurer to prepare the year's budget.

We run a Sponsorship program where we approach vendors and organizations to sponsor the RASC. These organizations appear prominently on the RASC's website.

Product Sales

The Society sells various products—publications and promotional items. The income from products such as the *Observer's Handbook* and *Observer's Calendar* helps to support our various activities. We process orders for publications and promotional items from both members and customers. We work with committees to develop new publications and promotional products to sell.

We support the publications and promotional items we offer by sending out order packages in the fall when the new *Observer's Handbook* and *Observer's Calendar* are to be published. We also work on finding new customers.

There are over 100 institutional subscriptions to the *Journal*—these are renewed annually and these customers call from time to time with questions or require replacement copies.

We keep the website eStore pricing up to date and run monthly sales campaigns.

Administrative Support

Various administrative duties are carried out daily. We handle calls from the public, usually dealing with something someone saw in the sky or a rock they found on the ground. We also handle interview requests from the media.

We maintain and organize Society files, documents, the archive, and library. We provide support for the Board of Directors and Committees. Every spring, we prepare and distribute the Annual Report. We update the website with Society news and information. We look for every opportunity to promote the Society any way we can!

This is just an overview of what goes on in the Society office. I have probably missed a few things and certainly there are many other day to day tasks that we just do. With the addition of *SkyNews* to our responsibilities, the office will be busier than ever. We are considering moving to a larger space as we expand, time and place to be determined.

Next time you are in the neighbourhood, make sure you drop into the Society Office and say hello! ✶

The RASC Purchases *SkyNews*

by Randy Attwood, Executive Director

The RASC has enjoyed a long and successful relationship with *SkyNews*. SkyNews Incorporated, under the direction of Terence Dickinson, Greg Keilty, and Colleen Moloney, publishes *SkyNews*—Canada's astronomy magazine—hosts a website (www.SkyNews.ca) and publishes an electronic newsletter. Since 1997, all RASC members have received a copy of *SkyNews* as a benefit of membership. Many RASC members, including Terence Dickinson as the editor, have been involved with the production of *SkyNews* over the past 20 years.

Many if not all of the members of Council were surprised when it was announced at the National Council meeting in Halifax on July 2 that the RASC had purchased SkyNews Inc.

Figure 1 — Terry Dickinson and Randy Attwood celebrate the SkyNews *acquisition at the Halifax General Assembly.*

How did this happen?

In early April, we learned that SkyNews Inc. was for sale. The owners had reached retirement age and were ready to hand the publication over to new owners.

Would the RASC be interested? The responsibility for making the big decision was that of the RASC Board of Directors. All aspects of the purchase of SkyNews Inc.—good and bad—were reviewed. *SkyNews* is an important benefit for the membership. It is also popular—during the last survey over 90 per cent of members found *SkyNews* an important benefit. If someone else purchased the magazine, there was no guarantee it would be available as a benefit of membership. Would new owners even keep it in the same format? No one knew.

But, what do we know about publishing a magazine? Fortunately most of those responsible for writing, editing, and producing the publication, as well as those who brought in advertising and who supported subscribers, would be staying. Only a few personnel changes would be required. As new owners, we would oversee the existing framework—for the most part it would be business as usual for *SkyNews*.

The Board decided to establish a task force made up of Randy Attwood (Executive Director), Denis Grey (RASC Treasurer and Board member), Colin Haig (1st Vice-President and Board member), Chris Gainor (2nd Vice-President and Board member), Mary Lou Whitehorne (Past President), and our solicitor, James Gorkoff. A budget was set to seek out accounting and legal assistance and advice.

There were a few areas of concern. *SkyNews* subscriptions have been on the decline over the past five years. Like many Canadian magazines, *SkyNews* depends on annual grants from the government to exist. If these were ever terminated, the magazine would fold. These issues were evaluated and the decision was to move forward with an offer.

It is rare for a magazine such as *SkyNews* to survive as long as it has. Canadian magazines do not have a long track record. Its success is a testament to the people who write and produce it every two months. The Board was aware of this and made it clear that if it were to become RASC property, it would not be tampered with. Upon a request of the owners, the RASC Board prepared an offer in early June. The offer was accepted and work began on a very tight schedule to close the deal by the end of June so that we could announce the sale at the General Assembly in Halifax.

Thanks to many long hours by RASC Staff and Board members, the agreement was ironed out with the owners and the deal closed late afternoon June 30.

What is in it for us?

One can think of SkyNews Inc. as one of the investments of the RASC. We chose to take a little less than 20 per cent of our total investments in stocks, bonds, and GICS and invest in a unique venture. As owners of SkyNews Inc,. we are now the publishers of Canada's only adult English science magazine. It certainly aligns itself nicely with our mandate of promoting astronomy and allied sciences. Owning *SkyNews* means we now have access to a group of very talented people. Their skills and talents will serve the Society and help us to grow in different ways.

What is Next?

We are well into the transition. People need to be found to replace those who are stepping back. Fortunately everyone is working together to make the transition smooth, and it will probably be a few issues before the that is complete. We have already brought the finances and accounting into the RASC office.

Essentially SkyNews Inc will run as it has before. Instead of three owners, there is a Board of Directors, which reports directly to the RASC Board of Directors. Once the transition is complete, *SkyNews* will no doubt evolve under the new leadership. New efforts are underway to increase subscribers. We may see more projects like the "Getting Started in Astronomy" insert that appeared in the May/June 20th Anniversary issue.

RASC members are now all owners of SkyNews Inc. I encourage members to promote the magazine in as many ways as possible. A perfect and easy way is to give gift subscriptions to members of your family, your friends, or a local school or library. In the September/October 2015 issue, there is a reply card you can use. And there is a contest—for giving a gift subscription you could win a Celestron NexStar Evolution 6 telescope. We are considering setting up a formal email campaign that will make it easy for members to give gift subscriptions in time for Christmas. More information will be published in the monthly Bulletin. Why not give a few gift subscriptions for Christmas and help support our new investment?

The purchase of *SkyNews* is a major step forward for our organization. I am excited about the various possibilities this purchase will offer our Society in the future. ✶

Binary Universe

DSLR Astrophotography

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

I am relatively new to the fast-moving world of digital single-lens-reflex photography.

In the summer of 2012, I acquired a used Canon DSLR. I read the manual for the 40D and was gob-smacked. I read the manual again. My first thought was: how am I supposed to remember all this?! The modern camera is like a computer! I had been out of the SLR game for a while so had to blow out the cobwebs. But on top of this, regaining total image control, there were new features and capabilities that were enticing and, frankly, terrifying at the same time. Being able to use continuous shooting, the proprietary RAW file format, bracketing, mirror lockup. Being able to change focus points, colour space, and white balance. I found it overwhelming. And three years later, I'm still learning.

In addition to the camera itself, there was software to master. To the chagrin of Nikon DSLR owners, Canon includes free apps. Two caught my eye right from the get-go. The *EOS Utility* is for remote image transfer and camera control. The *Digital Photo Professional* is for post-processing, organisation, batch manipulation, etc.

Immediately, I started testing the *EOS Utility*. From the computer I enjoyed focusing the lens and adjusting the camera settings. It was a treat to have Live View (with Exposure Simulation) showing on the larger computer monitor. I was very pleased to have Interval Timer Shooting control so that, in lieu of programming a portable intervalometer, I could set up imaging runs, not to mention break through the camera's 30-second barrier. This was the cat's meow. Or so I thought.

Quickly I started to hit the limit of the EU app. I wanted to zoom to higher levels. I needed to be able to focus with greater precision. My imaging runs were…flat; I wanted to be able to program change aperture (with a lens), speed, and ISO during the run. I wanted to know the temperature inside the camera. Desperately needed red light mode!

I investigated *Magic Lantern* (based on CHDK) but found development started for cameras after the 40D. I tried a number of separate, small, and custom apps including *EOS Mov Rec*, *Astrojan Tools*, and *Bahtinov Grabber*. Some of these worked well; others didn't. In the end, I decided to purchase *BackyardEOS* from BinaryRivers. It is an amazingly powerful and useful application.

Until recently, only Canon users could enjoy the extensive feature set offered by the Ottawa-based developer. Now, happily, Guylain Rochon supports Nikon DSLRs alongside Canon. As noted, I use the Canon EOS version but I have reviewed and done limited testing in the Nikon application and it is essentially the same. Where features are different, that I know of, I will draw attention to them. I will refer to the specific product by acronym BYE or BYN and when speaking generally or to both products I will simply state Backyard.

I purchased the Premium edition and I will discuss the features it offers. There is a less-expensive Classic edition that omits some features (e.g. Half Flux Diameter and Bahtinov focus options). One can download the Trial edition and for 30 days try all Classic and Premium capabilities.

Backyard performs a numbers of functions but these can be divided into four main categories:

- focusing
- deep-sky imaging (with stills)
- planetary imaging (with video)
- drift alignment

Buttons at the top-left of the main screen allow one to access the appropriate module.

When the *Frame & Focus* module is active, the software orders to camera to go into Live View mode, which flips the DSLR mirror up. Once gross focus and centring is achieved, one can bull's-eye a star in the main window. The *Zoom Box Center* area then shows the star at a higher magnification, from 2 to 10

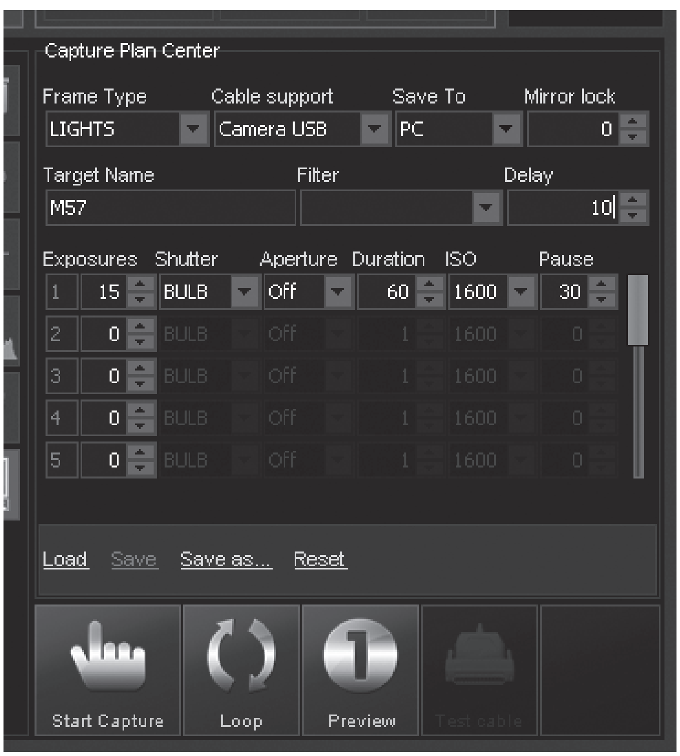

Figure 1 — The main interface from BackyardNIKON with camera attached and Frame & Focus *mode active.*

times. Backyard supports four focusing methods: Full Width Half Maximum, Half Flux Diameter, Standard Deviation, and when one uses a Bahtinov (or similar) diffraction mask. When using the FWHM technique, I hope for good seeing and watch for a small historical value in the *Minimum* box. Faint stars can be enhanced (by on-the-fly stacking or integration) with the *HD* mode.

Backyard works with cameras that don't have Live View by shooting and then displaying the image. The settings below the *Zoom Box Center* allow immediate control of the camera and looping for the repetitive capture of photos for gauging the improving focus.

If one is planning an image run with still photos, say of deep-sky objects or double stars, the *Imaging* mode is chosen.

In the *Capture Plan Center*, one configures or programs, like using an intervalometer, the particulars of the capture run. Obvious settings include the *Delay* time, the number of *Exposures*, the *Duration* of each shot, the *Pause* between each capture, and where to save the images. However, unlike *EOS Utility*, Backyard allows the user to specify the *Shutter*, *Aperture*, and *ISO*. And all this is in one "slot." With 25 available spaces, one can program multiple segments with different settings. Other options include the *Frame Type* (e.g. *Lights* versus *Darks* or *Bias*). I make a point of entering the object being imaged in the *Target Name*. The key reason for this is that Backyard embeds some of this information in the filename for each image.

This feature proves remarkably useful a few days after a good night when you can't remember the particulars of your setup. Noted below is the filename produced (using the default settings) during a recent double star imaging run.

> HD 164492_
> LIGHT_5s_1600iso_+17c_00110stdev_20150801-
> 23h16m37s531ms.CR2

The object name begins the string, followed by the type of frame, the duration, the ISO, the temperature of the camera sensor, and the standard deviation of the entire image. The filename ends with the date and time (down to the millisecond).

If interested in imaging planets using lucky techniques, one selects the *Planetary* module.

The *Planetary Capture Plan* area now allows control of the DSLR for collecting multiple frames, of course, possibly into the thousands. Once again, the *Shutter* and *ISO* are set, a *Target* name is entered, and the *Save To* option adjusted to indicate the types of files to produce (e.g. AVI).

I particularly like this feature as the Canon 40D itself does not have video recording capabilities. But Backyard, by reading

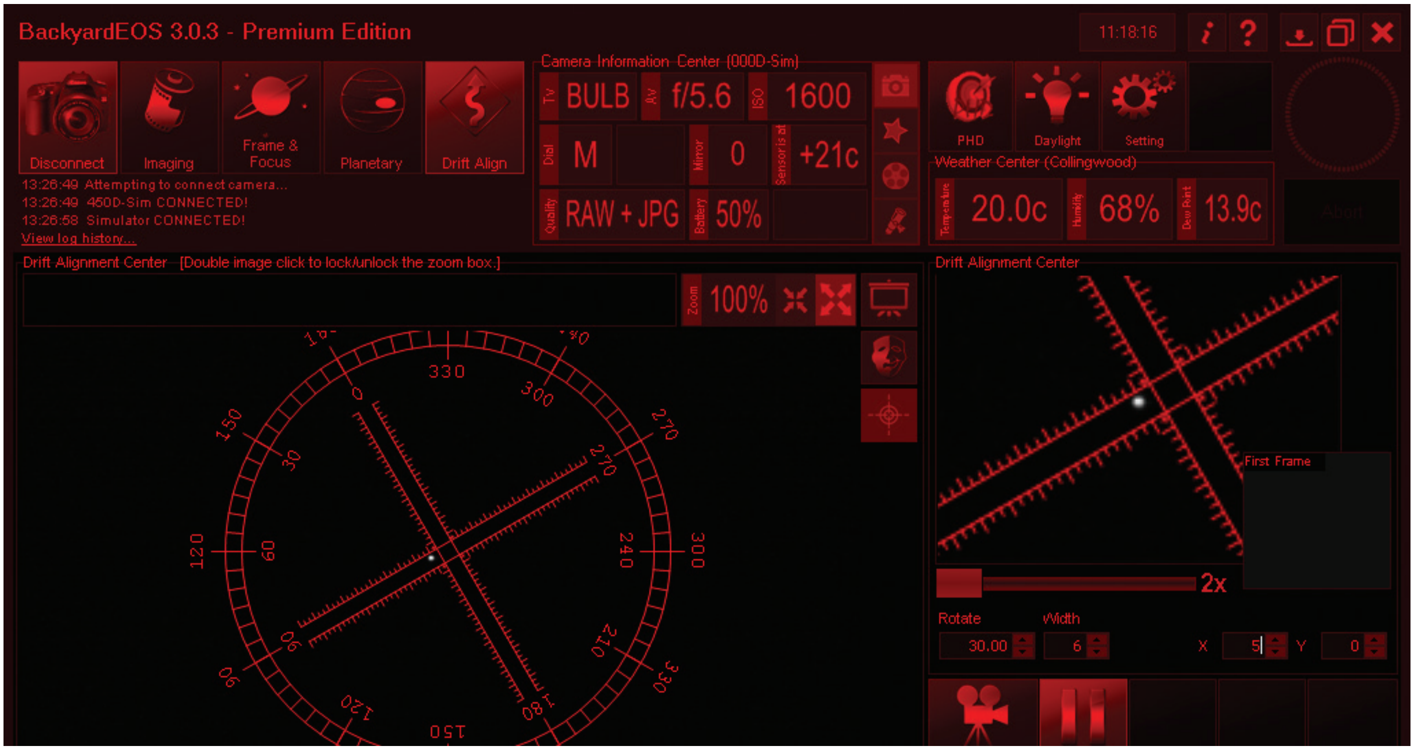

Figure 2 — Detail from main screen. Capture Plan Center *section allows the configuration of still imaging runs.*

the Live View data from the camera, can use these individual images as the frames in a movie file. That's a neat trick!

The final mode, *Drift Align*, is very useful when validating or refining one's polar alignment.

The Backyard app shows a rotatable reticule pattern. As when using a reticule eyepiece, after selecting an appropriate star and aligning for the declination axis, one monitors the chosen star for vertical drifting. To enhance the effect, Backyard allows recording during the alignment process which does on-the-fly stacking of images, in turn creating a trail. Then the equatorial mount can be adjusted accordingly. I already have a Celestron Micro Guide eyepiece but this software feature means one does not need to purchase such an ocular for polar alignment. As well, it likely means less back-breaking contortions inside the observatory!

All these features of Backyard are excellent and work very well. Not only do they make using the camera easier and faster, but they extend its capabilities.

In addition to these main functions, there are a number of other options available in the application, some of which work with specific telescope accessories, like an electronic focuser or filter wheel. The *Camera Information Center* shows the state of the camera, including image quality. BYE also shows the chip temperature. I like the *Weather Center* panel which can use the Yahoo Where On Earth ID or *WOEID*, I have configured BYE for my local weather sites. This weather information, along with the aforementioned Target and Filter information, can be added to the image EXIF data. Various easily-read progress indicators appear during image or video recording to keep one informed of the status of a capture or the file download. Captured stills appear in a filmstrip for reviewing and can be shown in Presentation mode to utilize the full screen. The Histogram Center shows when reviewing recently shot images. Backyard offers dithering guiding control. Many preferences are easily tuned in the Setting dialogue box.

If using an auto-focus camera lens, perhaps when taking some wide-field shots, Backyard allows one to drive the lens too. Certainly this is true for *BackyardEOS*; I did not see the same feature in *BackyardNIKON*.

The Backyard software comes with a PDF user guide, which is adequate. It is well-supported on the O'Telescope.com forums.

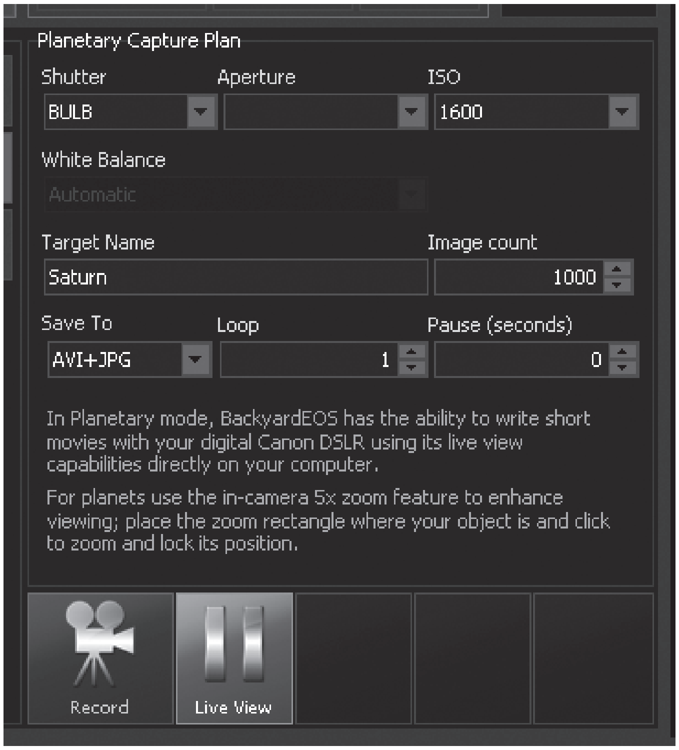

Figure 3 — Detail. Planetary Capture Plan *area permits camera control and configuration of recorded movie file.*

Sometimes it runs slowly on my old netbook but is, in general, reliable and stable. Similar apps I tried crashed or did not work. I trust Backyard.

As noted, a trial version is available so, after verifying your camera is supported, you can try-before-you-buy. The Classic version costs $35 and the Premium $50 (prices in US dollars). One buys a software activation key and then downloads the application.

Backyard is a Microsoft Windows application but I know of a number of RASC members using the product on the Apple Macintosh in a Windows emulator, specifically Parallels.

More and more I am using my *BackyardEOS* software for focusing and capturing data. I can fully control my camera (and lens when used) without physically touching it. I can stay dark-adapted. It is a wonderful application and I appreciate having everything in one place. It's good seeing Nikon users jumping on the bandwagon.

Oh. I almost forgot. BinaryRivers also makes a little applet called *BackyardRED*. This free Windows tool allows one to turn the entire screen dark red, regardless of application. Handy. One will find it included in *BackyardEOS* or *BackyardNikon*.

I thank Wayne Gilbank, Risa Horowitz, and Ian Wheelband for letting me try out their computers and Nikon DSLRs. I also would like to thank Guylain Rochon, the developer of Backyard, for providing *BackyardNIKON* for testing and evaluation. ✶

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

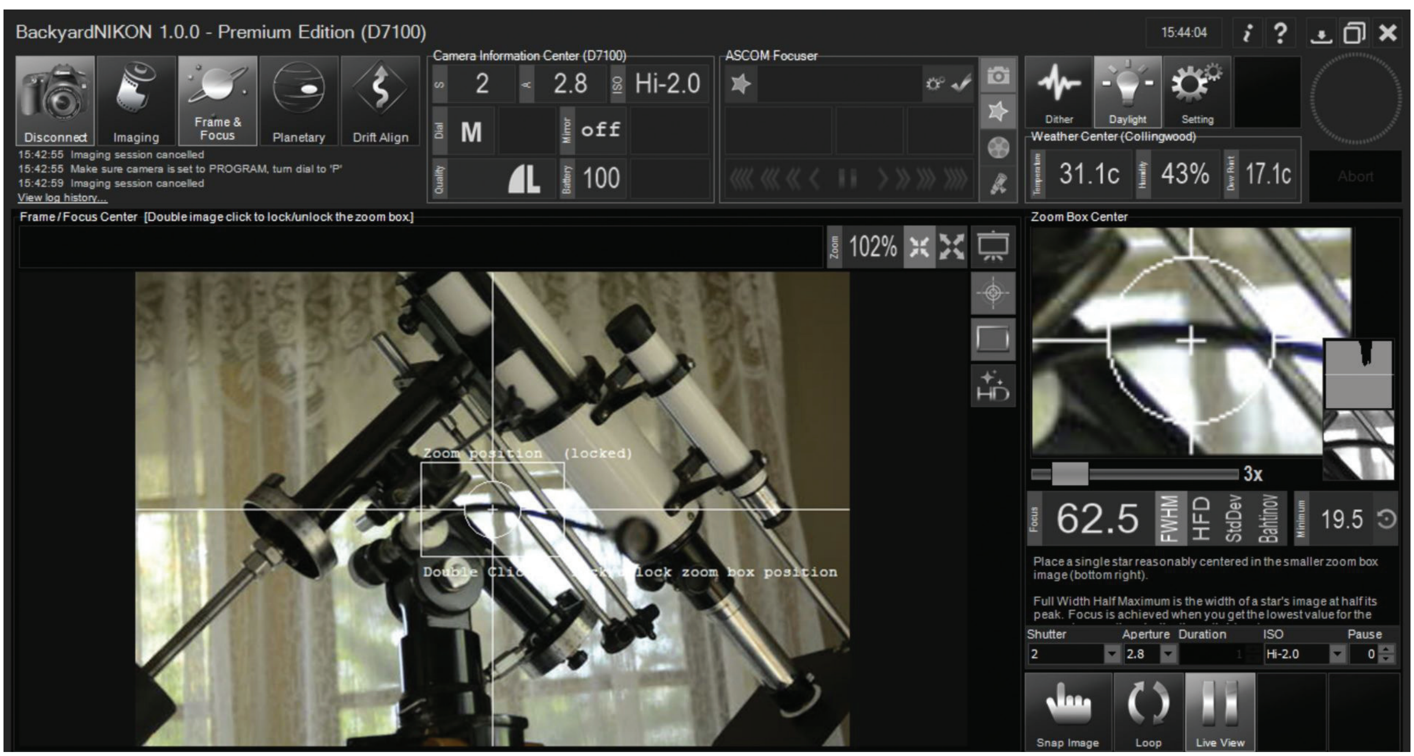

Figure 4 — When the Drift Align *module is active, a reticle is displayed, superimposed over the Live View display. Submarine lighting, via the* Daylight *button, is clearly enabled.*

Imager's Corner

Non-astro Techniques

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

In this edition, I'll answer a recently asked question and have some fun with a nightscape image I took on a recent trip to New York City. The question was simple, "Can any of the techniques used in your Imager's Corner column be used for nonastrophotos?" The answer is…well for that, you will have to read the rest of the column.

Let's take a look at the original nightscape taken from the observation deck of the Rockefeller Center, 70 floors up in the nose bleed section.

Figure 1 — Original nightscape from 70 floors up, exposed to prevent clipping the highlights as much as possible.

The image was exposed to protect it from saturation as much as possible so it looks a little dark. Now this can be fixed with a simple curves adjustment at the expense of the highlights, which are difficult to control without a mask. Here is where SMI (screen mask invert) processing comes in handy. I demonstrated this technique a while ago here in this column with an M8 image.

SMI processing has the advantage that the mask inherently protects the highlights and brightens the darker portion of the image. This works well for bringing out the faint dust in an image of M8 or equally as well for brightening the faint areas in the nightscape image. Start by duplicating the image on another layer and apply a slight Gaussian blur to the new layer. Next make a mask of the blurred layer and invert it. Apply the mask to the top blurred layer and then set its combine mode to screen as shown in the layer stack above at right.

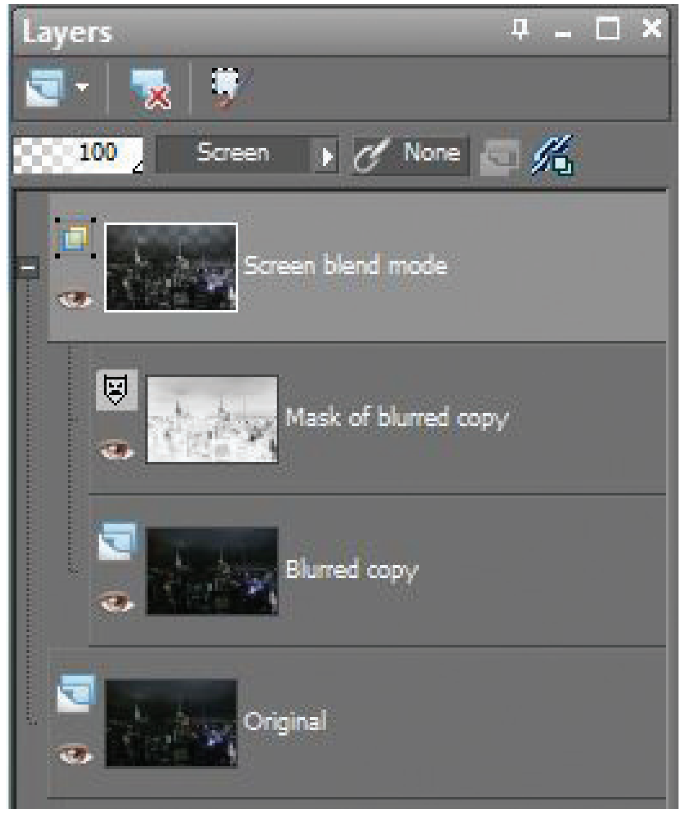

Figure 2 — Layer stack for SMI processing

This produces an image that is significantly better than the original and since the technique actually improves the SNR at the low end of the histogram it has reduced the noise in the dim areas when compared to using a simple curves adjustment.

Figure 3 — SMI processed image

Add in a final contrast tweak and some colour correction and we have the completed nightscape to hang on my wall. (See the next page)

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. ✶

Figure 4 — Completed image

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.

Educating Astronomers in Canada—Then and Now

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

In preparing a talk for a one-day symposium on the occasion of the 80th birthday of the David Dunlap Observatory (DDO)[1], I had occasion to read and think about how astronomers were educated in Canada, from the mid-19th century to the present. My own experience extends from the mid-20th century, and encompasses a third of the time interval in question. Much has changed—for the better, I think. I will highlight the situation at the University of Toronto (U of T), partly because that's what I know best, partly out of pride (and chauvinism), but mainly because "Until quite recently, the story of the training of professional astronomers in Canada is simply the history of the Department of Astronomy, University of Toronto" (Jarrell 1988, page 127).

Richard Jarrell (1988, page 126), in his definitive history of astronomy in Canada, makes two interesting and related comments on this topic: "One of the curiosities of the development of Canadian astronomy was the emergence of national institutions for astronomers but no provision for their training in Canada. Nineteenth-century astronomical education was limited to superficial arts courses, rarely accompanied by practical work." Introductory astronomy was taught in several colleges across the country, usually by mathematicians, and usually with a mathematical flavour. In any case, those were the days before specialization. A well-educated scholar could teach many different subjects—including astronomy—at the introductory college level.

Now Canada—particularly U of T—is a major centre for undergraduate and graduate education in astronomy[2]. How did we get from there to here? These changes occurred against (and were affected by) the backdrop of other changes: the growth and diversification of astronomy and astronomical observation, the professionalization of science and the emergence of "big science" and, in the case of U of T (and some other Canadian universities), the transition from being a teaching college to what we would call a "comprehensive university" to research powerhouse such as U of T is today.

Clarence Augustus Chant

Chant was the "father" of astronomy at U of T, and a "co-father" of astronomy in Canada. He graduated with a B.A. in physics from the University of Toronto in 1890, and joined his alma mater as a lecturer in physics in 1892. Over the next few decades, he built up the astronomy program, was a guiding light for the RASC for 50 years, and was a prolific and effective communicator of astronomy, which eventually led to the donation and founding of the David Dunlap Observatory in 1935.

Prior to Chant's time, practical astronomy was taught in Toronto in the School of Practical Science, which was not yet part of U of T. A course in mathematical astronomy was available to U of T students in the fourth year of a mathematics degree. Some general astronomy was taught in courses in Natural Science. Physics did not become a separate department until 1887. By 1918, Chant was able to establish a separate budget for astronomy, create lecture and lab courses in observational astronomy and in astrophysics, and to create a separate Department of Astronomy. In adding lab courses, Chant was building on the work of James Loudon, Professor of Physics who, in 1878, initiated the first laboratory in Canada for undergraduate physics students. Now, we regard lab work as an essential part of a science education. A century ago, there were still some university faculty members and administrators who thought labs served only for technical training, and had no place in a university (Allin 1981).

Teaching was done primarily through lectures, using a standard textbook, with little or no interaction with the instructor. Nowadays, our undergraduates take lab courses and tutorials in physics from their first year on, and have multiple opportunities for supervised individual research, both during the academic year and in the summer. Our Summer Undergraduate Research Program[3] is especially strong, since it stresses both research experience and professional development.

On reflection, I find Chant's accomplishments remarkable. He was the only astronomer in the physics department. He was not a researcher. He was not promoted to Associate Professor until 1908–09 or to Full Professor until 1925. Knowing something of university administration and politics, I think he must have been incredibly motivated, visionary, persistent, and persuasive!

The other two "co-fathers of Canadian astronomy"—William Frederick King (1854–1916) of the Dominion Observatory, and John S. Plaskett (1865–1941) of the Dominion Astrophysical Observatory—had B.A.s, in physics and mathematics, respectively, but did not have earned doctorates. They gained their research skills in other ways. In fact, Plaskett was a technician in the U of T physics department when Chant was a lecturer there, and only later studied for his B.A. Chant obtained a Ph.D. from Harvard in 1901. His stay at Harvard was important in exposing him to forefront astronomy and astrophysics.

Graduate Studies in Astronomy

The University of Toronto did not introduce the Ph.D. degree until 1897. The first recipient was John Cunningham McLennan (later Sir John), after whom the present physics building is named. Among McLennan's many contributions to physics, he identified the origin of the auroral green line—a transition in the oxygen atom that is "forbidden" at normal gas densities, but which occurs in the low-density gas in the upper atmosphere. He joined the physics department in 1902 and was extremely research-active. He was also a "showman" who gave well-prepared, well-received public lectures to the Royal Canadian Institute[4]. This was an important way to connect researchers to potential sponsors; there were no government research grants in those days. By 1908, the physics department had 8-10 graduate students each year.

Peter Broughton (2003), in his comprehensive statistical analysis of 50 years of Canadian Ph.D. theses in astronomy, points out that the first was by Allie Vibert Douglas at McGill in 1926, and that there were two Ph.D. theses written in the U of T Department of Mathematics, by John A. Rottenberg (on a topic in mathematical astrophysics) in 1949, and by Alfred E. Schild (on a new approach to kinematic cosmology) in 1946.

M.A. theses in astronomy were submitted, starting in 1917 (Broughton 2003), but the Ph.D. program in astronomy at U of T was not introduced until 1947. Chant, as mentioned, was not a researcher. In 1924, he was joined on faculty by Reynold K. Young, a Canadian who had received his Ph.D. from Lick Observatory, University of California. Young was very research-active; he has 89 research papers and abstracts listed on ADS (the Astrophysics Data Service[5]). With the opening of the David Dunlap Observatory in 1935, other faculty were hired—Jack Heard, Frank Hogg, Peter Millman, and later Helen Sawyer Hogg; their doctorates were from McGill and London (Heard) and Harvard (Hogg, Sawyer Hogg, and Millman). But World War II intervened, and the scientific staff of the observatory was greatly reduced. The first doctoral students were William Hossack (Ph.D. 1953) and Ian Halliday (Ph.D. 1954). Halliday went on to an outstanding career in Canadian astronomy, including Editor of this *Journal* (1970-1975); Hossack took a position in Operations Research at the Department of Defence, and died tragically at a young age.

Much changed in the 1960s. Science support and education expanded, in part due to the Space Race. Universities expanded, in response to the post-WWII "baby boom." Many new astronomy faculty members were hired, most of them trained in Canada. Almost every university offered introductory astronomy courses for non-science students, and over a dozen universities, from Victoria to Halifax, offered undergraduate and graduate programs in astronomy. At U of T and elsewhere, research expanded beyond observational optical astronomy to include radio astronomy and theoretical astronomy and astrophysics. Since that time, U of T has had 30-40 graduate students in its astronomy program at any one time. As of the date of Broughton's (2003) study, over 400 astronomy Ph.D. theses had been produced in Canada.

The Graduate Curriculum

Generally, there have been two models for graduate education—one emphasizing a heavy program of courses, and the other emphasizing individual research projects. These represent the extremes. At U of T, we have oscillated around the middle of this spectrum. Currently, our students take at least four half-courses, undertake two different research projects, and take a qualifying (general) exam, before beginning their Ph.D. project. Most also work as teaching assistants, and take an active part in our extensive public outreach program[6].

In 2002–2003, University of Calgary graduate student Kevin Douglas and I conducted a comprehensive survey[7] of graduate astronomy education in Canada, in preparation for a special session on that topic at the January 2003 meeting of the American Astronomical Society. We were struck by the variety of models of graduate astronomy education in Canada. We had the sense that the effectiveness of the program depended less on its structure, and more on how well it was executed. University professors receive years of training in research, but little or no training in teaching, supervision, or mentorship.

One of the highlights of the AAS session was a presentation by University of Arizona astronomer Chris Impey and his graduate student Chien Peng. They emphasized the importance of a "mentoring panel" for each graduate student, "career seminars" on topics such as teaching and proposal writing, facilitating the transition from undergraduate to graduate education, and tracking Ph.D. students after graduation to get feedback. Their suggestions were consistent with those of a study by Smith et al. (2002), who surveyed physical science graduates, several years after graduation. Graduates felt that, although they were well-prepared in some areas, they were lacking training in oral and written communication, teaching, project management, and especially in working in an interdisciplinary environment. These skills are important, both for graduate students who go on to careers in academia, and for those who don't.

Graduate Education: Present and Future

At U of T, and elsewhere, I suspect, many of these suggestions have gradually been implemented. In addition to graduate courses, we have mini-courses, often on topics requested by students. The Dunlap Institute[8] holds an annual one-week summer school on instrumentation, a topic not always part of the regular curriculum. The Canadian Astronomical Society's Graduate Student Committee organizes one-day professional-development workshops at the annual CASCA meeting. The U of T School of Graduate Studies offers several dozen professional development courses, which can be entered on the students' official transcript. In the Department of Astronomy & Astrophysics, we have a well-attended weekly discussion group, which addresses issues related to astronomy education and careers. Our graduate students and postdocs (post-doctoral fellows) are enthusiastically and effectively engaged in teaching and outreach, immersed in inquiry-based teaching and learning, developing activities for teachers, organizing teacher workshops, and giving engaging presentations in settings ranging from school classrooms to libraries to pubs. But much remains to be done. Our graduate students and post-docs still feel that they are lacking information about and preparation for careers, both in and outside academia.

These are exciting times for Canadian astronomy. The federal government has promised support for the Thirty-Meter Telescope Project. Canadian astronomers are actively involved in other international mega-projects, such as the James Webb Space Telescope, the Atacama Large Millimetre Array, and the Square Kilometre Array. We need to do the best possible job of preparing our undergraduate and graduate students to be part of these exciting projects. They will become part of the next generation of astronomers around the world. ✶

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

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Second light

"Comets are the pits"

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

The European *Rosetta* spacecraft is currently orbiting the comet 67P/Churyumov-Gerasimenko, and is sending back large amounts of data taken from a distance of just 30 km. Previous observations of comets revealed the presence of "pits", for which a clear explanation was not apparent. Jean-Baptiste Vincent of the Max Planck Institute for Solar System Research in Göttingen, Germany, along with many collaborators from around the world, have analyzed images from *Rosetta* and concluded that the pits probably arise like sinkholes, with water ice sublimating from below until the overlying crust collapses.

Previous ideas about the origin of pits include explosive events (some readers might remember that the movie *Deep Impact* showed something similar), or impacts by other bodies. Calculations of the frequency of impacts, and laboratory experiments, ruled out the impact option. On comet 9P/Tempel 1, pits were associated with explosions. The *Deep Impact* mission found that the largest ejected ~10^5 kg of material. One explosion (on April 30) has been seen on 67P.

But a large pit on 67P would contain ~10^9 kg of material, based upon its average density of 4.7 g/cm^3—that's 10,000 kg more material to be ejected than on 9P, which Vincent and colleagues find is too much to be plausibly ejected in an explosion.

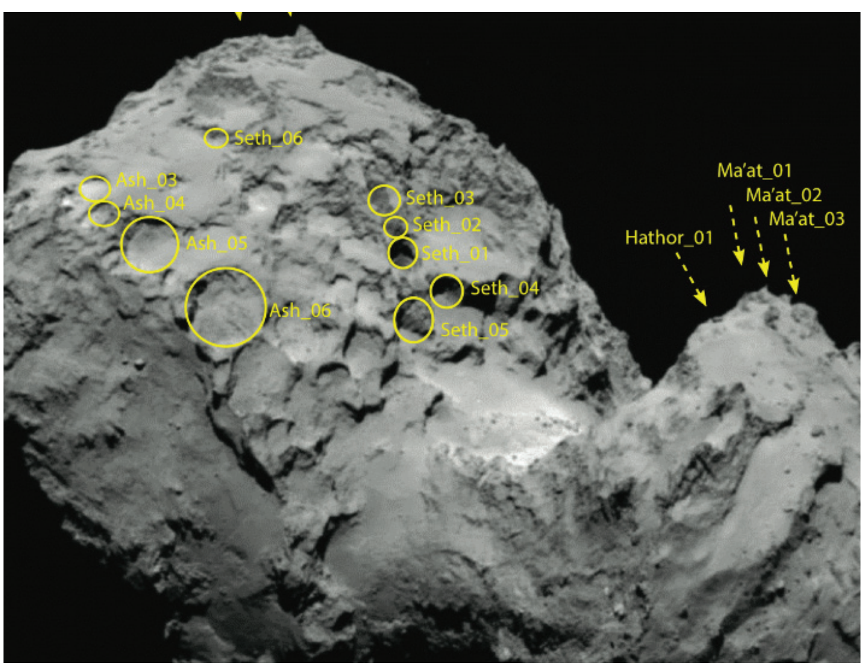


Figure 1 — Locations of some of the pits on comet 67P are indicated in yellow. Courtesy of Jean-Baptiste Vincent and Nature.

Vincent and his colleagues used stereo reconstruction of images from one of the cameras on *Rosetta* to find that fine dust jets could be traced back to some of the pits. They measured the depths of the pits, and calculated the ratio of depth to diameter. They found that the active pits—the ones with jets coming from them—had ratios that on average were a factor of 3 larger than those of the inactive pits, such that the active pits almost look like cylinders.

The jets come from the edges of the active pits, but Vincent argues that the pits did not grow to their present sizes through sublimation of ice from the edges, because they would not be so cylindrical, and the process is too slow.

Their preferred explanation is that the pits formed through sinkhole collapse, as the underlying volatile material (various ices that sublimate as the comet warms) is removed.

One of their observations is that the size of the pits in a particular terrain—they see in broad stroke three types of terrain—are very similar. This would naturally be explained in the sinkhole model, because the collapse of the roof would happen when it reaches a particular thinness, which would happen at about the same thickness in each terrain, as the escaping volatiles leave an empty space behind. These collapses may be the sources of the explosions on comet 9P, and the one explosive event seen on 67P.

The collapse exposes fresh volatiles on the sides of the pits, which explains the jets coming from the sides. The pits will expand slowly outward as the volatiles on the walls sublimate. The rocky/dusty material left behind would gradually collapse into the pits, starting to fill them in.

Vincent et al. conclude that a fresh cometary surface will have a ragged structure with many pits, while an older surface will be smoother.

Data are still coming back from *Rosetta*, and more papers are in the pipeline. I doubt that this will be my last column about what's happening on comet 67P. ✶

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.*

Dish on the Cosmos

ALMA Proposals

by Erik Rosolowsky, Department of Physics, University of Alberta

In a small hotel room in Osaka, Japan, I joined six other astronomers to help decide what the next set scientific discoveries for the ALMA observatory was going to be. I was one of three Canadian representatives to the ALMA Review Panels, which evaluated the 1600 different proposed scientific plans that were submitted for the fourth cycle of ALMA observing. Since ALMA will only have about 4000 hours of scientific observations over the next year, the community needs to decide how best to spend those observations. Groups of astronomers submit proposals: four-page papers that outline a science case for using the telescope to make a specific discovery. Proposed topics range from studying the fundamental physics that governs the beginnings of the Universe to studying moons in the Solar System. The goal of the ten review panels is to decide which of the proposals make the best use of the telescope's limited time. Nearly all research telescopes use some form of this process to decide what they should observe.

It is hard work. Every panel member reads about 150 proposals, and nearly all of them propose exciting new ideas. Nonetheless, the panels must decide which 20% are the "best," and in doing so, we do a small part in steering the news you will hear coming out of ALMA in two years. The process is far from perfect, as committees often are; but some clearly wonderful ideas will almost certainly be approved, observed, and ultimately turned into scientific discovery. It is easy to lose track of this goal when debating which research group had the most efficient observing strategy for a given question. The overall impression I left with was that the next set of observations was going to answer some long-nagging questions for the field.

One topic that astronomers across the field eagerly want to use ALMA to answer is how high-mass stars form. Stars like our Sun are considered to be "low mass," and the line between low- and high-mass stars is usually drawn at 8 times the mass of the Sun (i.e. 8 solar masses). Notably stars larger than 8 solar masses will end their lives in a supernova explosion, while stars less than this mass fade away forming planetary nebulae and leaving behind white dwarfs. However, ALMA is focused on the origins of stars, and high-mass stars pose distinct problems here. Low-mass-star formation is relatively well understood and the questions in that field are turning to how planets form around these stars. The birth of high-mass stars is harder to unravel for many reasons: they are rare, they evolve quickly, they form in clusters, and they are intensely destructive to their surrounding medium.

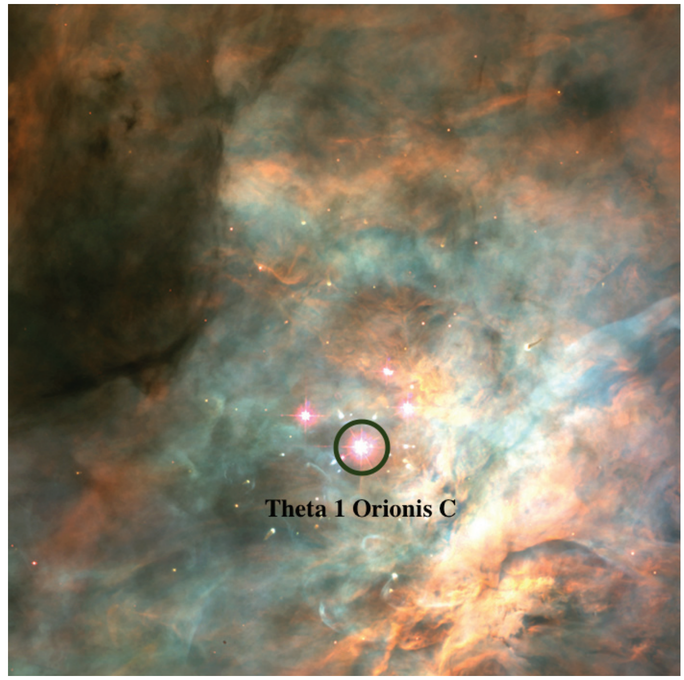


Figure 1 — Visible-light image of the Trapezium cluster in the Orion Nebula (M42) from the Hubble Space Telescope*. Theta 1 Orionis C is highlighted, representing one of the most easily seen high-mass stars in the sky. The radiation from this star plus other lower-mass stars in the region have stripped away the gas that gave birth to them, though some of the remnant gas can be seen in extinction on the left side of the image. Image credit: NASA, C.R. O'Dell and S.K. Wong (Rice University)*

One of the nearest high-mass stars is Theta 1 Orionis C in the Orion Nebula (M42; Figure 1). It is 40 solar masses, but it gives off 200,000 times more light than the Sun does. Because it is hotter, much of the light is skewed more into the ultraviolet and carries enough energy (per photon) to destroy hydrogen atoms and molecules. This light shreds the dark nebula surrounding the star, destroying simple clues about its formation. This huge fountain of radiation comes at a cost for the star: it can only sustain its light for a few million years, hundreds of times shorter than a slow-and-steady star like our Sun. In a cosmic moment, it runs out of fuel and explodes as a supernova. This short lifetime is mirrored in the formation process. Where a star like the Sun assembles over a few million years, Theta 1 Orionis C likely only took 10,000 years to form (though it did so over a million years ago). Finding something that forms in astronomy over a length of time that is merely the span of human recorded history is rare indeed. Stars like Theta 1 Orionis C are also intrinsically rare; the Milky Way forms 6000 Sun-like stars for every star like Theta 1 Orionis C. The short formation times and overall rarity compound to mean that these star-formation events are usually quite far away. The Orion Nebula is the closest site of high-mass-star formation, and most high-mass-star formation is occurring down in the centre of the Galaxy.

Despite their rarity, and short lifetimes, these stars play an out-sized role in galaxy evolution because of their

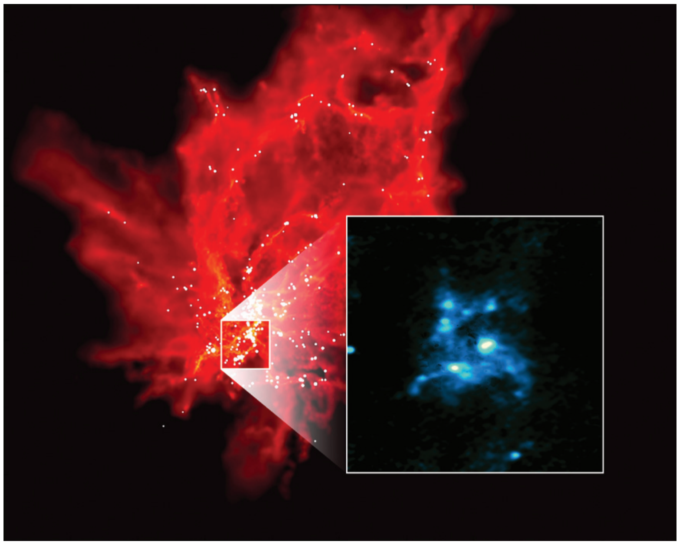


Figure 2 — Computer simulation of star formation with inset image of ALMA observations. In the simulation, the red region shows the gas and the white points represent forming stars. These data show the predicted complexity of the star-formation process. The inset image shows ALMA maps of a real star-forming region, which will join with others to explain the origins of high-mass stars. Image credit: ALMA(ESO/NAOJ/NRAO), H. B. Liu, J. Dale.

huge radiation output, their strong stellar winds, and their cataclysmic supernova at the end of their lives. When we look across the visible Universe and see galaxies, we are seeing the signatures of high-mass stars living and dying. Astronomers dearly want to understand the details of this formation since it underpins how we can interpret light from the most distant galaxies.

The mystery of high-mass-star formation is connected to the extreme properties of these stars. Low-mass stars form by collapsing over millions of years from a cold cloud of gas. They gain their mass as cold gas streams down from the host cloud and onto a forming star. As the star gains enough mass to support nuclear fusion in its core, the star gently turns on and the warm light pushes back the natal cloud. High-mass stars, in contrast, give off so much radiation during their formation process that they should push back all of the material streaming onto them, quenching their formation and start their lives with much lower mass. But, as Orion will testify, they clearly must be able to form! Theorists have come up with two possible explanations. The stars could form simply by dumping a huge amount of material onto stars from one direction while radiation pushes out in another direction. The other possibility is that high-mass stars could form in clusters of initially low-mass stars. Then, these protostars will progressively smash into each other and stick together to form higher-mass stars. In the first case, ALMA should be able to look at a cloud where we expect high-mass stars to form. If ALMA finds several big, dark "cores" of gas with masses each much larger than a single high-mass star, this would support the first scenario. Alternatively, ALMA could find many low-mass cores in the star-forming region, but no direct progenitors of high-mass stars, which would support the latter conjecture.

To this end, many astronomers have proposed to use ALMA to sift through the cold, dusty gas that should host the next generation of stars in search of the progenitor material for high-mass stars. Figure 2 shows a computer simulation of one way these high-mass stars might form (red), with some early ALMA data in this region. By using the new capabilities of ALMA in its fourth cycle, astronomers hope to peer into gas clumps like these to find the progenitors of high-mass stars. How that material is distributed will provide clear insight into once of the major questions that has bothered astronomers for decades. These questions turn on the review panel's deliberations as to whether a proposal made the case that deep continuum would be better than diazenylium spectroscopy or whether one team's target was a better choice than another. While every case raised excellent points, a few proposals will soon turn into data and from that into insight. I left that week knowing, among many other discoveries, we will soon be much closer to understanding how forming high-mass stars overcome their own radiation and build up their mass. ✶

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

2015 Award Citations

SERVICE AWARDS

David Chapman

Dave is a Life Member of the Society, having rejoined the RASC (Halifax Centre) in 1984 after an absence of several years. He has been an active member of the Centre and the Society ever since, in a variety of capacities.

At the Centre level, he served as Centre librarian in 1985, and as Centre president in 1995–96. In addition to mentoring members, he was the Centre Webmaster for several years. He's an active outreach volunteer, at many public talks and outreach events.

Dave developed the "Mini-Messier List," an introductory observing program for new observers. Many keen observers of the Halifax Centre got their start with Dave's Mini-Messier List.

Dave was one of the driving forces behind the 16-inch Dobsonian Saint Croix Observatory, running training sessions on proper care and feeding. He has been a leader in social media to raise awareness of the night sky, astronomynovascotia.ca includes a Twitter and Facebook account, and remains a one-stop information source for all things astronomy-related in Nova Scotia. Six years later, Dave is still the site administrator.

Nationally, late 1990s saw him serving on the Awards Committee (think Simon Newcomb Award). Kejimkujik National Park Dark-Sky Preserve and Keji's highly successful annual Dark-Sky Weekend event.

Dave is an experienced lunar observer; for seven years, he wrote over 50 JRASC articles. Then he began a five-year term as editor of the *Observer's Handbook*, which he maintains to his usual high standard.

Internationally, Dave has taken astronomy EPO to Cuba in recent years, contributing equipment and publications to Cuban astronomers and educators. A Spanish translation of the *Explore the Universe* certificate program has been exported to Cuba. Dave has successfully provided knowledge, as well as the tools and expertise needed, to establish an effective dark-sky program and EPO in Cuba.

Whether at the local, national, or international level, Dave Chapman exemplifies the goals and objectives of the RASC. For all of the reasons given, he is highly deserving of the Service Award.

Respectfully submitted,

Mary Lou Whitehorne , Chris Young, Quinn Smith, Roy Bishop, Pat Kelly, Dave Lane

Colin Haig

What I admire most about Colin is his eagerness to do things and to do them well. He often drops by the Society Office to ensure things are running smoothly, to check on the computer systems, to co-sign cheques. When the Society moved offices a few years ago, Colin went to the new location and wired the computer systems, ensuring that it all worked properly, and that the cabling was out of the way and well hidden.

In his role as 1st Vice-President, Colin has been the Chair of both the Constitution and the Publications Committees. Prior to that, Colin served two years as 2nd Vice-President, chairing the Nominating Committee. And all the while, over those numerous years, and even before, Colin has been a member of the Information Technology Committee, lending his expertise of computer systems whenever it was needed. He is a stalwart!

Not only does he lend his expertise at the national level, he has been a Hamilton Centre member for over 20 years, editing the newsletter, managing the Centre as president for 3 years, and helping out with events such as the "World's First Virtual Star Party," using CCD cameras from around the world to observe Comet Hyakutake.

Unknown to many people, Colin's suggestions over the past few years have found fertile ground, flourished, and have borne fruit. The Fellowship concept was first his; the suggestion to jointly participate with *SkyNews* in developing the *Getting Started in Astronomy* booklet was partly his idea; he has championed a RASC *Guide to the 2017 Solar Eclipse*; and he most recently chaired the working group to search for a new Society Executive Director.

Colin's unselfish contributions are the epitome of service to the Society, and I can think of nobody who is more deserving of recognition by his peers.

Respectfully submitted,

Roger Hill, former Hamilton Centre President
James Edgar, President

Chris Malicki

Chris, a RASC member for over 35 years, volunteers at both the centre and national levels. He's been the Secretary of the Mississauga Centre since 2006, and in its previous incarnation as the Mississauga Astronomical Society, amply demonstrating his attention to detail.

Chris acts as the Centre's observing guru, helping at outreach events, giving many observing talks. He was instrumental in the Centre acquiring a solar scope.

He has been an *Observer's Handbook* proofreader since 2011, and has become a valued fact-checker and quality monitor.

Chris is an accomplished amateur astronomer, searching for faint galaxies with his 14-inch scope. Eclipse chasing with his wife Liz, they have travelled around the world to observe 13 total solar eclipses. His presentations on these events are so vivid and exciting that a listener often feels that he or she was there.

For all of the foregoing accomplishments, Chris Malicki is deserving of the Society's Service Award.

Respectfully submitted,

J. Randy Attwood, Executive Director
David Chapman, Editor, Observer's Handbook
Leslie Strike, President, Mississauga Centre

PRESIDENT'S AWARD

Walter MacDonald, for his diligence, attentiveness, and steadfast pursuit of excellence as the Society's Webmaster.

Walter has served quietly in the background for numerous years, ensuring that the RASC Web-based systems and all that goes with them are running smoothly—making the necessary corrections, assisting others, maintaining the Society's written, audio, and visual history on the website, and keeping a watchful eye on the running of the site. His valuable knowledge and abilities continue to ease our use of the many forms and procedures he has created. Walter is on the Working Group that oversaw the employment of Joseph Astillero, who re-built our website over the past few months.

Walter's value as a resource person cannot be overstated, and he is richly deserving of the 2015 President's Award.

Respectfully submitted,

James Edgar, President

FRASC

Robert Dick

Rob has been active in the RASC over the past 45 years with contributions at the local, national, and international stage. A Life Member, he served as a Councillor for the Ottawa Centre. As Chair of the Centre's "Observers Group," he managed the site preparation for the Fred Lossing Observatory (FLO) which remains the Centre's primary observing site. Rob served as Vice-President, and President, as well as National Council Representative. In the 1970s, he was involved in the engineering of two large parabolic antennae, that once was the largest amateur radio telescope in the world.

In the early 1990s, with light pollution compromising the effectiveness of Ottawa Centre's observatory, Rob led the development of a light-pollution abatement program. In 1998, he adapted the program to a national scale, and under Rob's direction, the RASC Dark-Sky Preserve Program began in 2000 with the designation of Torrance Barrens. He has since expanded LPA to the development of the science of scotobiology (the study of the biological need for periods of darkness). Robert developed and authored the Parks Canada Guideline for Outdoor Lighting, which was adopted in 2006 by the RASC as the Lighting Protocol for DSPs, and in 2012 by the International Dark-Sky Association. It is now the only internationally recognized guideline, which allows the RASC to have the most extensive network of Dark-Sky Preserves in the world. Rob continues to be "the-guy-to-call" regarding Dark-Sky Preserves and Urban Star Parks.

During his many media interviews, he highlights the RASC's leading role in protecting the night environment. Robert has been an advisor to the American IYA Light Pollution Program in 2009 and continues to be consulted by the Dark-Sky Working group of the International Union for the Conservation of Nature (IUCN) regarding light pollution awareness in world parks.

He oversaw the creation of the Special Supplement to the *Journal* in December 2012. These activities have resulted in the RASC being recognized as the *de facto* leader in dark-sky preserves and low-impact lighting.

On a more personal side, he designed and built a large telescope and observatory at a dark rural site in 1986, hosting "open houses" at his lakeside observatory for people in southern Ontario.

This long list of activities and accomplishments can truly be considered a "career."

Respectfully submitted,

Roland Dechesne (Calgary)
Richard Huziak (Saskatoon)

Dave Lane

David Lane is Director of the Burke-Gaffney Observatory at St. Mary's University, and Systems Administrator for the University's Department of Astronomy and Physics. He has been an exceptional member of the RASC for more than a quarter century. The Society has benefited immensely from the good judgment, diplomatic skills, technical expertise, and dedication of this unpretentious gentleman from Stillwater Lake, Nova Scotia.

[Insert a great lot of exemplary activities…] In Halifax Centre — Secretary, Observing Chair, Editor of *Nova Notes* (for six years), Treasurer, and President.

At National: Dave led the reform and merger of the earlier incarnation of the *Journal* and former *Bulletin* publications, and served as the first *Journal* Production Manager; he was the Society's first Webmaster; he has been a regular contributor to the *Observer's Handbook*. On the Executive for over eight years, Dave oversaw the sale of the old National Office, IYA2009, hiring our first ED, and numerous other items requiring his exquisite attention to detail.

For nearly 30 years, David Lane has made extraordinary contributions to a diverse palette of core RASC activities beginning with effective local contributions followed by truly exceptional national service and leadership. His sustained efforts have materially contributed to the high international regard in which the Society is held. For these and many other reasons, we recommend that he be appointed a Fellow of The Royal Astronomical Society of Canada.

Respectfully submitted,

Dr. Roy Bishop, FRASC
Dr. James Hesser, FRASC

Dr. John Percy

The award of Fellow of the RASC (FRASC) was created to acknowledge the work of long-serving members who have made extraordinary contributions to the Society, much of which service has been rendered at the national level. We provide evidence that John R. Percy more than satisfies these criteria, and recommend that he be appointed Fellow of the RASC.

He was Toronto Centre President in 1970–71 and served several times as Centre Vice President in charge of programs. He served on the National Council from 1965–1984, and was Editor of the *Observer's Handbook* for the decade 1970–80. Since 2013, he has been our Honorary President. Through his career in the RASC, John Percy's work to the highest possible standards has been guided by a strong and consistent theme of bringing astronomy to people, wherever there are people. He does so in a manner that is relevant and meaningful to them. He has had—and continues to have—enormous, lasting impact, not only on the Society, but on Canadian and international education and outreach.

John has been—and remains—a remarkably effective local, regional, national, and international ambassador for science, astronomy, and education, as well as for the benefits to be gained through organizational partnerships, and through professional-amateur collaborations. The RASC has always been a cornerstone, and primary beneficiary, of his work.

For the foregoing and many more reasons, we nominate Dr. John R. Percy for the Society's Fellowship Award.

Respectfully submitted,

Mary Lou Whitehorne (Halifax Centre)
Dr. James E. Hesser, FRASC (Victoria Centre)

Mary Lou Whitehorne

Mary Lou's contributions and commitment to The Royal Astronomical Society of Canada, both administratively and in terms of education and public outreach, are outstanding. The Society was particularly fortunate to have her as its president during the years 2010-2012 when changes to its governance structure were required by revisions to federal law.

Her passionate leadership, quick intelligence, and sheer hard work on behalf of the RASC in those years were invaluable. We have had few women Presidents—Mary Lou is in the same league as two of those: Helen Hogg and Mary Grey, who were both nationally recognized for the excellence and impact of their contributions.

Mary Lou read in an astronomy column by Terry Dickinson that one could see the moons of Jupiter through binoculars. She looked, and became hooked on astronomy! She joined the Halifax Centre in 1985 and has since become a Life Member. Her sparkling personality and growing interest in the heavens led her into many Centre executive positions, including Councillor, Secretary, Observing Chair, and three years as Centre President, plus chair of the committee hosting the 1993 GA in Halifax.

Her observations of B(e) stars with the Burke-Gaffney scope resulted in two papers in the *Journal*, and the Chant Medal.

To promote astronomy education, she wrote *Skyways, Astronomy Handbook for Teachers*, now in its second edition. She also authored the *Moon Gazer's Guide*; edited the sixth edition of *The Beginner's Observing Guide*; contributed to the *Observer's Handbook* and the *Observer's Calendar*; she inspired the IYA2009 book *Mary Lou's New Telescope*.

Mary Lou's major national service began in 2006, when she ran for the position of 2nd Vice-President. Upon her election, she began an 8-year sequence of service leading to her presidency in 2010, which leads to Past Presidency and Chair of the Awards Committee. In 2007, Minor Planet 144907 was named "Whitehorne" in her honour.

Mary Lou Whitehorne has constructively and effectively brought unique perspective, analysis, determination, and leadership to the betterment of all aspects of The Royal Astronomical Society of Canada. What better qualities for a Fellow of the RASC?

Respectfully submitted,

Dr. Roy Bishop, FRASC
Dr. James Hesser, FRASC

QILAK

The DDO volunteers (too numerous to list) of the Toronto Centre have spent the last five-and-a-half years ensuring that the David Dunlap Observatory in Richmond Hill continues to function, indeed, to thrive, despite all odds.

The David Dunlap Observatory (DDO) offers a rich variety of public outreach and education programs to school groups, Scouts and Guides, and the public. These programs, run by the DDO volunteers, require more than 2500 person-hours per season. In addition, many more thousands of volunteer hours are dedicated to the ongoing maintenance of the great telescope and its precinct.

Toronto Centre, through the DDO, engages in public outreach on a broad level. The observatory is a magnet for journalists putting together astronomy or space-related stories. Centre members have provided educational and inspirational interviews from the site for national, regional, and local reporters. It's an important opportunity to promote astronomy.

The dedication of Toronto Centre's DDO volunteers has produced impressive results. Since assuming stewardship of the facility in 2009, the Toronto Centre has welcomed more than 20,000 visitors, introducing new generations to astronomy and encouraging young people to pursue careers in the sciences.

For all of the reasons given, and many more, we believe the DDO Volunteers deserve the Society's 2015 Qilak Award.

Respectfully submitted,

Paul Mortfield, President Toronto Centre

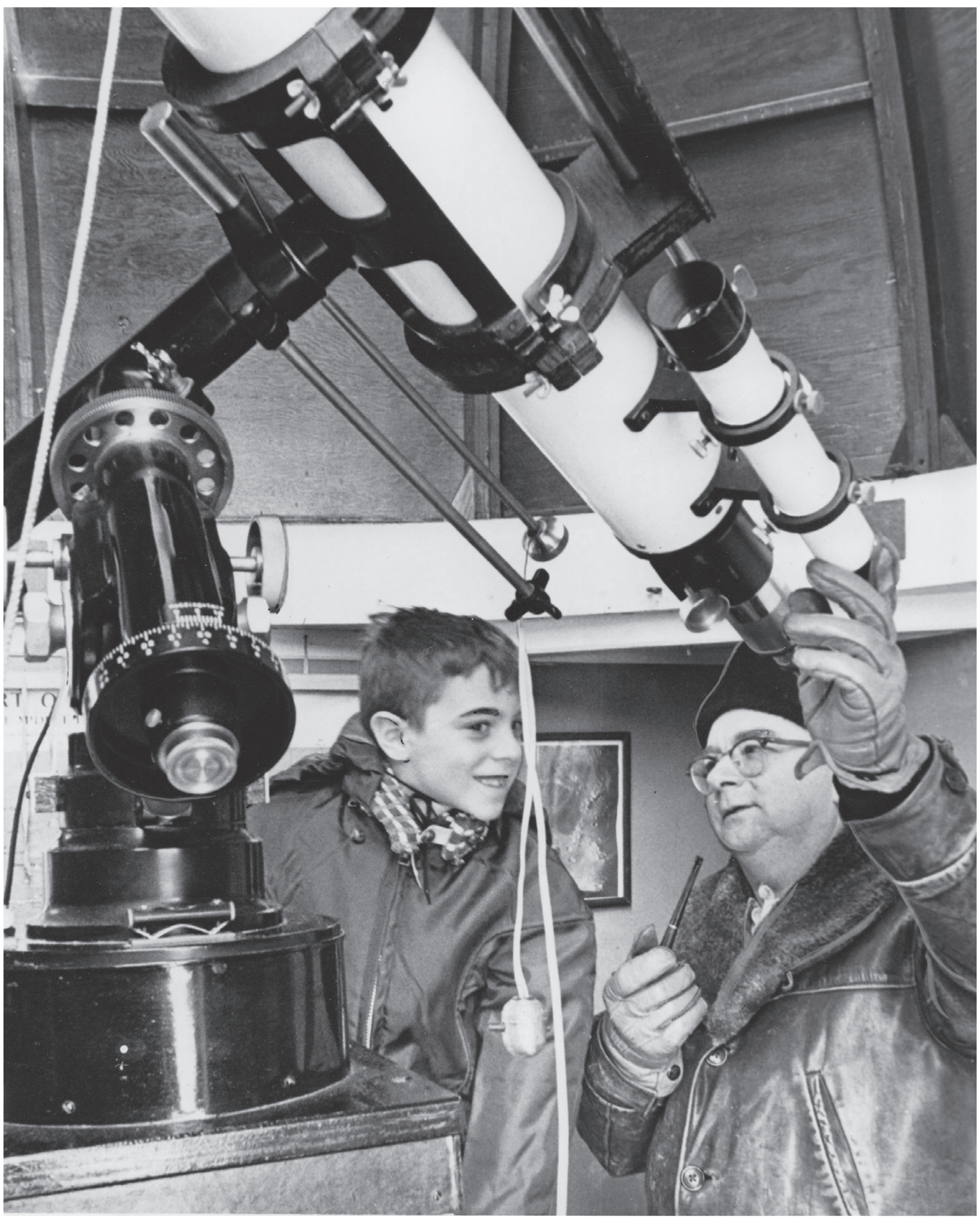
In Memoriam

Outstanding Canadian amateur astronomer Ray Thompson, 1923–2015

by David Thompson

Ray Thompson died June 22 at his home in Halifax, at the age of 91. He was born in Gillingham, England, and grew up in Bermuda. After attending the University of Toronto and Toronto Normal School, he began a long career teaching, first as an elementary teacher in the public schools and later as a private music teacher. He was interested in astronomy since his teens, but after settling in the then-tiny rural village of Maple, Ontario, (as principal he taught grades 5–8 and the other teacher taught grades 1–4) just north of Toronto, he began to expand the reach of both his instrumentation and his astronomical activities. The first Maple Observatory housed a 6″ Unitron refractor, then also a 4″ Gerrish polar axis telescope. In 1971, a larger two-story structure housed the Gerrish and 8″ *f*/15 and 6″ *f*/10 refractors, later replaced by a 10″ SCT.

Never overly interested in just looking at celestial objects, Ray concentrated on ways in which he, as an amateur, could make useful contributions to science. He was a long-time variable-star observer accumulating over 10,000 visual observations for the American Association of Variable Star Observers (AAVSO) and later adding photoelectric photometry to his repertoire. He also made nearly daily sunspot observations for almost 50 years. He contributed to or co-authored many scientific papers, especially in collaboration with John Percy. He also never tired of introducing students, Boy Scouts, or anyone else to astronomy.



Ray and David Thompson at Maple Observatory.

Ray was a Life Member of the RASC, President of the Toronto Centre from 1963–1964, and winner of the Society's Chant Medal in 1967 for his many contributions to instrumentation, observational astronomy, and education, and of the 1996 Ken Chilton Prize for his photoelectric photometry work.

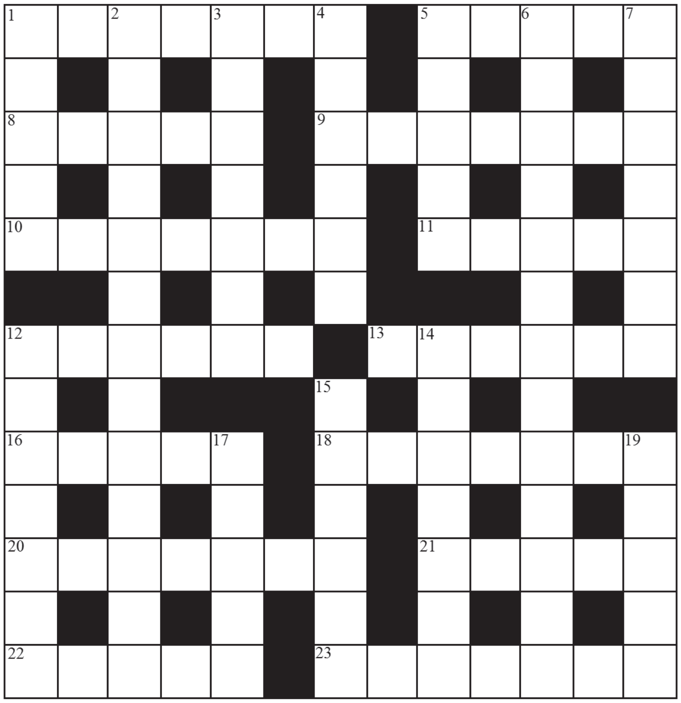
A true renaissance man, Ray was an accomplished pianist (an Associate of the Royal Toronto Conservatory) and violist who loved both orchestral and chamber music. He was an enthusiastic gardener and also a witty writer and even a talented artist—some of his children's fondest memories are of the stories he made up for them when they were young, illustrating them as he told them. He was widely read and his (left-wing) politics were never long left out of any conversation.

Ray was an amateur in the best sense of the word, contributing to astronomy for the love of it. ✶

David Thompson is a laser and optical physicist at Los Alamos National Laboratory in New Mexico, and is Ray's son.

Astrocryptic

by Curt Nason



ACROSS

1. Richard or Mary supervises exams (7)
5. Sky supporter seen around Saturn (5)
8. Another supporter follows half a lion in the ecliptic (5)
9. Roam around after friend at astronomers' Mount (7)
10. Comic Doctor with quirky quark (7)
11. Ring spokes detected by radio with I/O transition (5)
12. Olympian queen flips over album by Big Bang promoter (6)
13. Greek character with endless trust depicts Europa's captor (6)
16. Stop back in Québec at a planetary upland (5)
18. I turn gamers into modern astrophotographers (7)
20. Minkowski or seasonal red light provider (7)
21. JRASC, for many, is advertising easy in East (5)
22. German mounted invader of England (5)
23. I turn right after each supermoon time (7)

DOWN

1. Paul's turn to observe a lunar marsh (5)
2. Night sky conundrum made old boxer spar a round (6,7)
3. Neophyte electrical engineer follows meteor remnant (7)
4. Randy Attwood at a fixed mount by Rupes Recta's blade (6)
5. Stellar composition pioneer sent everyone to the emergency room (5)
6. Solar feature or effect (4,9)
7. Astronomy popularizer was awarded for service, I hear (7)
12. Are insects around a supergiant? (7)
14. Like most RASC astronomers, Edgar begins in confused trauma (7)
15. Tidal Prince is on Board with King and Queen (6)
17. Come across spectral lengths in his book of astrophysical quantities (5)
19. Steer around a volume of space (5)

Answers to August's Astrocryptic

ACROSS

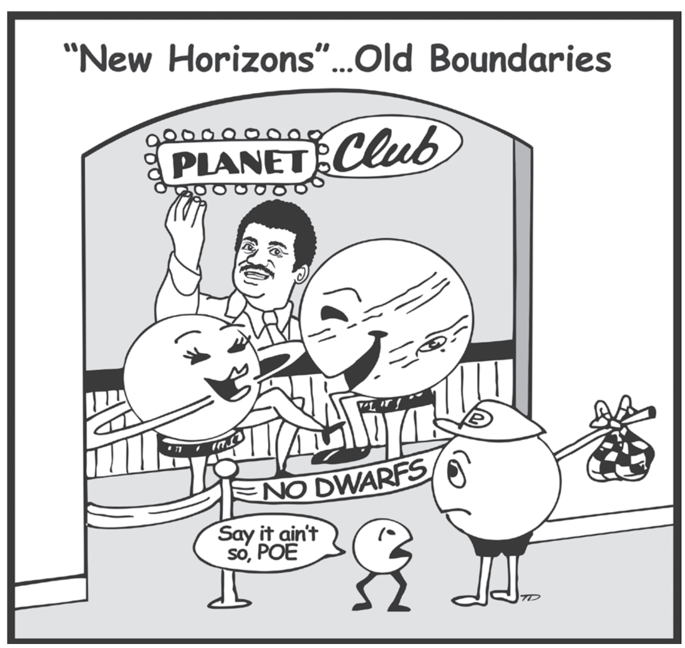
1 MOONSET (moo + NS + ET); **5** SCUTI (Its (rev) around Cu); **8** SOUTH (s(out)h); **9** OERSTED (anagram + d); **10** A-BAND (an(N)ag); **11** IOPTRON (I + opt + Ron); **12** OBSERVATORIES (anag + tories); **15** BURNHAM (burn ham); **18** GENUS (Sun + eg (rev)); **20** TACHYON (t(achy)on); 21 NIOBE (2 def); **22** LARGE (anag); **23** HICKSON (hicks + no (rev))

DOWN

1 MUSCA (hidden); **2** OCULARS (anag); **3** SCHEDAR (an(he)ag); **4** TROPICAL MONTH (anag+h); **5** STRIP (anag); **6** UTTER (hid); **7** IODINES (anag); **12** ORBITAL (or(bit)al); **13** ORGANIC (anag); **14** IGNEOUS (an(o)ag); **16** RECUR (hid); **17** HOYLE (2 def); **19** STERN (2 def)

It's Not All Sirius

by Ted Dunphy



"New Horizons"...Old Boundaries

THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

Great Images

Craters as small as 6 km in diameter can be seen in this detailed view of the region of the lunar terminator (the dividing line between day and night). The large, multi-walled crater just left of centre near the bottom edge in this view is 93-km-wide Copernicus. Also visible is "Rupes Recta," otherwise known as the "Straight Wall." Michael Watson took this image on 2015 Aug. 7, from Toronto using a Nikon D810 camera on an Explore Scientific 152-mm apochromatic refracting telescope, on a Sky-Watcher AZ-EQ6 SynScan mount.

Journal

Great Images

On 2015 July 14, NASA's *New Horizons* made history as it flew by the dwarf planet Pluto. This enhanced-colour image reveals in exquisite detail the different composition and textures on the surface of Pluto. The photograph is a composite of four images taken by *New Horizons*' Long Range Reconnaissance Imager at a distance of 450,000 km.

Photo credit: NASA/Johns Hopkins University Applied Physics Laboratory/Southwest Research Institute