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Journal

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PROMOTING ASTRONOMY IN CANADA

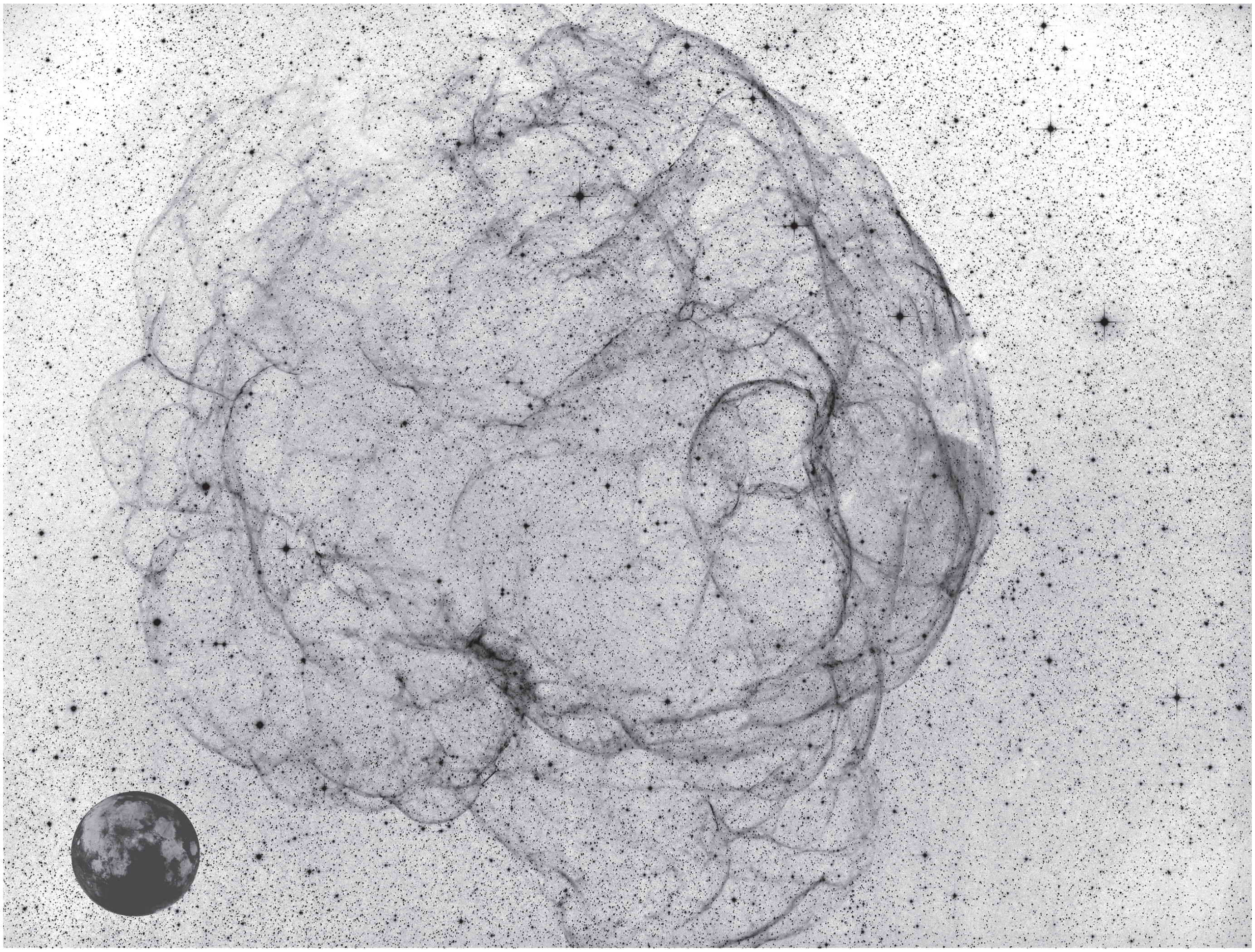
February/février 2014
Volume/volume 108
Number/numéro 1 [764]

Inside this issue:

The Soul Nebula: Star Cradle

Astrophotographers take note!

This space is reserved for your B&W or greyscale images. Give us your best shots!



James Black invested 12 hours to collect this Hα image of the supernova remnant Simeis 147 in the constellations Taurus and Auriga. The scale of Simeis 147 can be judged by the inset of the Moon. The 40,000-year-old remnant lies about 3000 light-years distant and has a physical size of about 140 light-years across. James used a Takahashi FSQ 106ED telescope with a 7-nm filter and a Starlight Xpress SXVR-H36 camera.

Journal

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Société Royale d'Astronomie du Canada

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Front cover *— The Soul Nebula in Cassiopeia is a chaotic region of intense star formation in the shape of an immense bubble created by the winds of young massive stars. This portion, along the rim of the nebula, was photographed by Lynn Hilborn of WhistleStop Observatory in Grafton, Ontario, using a TEC 140 refractor and a FLI ML8300 camera in RGB, OIII, SII, and Hα wavelengths. Exposure was a total of 11 hours, accumulated last November.*

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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News Notes / En manchettes

Compiled by Andrew I. Oakes
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Spacecraft to encounter Comet 67P this summer after 10-year journey

Rosetta, the European Space Agency's (ESA) most ambitious space mission to date, finds itself about 9 million km from Comet 67P/Churymov-Gerasimenko, a dirty snowball of ice and dust with which it will rendezvous later in 2014. The spacecraft is scheduled to orbit the comet's nucleus and deploy a small laboratory of scientific instruments to the comet's surface.

The ESA has programmed *Rosetta*'s internal alarm clock to bring it out of deep-space hibernation at 10:00 UTC on 2014 January 20. It originally went into sleep mode in July 2011 for the coldest and most distant leg of its journey.

Rosetta launched on 2004 March 2, and through a complex series of flybys—three times past Earth and once past Mars—set course to its destination, while at the same time flying by and imaging two asteroids, Steins on 2008 September 5 and Lutetia on 2010 July 10.

Once awake, *Rosetta*'s first series of tasks will be to warm up its navigation instruments, spin down to point its main antenna

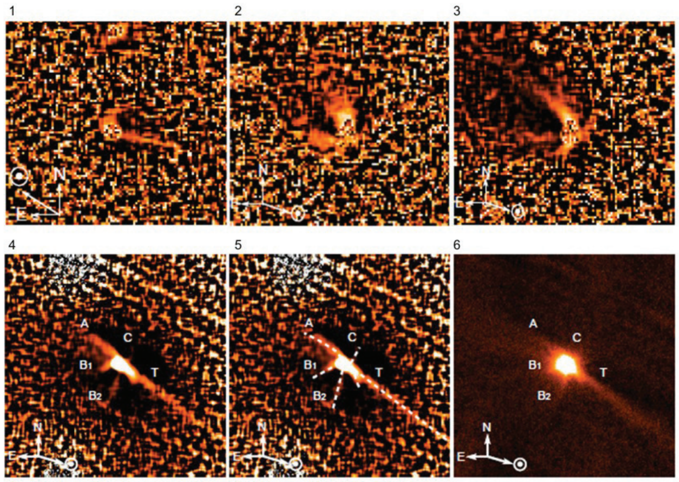

Figure 1 — Images acquired between June 2008 and February 2009. The location of the dust coma structures are enhanced by different filtering techniques (1-3) adaptive Laplace-filtered images, (4) adaptive Laplace-filtered image with the structure geometry indicated by annotations and (5) dashed lines, (6) Larson-Sekanina filtered image. Credit: J-B Vincent/MPS/GP Tozzi/L Lara/Z-Y Lin.

at Earth and, finally, to advise the ground team that it is still alive. As the spacecraft moves closer to its rendezvous with Comet 67P/Churymov-Gerasimenko, the 11 instruments on the orbiter and 10 on the lander are being recommissioned.

In early May 2014, *Rosetta* will be 2 million km from its target. Near the end of that month, it will execute a major manoeuvre to line up for rendezvous with the comet in August. Scientists are expecting the first images of the distant comet in May, which will improve calculations of the comet's position and orbit. Closer in, images will provide further details of the comet's major landmarks, its rotation speed, and spin-axis orientation.

After recording measurements of the comet's gravity, mass, and shape, the spacecraft will make an initial assessment of the comet's coma—its gaseous, dust-laden atmosphere. It will also probe the plasma environment, analyzing its interaction with the solar wind. Following extensive mapping of the comet's surface during August and September of 2014, scientists will select a landing site for the mission's 100-kg probe, called *Philae*—the first time that landing on a comet will have been attempted.

The comet, which has a 4-km-wide nucleus, features an almost negligible gravity. As a result, *Philae* will actually "dock" with the comet. As it reaches ground level, the probe will apply ice screws and harpoons to stop it from rebounding back into space.

While on its millions-of-kilometres journey, an international group of scientists back on Earth has been using ground-based telescopes and computer models to understand the behaviour of the comet as it approaches the Sun and begins to form its tail. The group presented its initial findings during the September 2013 European Planetary Science Congress (EPSC) at University College London (UCL), London, UK. The EPSC is the major European meeting on planetary science, held annually in Europe.

Scientists have been observing the comet for about three orbits, using images and modelling to study the development of gas jets as the comet becomes active. To date, the comet appears to behave in a very consistent way. Its southern hemisphere appears to be more active than the northern, and there are three major active regions from where gas jets evolve, ejecting dust particles at around 50 km/h

The *Rosetta* Mission involves several "firsts" in space exploration:

- First mission to journey beyond the main asteroid belt relying solely on solar cells for power generation, allowing it to operate 800 million km from the Sun;
- First to orbit a comet and to land a probe on the nucleus (making it one of the most complex and ambitious missions ever undertaken);
- First images to be taken by the *Philae* probe on the surface of a comet and make the first *in-situ* analysis of the composition by drilling into the surface; and
- *Rosetta*, the first spacecraft to witness, at close proximity, how a comet changes as it is subjected to the increasing intensity of the Sun's radiation.

The *Rosetta* Mission's main objective is to help understand the origin and evolution of the Solar System, and the role that comets may have played in seeding Earth with water, and perhaps even life.

New strategies assist NASA in storing science-based digital data

NASA has a ginormous task on its hands as it gathers hundreds of terabytes of data every hour from its many space missions. The enormity of the task is reflected by the fact that a terabyte is equivalent to the information printed on 50,000 trees worth of paper.

Data pours in daily to receivers from spacecraft monitoring everything from planet Earth to faraway galaxies. The digital records—images and information—all need to be stored, indexed, and processed so that spacecraft engineers, scientists, and others across the globe can use the data to understand Earth and the Universe beyond.

According to NASA's Jet Propulsion Laboratory (JPL) in Pasadena, California, mission planners and software engineers are coming up with new strategies for managing the ever-increasing flow of such large and complex data streams, referred to as "big data."

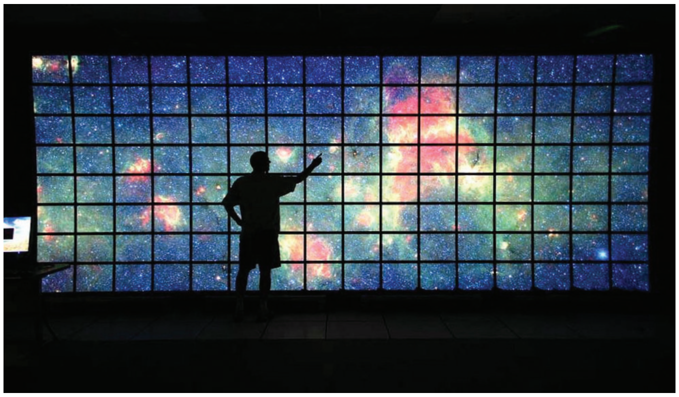

Figure 2 — Big Data on the Big Screen: The centre of the Milky Way galaxy, imaged by NASA's Spitzer Space Telescope*, is displayed on a quarter-of-a-billion-pixel, high-definition 7-metre LCD science visualization screen at NASA/Ames Research Center in Moffett Field, Calif. Image: NASA/Ames/JPL-Caltech.*

Scientists use big data for everything from predicting weather on Earth to monitoring ice caps on Mars to searching for distant galaxies, says Eric De Jong, JPL's principal investigator for NASA's Solar System Visualization project. The project converts NASA mission science into visualization products that researchers can use.

"We are the keepers of the data, and the users are the astronomers and scientists who need images, mosaics, maps and movies to find patterns and verify theories," he said.

There are three aspects to acquiring data from space missions: storage, processing, and access. De Jong explains that the first task, to store or archive the data, is more challenging for larger volumes of data. For example, the Square Kilometre Array (SKA), a planned array of thousands of telescopes in South Africa and Australia that is scheduled to begin construction in 2016, will scan the skies for radio waves coming from the earliest galaxies known. Some 700 terabytes of data are expected to be acquired every day—equivalent to all the data flowing on the Internet every two days.

Instead of building more hardware, engineers are busy developing creative software tools to better store the information, such as "cloud computing" techniques and automated programs for extracting data. Staff at the big-data initiative are modifying open-source computer codes to create faster, cheaper solutions. (Software that is shared and free for all to build upon is called open source or open code.)

A second challenge is developing new ways to visualize the information. For example, each image from one of the cameras on NASA's *Mars Reconnaissance Orbiter* contains 120 megapixels. Movies, computer graphics, and animations are created from data sets like these, enabling scientists and the public to get up close with the planet.

Finally, there is the challenging task of making it easy for users to grab what they need from the big-data archives. NASA's Infrared Processing and Analysis Center at the California Institute of Technology, Pasadena, archives data for use from a number of NASA astronomy missions, such as the *Spitzer Space Telescope*, the *Wide-field Infrared Survey Explorer* (WISE), and the U.S. portion of the European Space Agency's *Planck* mission.

Sometimes astronomers want to access all the data at once to look for global patterns, a study that's done via computer, as no human can sort through that much information. In fact, the ability to access all the data remains one of the benefits of big-data archives.

Hidden mega-canyon on Earth discovered beneath Greenland ice sheet

A multi-year NASA-operated airborne science campaign, studying the Earth's polar ice, has accumulated data showing that a large canyon lies hidden 1.6 km under Greenland's ice sheet.

The research, published in *Science*, reports that a 736-kilometre-long canyon with the characteristics of a winding river channel runs as deep as 800 metres. This feature is comparatively longer than the Grand Canyon and its depth is on a scale with the Arizona-located geological marvel. Scientists believe the immense feature predates the ice sheet that has covered Greenland for the last few million years. The continuous bedrock canyon runs from near the centre of the island northward to the fjord of the Petermann Glacier in northern Greenland, a feature that has remained hidden for all of human history.

Radar data from NASA's Operation IceBridge, collected from 2009 through to 2012, aided scientists in constructing the landscape underneath the ice. Other airborne radar data from previous work also assisted in this visualization. Combining these data sources made the discovery possible.

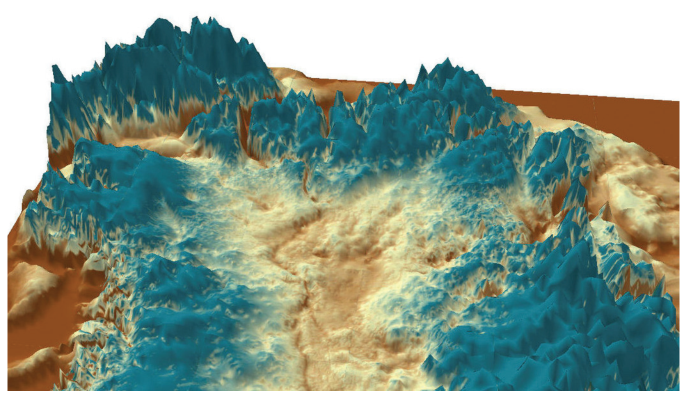

Figure 3 — A 3-D view of the subglacial canyon, looking southeast from the north of Greenland. Image: Jonathan Bamber, University of Bristol, UK.

According to scientists working on the topographical research campaign, certain radio-wave frequencies have the ability to travel though ice irrespective of its depth. The radio waves bounce back when they hit the bedrock. The differences in the timing of the radio signal's return provides data on the actual depth at each measured point of the canyon.

Scientists believe the canyon plays an important role in transporting sub-glacial meltwater from the interior of Greenland to the edge of the ice sheet and into the ocean. They also report that evidence suggests that before the presence of the ice sheet, water flowed in the canyon from the interior to the coast and was a major river system in Greenland.

The IceBridge campaign is expected to return to Greenland in March 2014 to continue collecting data on land and sea ice in the Arctic.

Dawn spacecraft set to visit dwarf-planet Ceres in early 2015

While the *Rosetta* mission makes its way to a distant comet for an encounter beginning in August 2014 (above), NASA's *Dawn* spacecraft is scheduled to arrive at the dwarf-planet Ceres by April 2015.

Ceres is the largest object in the main asteroid belt between Mars and Jupiter. It presents an icy counterpoint to the dry Vesta, another surviving proto-planet where the *Dawn* spacecraft previously spent almost 14 months, and from which it has been travelling towards Ceres since September 2012. Once *Dawn* enters orbit around Ceres, it will be the first spacecraft to see this dwarf planet up-close and the first spacecraft to orbit two Solar System destinations beyond Earth.

Dawn's two visits will give scientists information about the planet-forming conditions during the emergence of the Solar System, and will enable direct comparisons between these two giants of the asteroid belt.

On 2013 December 27, *Dawn* found itself closer in its journey to Ceres than to Vesta. According to the mission's schedule, the spacecraft's approach operations to Ceres will begin in late January 2015. Thirty days later, Ceres will be large enough in *Dawn*'s view to be imaged and used for navigation purposes.

Dawn will be captured by Ceres's gravity in late March or the beginning of April 2015. At that time, it will obtain science data at an altitude of about 13,500 km above the dwarf planet's icy surface before spiralling downward to an altitude of about 4430 km to secure additional data in its survey science orbit, a phase lasting 22 days.

The spacecraft is designed to obtain a global view of Ceres with its framing camera, and global maps with its visible and infrared mapping spectrometer (VIR).

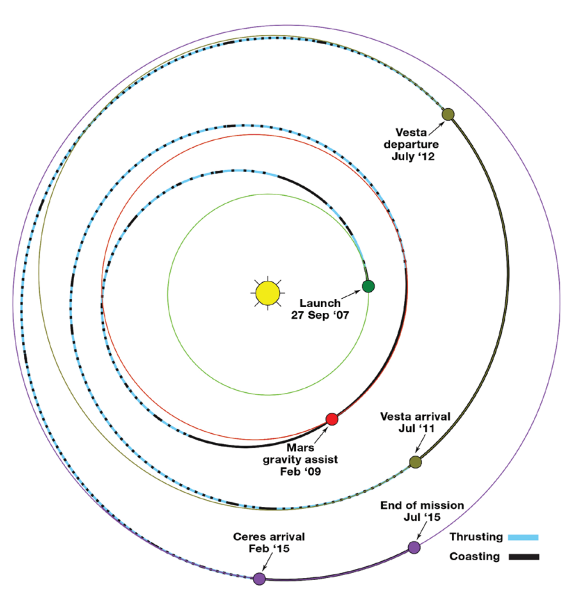

Figure 4 — This graphic—a simulated trajectory—shows the planned trek of NASA's Dawn *spacecraft from its launch in 2007 through to its arrival at the dwarf-planet Ceres in early 2015.* Dawn*'s primary mission will end in July 2015, followed by an extended mission that continues until year end. Image: NASA/JPL-Caltech.*

After continuing its downward spiral to an altitude of about 1480 km, *Dawn* will begin a two-month phase known as the high-altitude mapping orbit in August 2015. During this phase, it will continue to acquire near-global maps with the VIR and framing camera at higher resolution than in the survey phase, and will also image in "stereo" to resolve the surface in 3-D.

After continuing downwards for another two months, *Dawn* will begin its closest orbit around Ceres in late November 2015, at a distance of about 375 km. This three-month, low-altitude mapping orbit will allow the acquisition of data with *Dawn*'s gamma ray and neutron detector (GRaND) and include a gravity investigation. It is expected that GRaND will reveal the signatures of the elements on and near the surface, while the gravity experiment will measure the tug of the dwarf planet, as monitored by changes in the high-precision radio link to NASA's Deep Space Network on Earth.

The international partners on the *Dawn* mission team include the German Aerospace Center, the Max Planck Institute for Solar System Research, the Italian Space Agency, and the Italian National Astrophysical Institute. The mission is managed by the Jet Propulsion Laboratory for NASA's Science Mission Directorate in Washington and is a project of the directorate's Discovery Program. The University of California, Los Angeles, is responsible for overall *Dawn* mission science, while the California Institute of Technology in Pasadena manages JPL for NASA. ✶

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

Featured Articles / Articles de fond

Astronomy Outreach in Cuba: Trip Four

by David M.F. Chapman
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Preamble

Every one of our outreach trips to Cuba has been different from the last. The history of these trips has been documented well in the *Journal* (Chapman 2010, Chapman 2011, Chapman 2012). In 2013, we were not able to go in the springtime, owing to family matters, but an opportunity came up in the fall: my new friend Prof. Rolando Cardenas, head of the Planetary Science Group at Universidad Central "Marta Abreu" de Las Villas (Santa Clara), announced he was organizing the international conference Biogeosciences-13 for November 4–8 at a beach resort on Cayo Santa Maria. Well, this just happens to be a place that my wife and I wanted to visit, so we jumped at the chance. For once, the trip did not include visiting Havana and our friends there, and the outreach component was rather small, but I am sharing it anyway, for the sake of completeness. You could say that attending this conference (without any external support, I should add) was an excuse for a vacation!

The Conference

The conference turned out to be smaller than expected (around 20 persons, more of a workshop), and almost got cancelled due to the lack of foreign participation. When I told Rolando I was attending, he immediately invited me to speak, which I accepted, cautioning him that I did not have any original research or novel science to present. The participating countries turned out to be Cuba, Spain, Argentina, Brazil, Greece, and Canada. Although I was not officially representing RASC, my participation and RASC affiliation were noted in the opening remarks. The topics ranged widely from environmental science, through astrogeology and astrobiology, to light pollution (my presentation). My basic message was "responsible lighting in protected areas" and I emphasized the environmental impact of light pollution, how the RASC dark-sky program tackles that, and how Cuba has an opportunity to build responsible lighting into future economic development of their predominantly rural nation. Since some of the conference talks dealt with the ethical aspects of exploring planets, my talk brought this topic "down to Earth," and was received warmly by the participants.

On the last day of the conference, we all went on a bus tour of sites in and around Santa Clara. Two of these were well known to us from our visit in 2012: the site of the Battle of Santa Clara, where Che Guevara's men managed to derail a Batista troop train and bring an end to the armed conflict, and Che's

Figure 1 — The old Moon with earthshine, Cayo Santa Maria, Cuba, 2013 November 2.

Figure 2 — The partial solar eclipse of 2013 November 3 was viewed from Cayo Santa Maria, Cuba.

memorial, where his remains have been interred (after they were discovered and returned from Bolivia). The third site was Loma del Capiro, a park in Santa Clara where a chance road excavation uncovered an outcrop of the Cretaceous-Paleogene boundary associated with the Chicxulub asteroid impact. Although the actual boundary is hidden behind surface rubble, one can see the two rock types above and below, and there is a scientific paper (Alegret *et al.* 2005) confirming the find.

Outreach

Before travelling to Cuba, I asked Rolando if he needed anything, and it seemed that data storage devices were in short supply, so I ended up taking a couple of used external hard disk drives for the Planetary Science Group (thanks Dave Lane and Jim Miller!) plus several 16 GB USB "thumb" drives for students and junior faculty. On all devices, I placed some useful electronic resources, including two conference presentations that had proved difficult for the Cubans to download over their constricted Internet connections. I also took some solar viewers left over from the transit of Venus, which may prove useful for observing some upcoming partial eclipses and perhaps some naked-eye sunspots. I took a pair of those Celestron 15×70 binoculars that frequently go on sale for about $50; these were left behind to assist the Planetary Science Group conduct monthly public sky-viewing sessions at the university.

Figure 3 — A short lesson on paleontology with the limestones of Che's memorial.

On my way through Toronto, I had acquired two copies of the 2014 *Observer's Handbook*. One copy went to Renan Martin, the octogenarian founder of the first amateur astronomy group in Cuba in the 1950s (I worked with him in 2012); the second went to Isbel Gonzalez, the elected head of the observing group of Cuban amateurs (*i.e.* the Cuban Chris Beckett).

At night on the third day of the conference, we gathered at an unlit tennis court near the conference hotel, after checking with the hotel that this would be OK. I brought my 50 mW green-laser pointer (which seemed almost too strong for the job) and conducted a quick night-sky tour. At the latitude of 23°N, Polaris is about halfway down the sky from the position I am used to, so the Big Dipper was entirely absent from the sky at 9:00 p.m.! As a consolation, I was able to show them Fomalhaut (magnitude 1.2) and Achernar (magnitude 0.5), the 9th brightest star in the night sky (invisible from Canada). The Summer Triangle was setting in the northwest and Orion was rising in the east. Cassiopeia, Cepheus, Andromeda, and all the rest of the constellations associated with that Greek myth

Figure 4 — The author presents a copy of the 2014 Observer's Handbook *to Renan Martin, with Prof. Rolando Cardenas looking on.*

were overhead. In the tripod-mounted binoculars, we viewed the Double Cluster, the Pleiades, and the Orion Nebula. The sky was a little hazy with some moonlight and light pollution, so the sky-quality meter reading was only 19.6 magnitudes per square arcsecond. Even so, the Milky Way was visible, to the delight of the Greek couple, who had never seen it.

The Future

Circumstances did not permit me to attend the meeting of the Cuban amateur astronomers in the nearby town of Caibarien, right after the conference, but my donated binoculars did! Villa Clara province, in the centre of Cuba, seems to be the preferred meeting spot of the Cuban amateurs, as the next three annual gatherings will be in towns in that province, starting with Caibarien (again) on 2014 April 25–27. There are frequent tourist flights to Santa Clara airport at that time of year, so this bodes well for future trips involving astronomy outreach in Cuba. ✶

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Volunteering: A Guide (Part 1)

by Paul Heath
Halifax Centre

A Volunteer: He or she, who is placed (or places themselves) before the rolling stone on the mountain top. The further one goes down the slope, the faster one needs to travel and the larger the wall of snow building up behind becomes.

Volunteering can easily become a way of life.

Volunteers tend to be recruited by meeting other volunteers at events put on by organizations to which they belong. Some volunteer to give themselves something to do, others because they are passionate about a sport or hobby or an idea. Whatever the reasons, the rewards are often hard to measure: perhaps recognition by peers, the joy of teaching someone else what you are passionate about, or the pride in helping another reach a goal or improve a skill. Many volunteer because of the interest and passion inspired by a previous volunteer.

But perhaps the biggest reward for a RASC volunteer comes when you find that you have reached someone and have passed on some of your love and joy of astronomy. One incident that stays in my mind involved a young girl (6 or 7 years old) who had attended a constellation talk at the library. At the time, she had asked a few questions and had found a "Butterfly" constellation on her star sheet. Later, at a Brownie talk, she asked me if I remembered her. She explained "my constellation was a Butterfly." I did remember the Butterfly. But, what really lingers in my mind is what took place while I was setting up the telescope for observing after the talk.

The girl looked around the sky, then said to a couple of the other girls, "See those two stars, they point up to the North Star—right there (pointing); that bright one there is a red giant in the ice cream cone "Booties." She turned to me very seriously, "That's right isn't it?" "Yes," I said, as she had used the pointer stars of the Big Dipper to find Polaris, and the star she pointed to was Arcturus, the red giant in the "ice cream cone" of Boötes. The smile that filled her face from ear to ear said it all. Later, her mother said that she had been using the Star Finder she got at the library talk every chance she could.

Growing up with both parents having been Scout Leaders, volunteering became just a part of my life. As my sons grew, I also became a Scout leader, and a soccer coach, and so on. It seemed only natural that, when I joined RASC, I would offer to help wherever I could. With IYA2009, I began a more formal involvement with the Halifax Centre's outreach activities, and after five years, I am still very active in outreach.

Year	Number of events	Participants	Hours
2009	9	466	15.5
2010	22	1,732	77
2011	37	1,057	76.5
2012	52	2,081	101.5
Totals	120	5336	270.5

At a RASC meeting, it was suggested that I should tabulate my volunteer activities for the Halifax Centre. After doing so, I was surprised at the number of events in which I had been involved. They covered a range of venues, and grew steadily from year to year (see table above). The list includes a wide-ranging sample of the projects that any outreach volunteer could expect to join:

- Schools: classroom talks: curriculum-based for Grade 6 and 9, and general talks for other classes;
- Libraries: astronomy talks and Teen Zone presentations;
- Provincial and National Parks: daytime astronomy presentations with solar observing when possible; evening sky tours;
- Discovery centre: astronomy talks and science camp workshops;
- Summer camps: astronomy talks at summer Day Camps / half-day weeklong astronomy camps;
- Public outreach: group mall displays, outdoor shows, lifestyle exhibitions, Earth Hour, dark-sky weekends, the camp outs, Amateur Radio on the *ISS* event, homemade planetarium shows, observatory tours, school spring fairs, community fairs (solar observing and astronomy demos), and youth group presentations such as Brownies, Cubs, and the Young Naturalist Club.

Until I had actually put all this together, I did not feel that I was really doing all that much. I helped out where I could and had fun, especially working with the kids. There were frustrations, as when the computer crashed at the start of a solar-dynamics talk. Grade Nines tend to lose focus when you try to draw diagrams from memory! Or the time when only three people showed up to a Discovery Centre talk. We were not aware the "Pride Parade" was passing by outside. There were many "Oh My God" and "#&!* is that real?" moments when people got their first look at Saturn, Jupiter, or the Moon through the telescope. There were many discussions about "aliens" and "have you seen any?" (Yes—and I have pictures!). There were rewards too: that look of wonder and amazement when kids or adults grasped the size of our Solar System as we paced outward, step-by-step from the Sun, usually only getting to Jupiter before running out of field or school hallway.

While a Scout leader, I developed demos and models to help teach astronomy to Scouts and other leaders. For RASC outreach, I have expanded on these to help with classroom presentations, library talks, and astronomy workshops. I now have half a car full of demonstration material and a dozen PowerPoint presentations. (A more detailed review of my outreach activities can be found at http://halifax.rasc.ca/documents/novanotes/nn4402.pdf)

Figure 1 — Sharing telescopes at a public event is a delightful way to meet people and make friends—in this case, at a solar eclipse in Spain. Photo: J. Anderson.

So how does one reach this point in outreach? Or more important, how do **you** begin?

The following is intended as a guide to help you begin your outreach activities or expand those you might already be doing. I've divided it into three levels of involvement, outlining three events that reflect each level of involvement. My advice originates from almost 25 years of outreach, mostly with youth, and with many bumps on the road. I hope it helps and encourages you to begin or expand your own outreach activities in astronomy.

First, you must realize that outreach is *only as much or as little* as you feel that you can contribute. To begin, perhaps it is:

- Showing a neighbour a view through your telescope;
- Providing an extra telescope and operator at a public observing event;
- Staffing a booth at an exhibition.

Whichever way you choose to do outreach, you need to engage the audience. Hands-on activities, visual demos, and vivid graphics will keep your audience's attention. Plan your presentation—have more than you need for the time allotted. If something is not working, move on to the next item. Outreach is *not* a "this is on the exam" situation. The goal of outreach is to encourage an interest in and an exploration of the night sky and the Universe around us. Make it *fun*, make it *interactive,*

Figure 2 — Star Finder workshop at the Keji Sky Circle, led by volunteers Andrea Misner & Julius Lopez-Garcia (Winnipeg Centre) at the Keji Dark-Sky Weekend, Nova Scotia (Kejimkujik National Park). Photo: Dave Chapman.

and make it *hands on*, if possible. This applies to both adult and youth presentations.

Outreach also means being prepared to instruct, educate, and entertain and requires increasing amounts of equipment or instructional material. For instance:

- Your own telescope or binoculars, and a chair or stool;
- A simple sky chart to show others what they are looking at;
- Your knowledge of the night sky;
- Your enthusiasm for astronomy.

Now let's have a look at "To Begin"-level events.

Showing a neighbour a view through your telescope

Encourage friends and neighbours to come look through your telescope. It is a sure bet that when you set up in the dark, neighbours are going to wonder what is going on. If nothing else, inviting them to look will keep them from turning on the security lights or calling the police.

Next, explain to them what object they are looking at and point out where it is in the sky, a question that they will probably ask themselves. The answer should lead to further questions, which in turn may get them involved in amateur astronomy themselves.

Third, give your neighbours some hints for better viewing. Suggest they sit to look through the telescope, as it prevents them fighting their own balance while viewing. Advise them to cover one eye with a hand, so that they can look with both eyes without squinting. Talk about peripheral vision, and how they can shift their eye to make faint objects stand out.

Providing an extra scope and operator at a public observing event

Be prepared—do some "research" to familiarize yourself with objects in the sky that night. Focus on four or five at most, as the larger the public group, the fewer objects you will have time to show. The Moon, planets, bright nebulae, star clusters, double stars, and the *ISS* are good starters. At a public event, the organizers will usually begin by letting the public know what objects will be featured. If you are lucky, someone will do a short sky tour to orient the crowd to the night sky.

Second, follow the viewing suggestions for "showing a neighbour." Encourage people to look at the same object through different telescopes. This will highlight the different types of equipment used to look at the sky and demonstrate why there are no *Hubble*-like images in amateur telescopes. Have binoculars available for wide-field views of the night sky. Binos are a great tool to learn the way around the sky.

Staffing a booth at an exhibition

First, be aware of the materials that your club or Centre has available for you at the booth.

Depending on the type of show—sports, outdoor, tourism, or community group—your Centre may have many helpful materials: RASC signage, astronomy posters and images, telescopes or binoculars for display, slide or video presentations, brochures promoting local and national activities and interests, light-pollution information, information on local astronomy suppliers, links to astronomy Web sites, and Star Finders, Moon maps, and other handouts.

Second, your goal at a trade show is to make people aware of the RASC and how it can grow their interest in astronomy and space sciences. Let them know about the activities of your local Centre and how to use Facebook posts and Web sites to learn about meetings and outreach events.

Third, engage the visitors to draw them to your booth. As they approach, ask them questions: Do you look up at the stars? Do you have binoculars or a telescope? Are you interested in space?

At an exhibition, there are two groups of people: the collectors who just want what they can get for free, and those interested in learning. Assembling and demonstrating a Star Finder will draw a crowd and turn a collector into a questioner. Or perhaps you can demonstrate the difference between a refractor and reflector. Talk about upcoming outreach events and how your listeners can participate.

Questions will come from all directions. Answer as best you can, or direct the questioner to a person or resource that can help them. Expect questions about equipment and how to get started in astronomy. The answer to those questions will depend on your own experience, but there is no agreed-upon reply. You might suggest that the questioner ask others at the booth and let them arrive at their own answer according to their budget and level of interest. Invite them to attend public sessions to see what can be seen with different telescopes. Let the visitor know that astronomy, like any hobby, can be as little or as much as you want it to be. Astrophotography takes specialized equipment and skills, but to enjoy the night sky, you only need to look up.

Finally, be ready for "Out There" questions. You will be asked:

- How to find someone's Zodiac sign;
- If you believe in aliens!
- Why did you get rid of Pluto?
- How did you get interested in astronomy?

Be prepared—there are many ways of answering these questions!

Figure 3 — Sean Dzafovic at Halifax Centre booth at Saltscapes Exhibition. Photo: Blair MacDonald.

Going Forward—the Next Step

If you've travelled this far, the next step along your outreach path might become more involved:

- An astronomy talk or sky tour for a youth group;
- A general astronomy talk for a school class;
- An astronomy talk or sky tour at a park or campground.

To go beyond neighbours and friends into a more structured environment such as a school or youth meeting, you will require a few more materials to capture your audience. These might include:

- An introductory PowerPoint presentation with 6 to 7 slides that highlight a topic;
- A generalized PowerPoint presentation of 12 to 17 slides that gives a broad overview of a topic;
- A Solar System model or poster;
- Materials to show lunar phases, build lunar craters, demonstrate the scale of Earth-Moon and Solar System distances, or show how distances are measured in the Universe;
- Materials for small craft projects: build a scalar Solar System, make a constellation projector, construct a model star (connect with youth group leaders for craft materials);

Don't forget your telescope and binoculars for viewing, a red light, and a laser pointer (but do not pass to your audience www.rasc.ca/education/green-laser-pointer-usage).

Making Contacts

In many cases, requests to make a presentation will come from your astronomy club and astronomy friends. However, you can be proactive and investigate the following avenues:

- If you have children in Elementary or Junior High, let their teachers know you are available for an astronomy talk in class.

- Do you have children in Scouts or Guides? Let their leaders know that you are available to do an astronomy talk or sky tour.
- Does your Centre have a link on their Web site for "Astronomer in the Classroom" or "youth group outreach"? If so, let the contact coordinator know you are available.
- Do you attend a local park or campground regularly? Let the park officials know you can do a talk or sky tour for the park visitors.

Now, let's have a look at look at "Going Forward—The Next Step.":

Figure 4 — Solar observing at Keji Sky Circle, Keji Dark-Sky Weekend, Nova Scotia. Photo: Dave Chapman.

An astronomy talk or sky tour for a youth group

You've made the contacts and now it's time to make the presentation. Here are a few thoughts to consider:

First, be aware of the age group and how many will be there. Direct your presentation to an appropriate level. Use short 10–15-minute bits for each topic you present. Make it fun. Make sure you contact the group a few days before your talk to confirm it is still on; it also reminds them that you are coming.

Second, make it interactive. The more participation from the young people, the more control you will have. There is a lot of basic misinformation about astronomy in the community, so get a sense of what the group understands about the topic. By asking what they know or think about the topic, you can direct the discussion to the correct answer. Explain why something is, rather than stating "that's the way it is."

Third, demonstrate, demonstrate, demonstrate. A picture is worth a thousand words, but a demonstration makes it clearer. Get the group to participate in the demo—the more involved they are, the more fun they will have and the more they will learn.

Fourth, for sky tours, you will need enough equipment to keep the group from getting restless. Ask an astronomy friend to help by bringing an extra telescope. Ask the group leaders to bring binoculars. Discuss the use of red lights while observing and why it is important to keep your night vision. Start by demonstrating how the equipment works, then describe a few of the objects at which you will be looking. Do a short sky tour, and then start observing. Make sure the leaders and the group are aware of the need to be careful around the equipment.

For the youngest crowd, say ages 4 to 7 (Sparks and Beavers), focus on one topic (the Moon or constellations are the best); use three or four short 10–15-minute activities. Give a short PowerPoint presentation of 6-7 slides that highlight the main points of a topic. Try to use interactive demos to emphasize a point.

For a slightly older group, from 6 to 10 years of age (Cubs and Brownies, after-school youth groups), begin with: a generalized presentation to cover badge requirements; a PowerPoint of 10-15 minutes highlighting objects in the Solar System; a Solar System model; discuss how to find the North Star; or use a model or demo to measure the Solar System (*i.e.* a "toilet-paper Solar System").

In the early teen years, from 11 to 16, you are likely to encounter Scouts, Guides, and Cadets. For this age, you can bring much the same materials as for the previous group—PowerPoint images and Solar System models—but with a higher level of detail. An astronomy Q&A is likely to lead down many pathways. Your sky tour should have enough telescopes and binoculars to handle the size of the group. If outdoors, you can demonstrate how telescopes work, how to find Polaris, point out the constellations, planets, and other prominent objects, and recite some of the sky lore and myths associated with the patterns in the sky.

A general astronomy talk for a school class

For school classes, an observing session is usually not possible unless an evening visit can be arranged. If so, leave the details of location and time, and rain date, up to the teacher, though you will want to suggest the right lunar phase and planetary visibility. Encourage the parents to attend. For a classroom presentation, contact the teacher a few days beforehand as schedules change at times. Ensure equipment is available such as computer and data projector. Arrive a half-hour early, as most schools require guests to sign in and be taken to where the presentation will be given.

Keep your presentation to 35 to 45 minutes and allow 10 to 15 minutes for questions. Bring a short PowerPoint on a topic directed to grade level and a Solar System model with a demo to show the size of the Solar System. Make it interactive and fun.

For grades from primary to three, a Moon talk is the best with three to four short activities of 10 to 15 minutes each. Look at lunar phases, how does the Moon turn, discuss the shapes we see on the Moon, how craters are formed, the distance to the Moon, and show pictures of the Moon taken through telescopes or from satellites. Get students involved with the demonstrations. Consider a brief exercise such as a "Moon on a stick" to show lunar phases.

For older grades, up to grade 6, a Solar System talk may be your best option. Once again, a short PowerPoint presentation and a model of the Solar System will do the trick. Define the types of objects in the Solar System, and use a demo to look at size and distances of Solar System objects—a scalar Solar System is a good brief craft exercise to show Solar System spacing. Review the life zone of our star and where we are looking for life in the Solar System. Talk about the age of the Solar System and what will happen to it in the future. Expect questions to go in all directions—this is the age group that will ask the most questions, coming throughout your talk.

In most cases, for grades 7 to 12, teachers will request specific, curriculum-based presentations. Here you will find that *Skyways* is the best resource for such topics. Start with a PowerPoint that gives an overview of the topic, then use interactive demos to explain main ideas. For example, in Grade 9 solar dynamics, use a demonstration that shows how a star evolves and discuss how different stars age. Leave time for questions. Depending on topic, you can give the students an activity that will help them explore the topic discussed—perhaps follow the migration and evolution of a sun-spot group.

An astronomy talk or sky tour at a park or campground

Generally, parks will contact local Centres about doing presentations over the summer months. Let your Centre know that you are interested in doing those presentations, or that a park that you usually attend has asked for a presentation, as this will give you access to assistance such as extra telescopes or handout materials.

First, contact the park to determine what facilities are available and the type of presentation expected. Arrange the time and a rain date if possible. Facilities will vary from small auditoriums to picnic areas with a small field. You may be asked to do a daytime presentation or a short evening presentation with a sky tour. If power is available, a PowerPoint on the Sun and Solar System may be possible. If there is no power, you will need models and demos to help with your talk. Make the presentation as interactive as possible.

If asked for a daytime presentation, talk about our Sun and Solar System. Demonstrate sizes and distances within our Solar System. If possible, bring a model or bring flags that you can use to pace out the dimensions of our Solar System. Get the participants involved with these demos to make it fun. The easiest scale is 1 pace = 15 million km, so that 1 AU (the Earth to Sun distance) is 10 paces (150 million km).

It makes a nice add-on to the presentation if you are equipped for solar observing. Discuss safety first to make participants aware of what they should not try at home. Make a drawing of what they will see on the Sun, to help orient the participants. Leave time for questions.

For an evening presentation, start about an hour before dark so that you can demonstrate how the telescopes work. Show how we measure the sky, demonstrate the use of a Star Finder (a great hand out), and discuss the objects you will be highlighting. Do a constellation tour to orient the crowd. Add constellation lore and talk about seasonal and circumpolar constellations, satellites (*ISS*), the Moon, and planets. Then show them favourites in the night sky. A laser pointer is a great advantage, but it is **very, very important** that you do not loan it to any participants. Safety comes first. A short spiel about its use as a tool, not a toy, is a good idea.

In Part 2, I will discuss how to handle the "Next Level," where your talks are constrained by someone else's agenda: a curriculum-based presentation for Grades 6, 9, and 12; a library or science centre presentation on a specific topic; or running a planetarium show or an observatory tour. ✶

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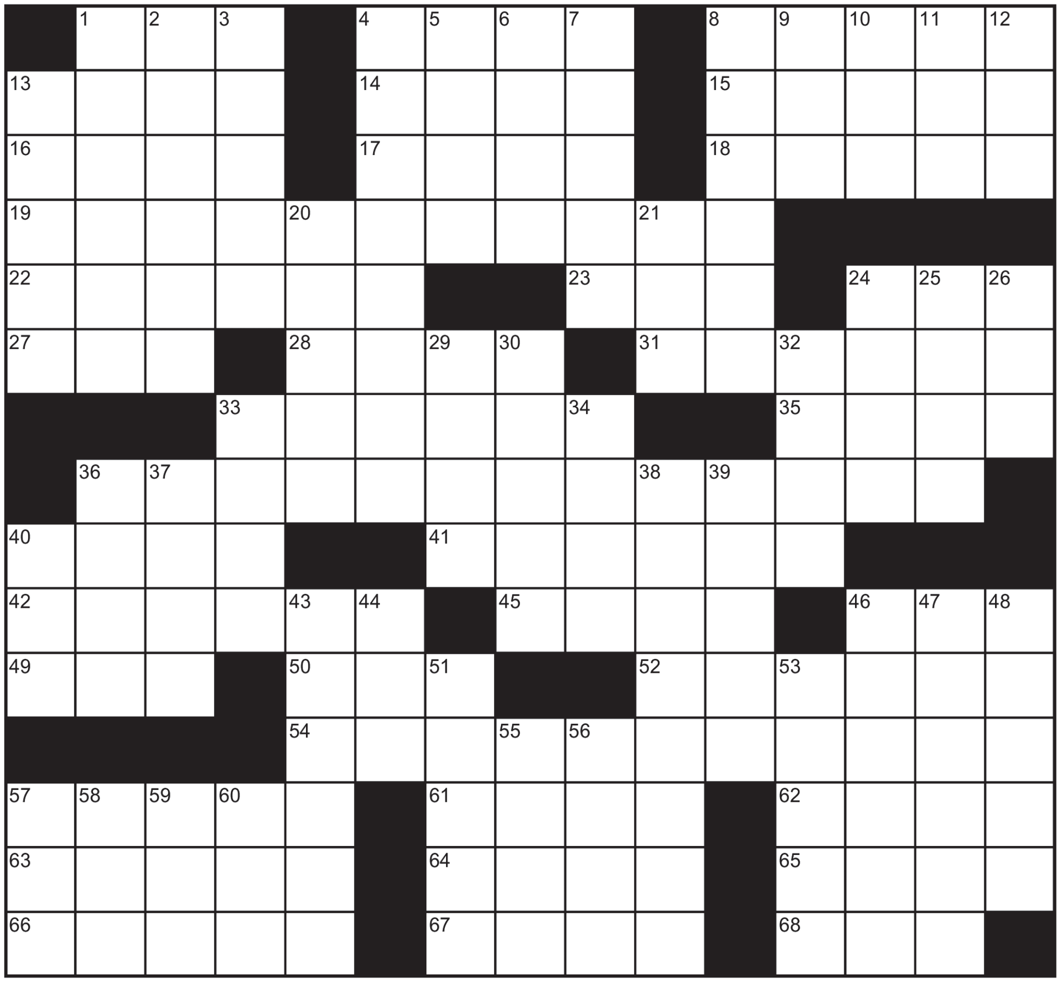
Also many other astronomy books and Web sites over the years.

Solar Eclipses Crossword

by Naomi Pasachoff



ACROSS

1. Opposite of nord, in Nantes
4. Old MacDonald's property
8. Strike a _____
13. Completed
14. Region
15. What one would like right after totality
16. Manchester United defender Patrice
17. Polaroid photography inventor
18. An observer in the _____ experiences a total solar eclipse
19. Solar eclipse phenomenon
22. "______ through the tulips"
23. Go to the ___ (fight hard)
24. Bikini top
27. Stellar explosions (abbr.)
28. Shoshonean tribespeople
31. Annular/total eclipse
33. Prime Minister after Churchill
35. Voided plays
36. Device for observing partial phases
40. Source of wisdom
41. Compressed-air-powered prototype vehicle
42. Part of eclipse when first contact occurs
45. ____ the corner
46. Flying mammal
49. Sky & Telescope supports ___-am collaboration
50. What one does after a clouded-out eclipse
52. Like 8, 23, and 45 across
54. Part of Sun visible to the naked eye only during totality
57. Wife of Nobel Prize physicist Enrico Fermi
61. Midnight snack at a telescope
62. Asteroid type
63. Part of VLA
64. Orion nebula observers note its greenish ____
65. New Jersey basketball team
66. Eclipse phenomenon shadow _____
67. College Board exams
68. Science Friday host Flatow

DOWN

1. Carly Simon's "You're __ ____" refers to 1972 Nova Scotia eclipse
2. Immature
3. Distributed the cards
4. Frankie Valli or Eddie Kendricks, *e.g.*
5. Tidal river Shatt-al-____
6. Astronomers Ong or Walterbos
7. First word of famous palindrome
8. Like a good bread roll
9. Something to raise
10. Celestial sphere
11. Play about robots' revolt
12. Watson and Crick discovered its structure
13. "Forgive us our _____"
20. Between childhood and adulthood
21. Morse Code syllable
24. Uncle Remus characters Fox or Rabbit
25. New Mexico State University astronomer Beebe
26. Don Draper products
29. "First Lady of Song" Fitzgerald
30. "Now you ___ __, now you don't"
32. Drew sap from a tree
33. Formicary inhabitants
34. Bridal color
36. Serve milk or juice
37. Sondheim's ____ the Woods
38. Fragile relatives of prunes
39. Original "shockumentary" _____ Cane
40. Coxcomb or dandy
43. Non-multiple-choice questions on 67 across
44. Overly
46. Postwar baby-______ generation
47. Lil Wayne album I __ ___ _ Human Being
48. Romanovs, *e.g.*
51. Things to keep off one's escutcheon
53. Persian
55. Song for Deborah Voigt
56. Jonathan Larson's magnum opus
57. With 60 down, a Lawrence Berkeley or MIT facility
58. Southern constellation
59. Large vase
60. See 57 down

The Little Prince, by Antoine de Saint-Exupéry

by Richard J. Legault
(richardjlegault@gmail.com)

> *"The little prince never let go of a question once he had asked it."*

Asked to draw you a picture of an extra-terrestrial (ET), I would disappoint on two counts. First, the visual arts and my hands have never been on very good terms. Second, and worse, I have never seen an actual ET. There would be nothing to use as a model. Nevertheless, there would be no excuse to abandon the question. The skeptics of course doubt that anyone, for sure, I mean, has ever seen an actual ET. You have to keep a grown-up attitude about these things.

The very best anyone could do with this question, would be to fall back on a method I first ran across, nearly a lifetime ago, in grade school. Antoine de Saint-Exupéry describes that method in *The Little Prince*. In his story, after several failed attempts to satisfy the Prince's request to draw him a sheep, the exasperated Aviator scribbles him a few lines and says, "This is just the crate. The sheep you want is inside." While this may seem like the fraudulent trick of a charlatan, as far as the story goes, the Prince is as satisfied and delighted as I was.

I think Saint-Exupéry's little prince may be the very first ET I ever encountered. However, to be precise, it would be a toss-up between him and Kal-el, better known as Clark Kent or Superman. Kal-el, after all, lived at our house all those years ago in that big box of comic books under the bed. That box, however, was the personal property of an older brother, territory forbidden on pain of torture before death. Worse, that was also long before I could even read. Accordingly, I never really understood that Superman was an ET until much later.

The title character of *The Little Prince* is a nameless ET whose home is an asteroid named B-612. Scholars and critics inevitably classify the story as children's literature, in with the fairy tales and fables. As is typical of fables, the story includes animals and plants that speak just as people do. The prose is delightfully simple, styled for the reading level of someone, say, nine or ten years old.

Early in grade school, our teachers approached it precisely as a fable. Most readers probably rarely get much past the moral teaching about things good opposed to things bad. They mainly learn, following the Prince's adventures from planet to planet, that without a sense of care and duty for something other than you, life is an absurdly great waste of time. In the story, the lives of most grown-ups such as the King, the Vain Man, the Drunkard, the Businessman, and the Geographer, are lives wasted on all the things that matter least. The truly important things in life are the things that arouse the Prince's fondness and respect—the Lamplighter and his sense of duty, for instance. (Warning: plot spoiler ahead.)

The ending leaves you wondering a little bit about whether the Prince ever makes it home to take up his duties—to the Rose that, rightly or wrongly, he had chosen to tame. Alternatively, maybe she had tamed him. Neither the Prince, nor we, are ever quite sure about that. In any case, as the story ends, we find the Prince has done his best. He has made an essential move required to make the trip home—the supreme effort. He abandons his earthly body.

That was about as deep into it as we ever got. Our teachers always ended the lesson with the assurance that there were many levels of much deeper meaning in this apparently very simple story. If we were lucky enough to ever make it to university and pursue a higher education, we would find out about all that. With or without a higher education, whoever fails to return to this story in adulthood will miss out on a treasure trove of wisdom. As things happened, I did manage, just barely, to get through life on campus. Alas, my adult paths would lead me far away from the Arts. It would be almost a lifetime before *The Little Prince* came back to pay me a second visit. It is only now, after 40 years as a lamplighter of sorts and now retired from a life of public service, that I come to appreciate much more what a superb classic *The Little Prince* really is and the much deeper lessons it has to teach.

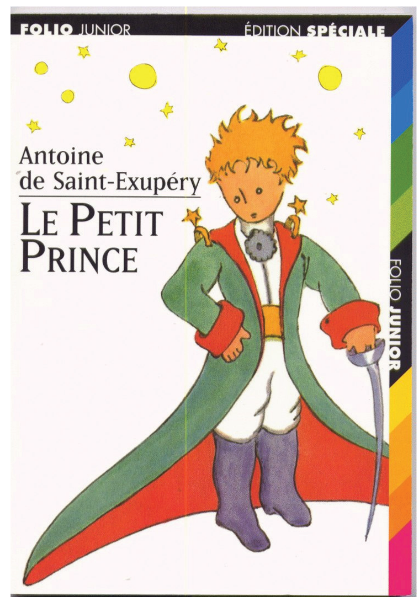


Figure 1 — The Little Prince, by Antoine de Saint-Exupéry

With so many more people now enjoying post-retirement leisure time, there is a trend for the re-kindling of interests set aside in youth but never forgotten. For those with more time to tend the garden, the fragrances from many a recently reseeded reading list will waft once more from all of those long-lost, but still-loved roses of prose and poetry, of history and philosophy, and of art and science.

What we learn in the story is that to become a serious grown-up, everyone must evolve to take responsibility at some point for the things they have tamed. To borrow a metaphor from the Darwinists, we all must leave behind the carefree comforts of a lofty canopy, come down to Earth, and adopt an upright posture to explore and eke out a living on the bland and dusty savannah. Those whose genome lacks the required mutation, like the Aviator perhaps, wind up lost in the desert. Mine, you see, was an adult lifetime of exploring the dusty plains of economics, finance, accounting, and business management—as arid a landscape as the Aviator's, to be sure.

My choice of the metaphor of evolution, from biology, is deliberate. It is only in my most recent reading that it became apparent to me how essential the fundamentals of science are to the entire narrative of *The Little Prince*. It is very easy to overlook this aspect when the approach is fabulist. Of course, it would be wrong to blame the teachers. In my own case, surely, the comic books with their superheroes and their pseudo-scientific backdrops that made up my early reading were as much to blame. In the 1960s, science and pseudo-science was not something that got much of our direct attention back then. It was simply part of the environment, in the very air we breathed. Like Marshal McLuhan's fish, we failed to discover the very water in which we swam.

A closer reading, magnified by the lens of maturity, will reveal just how deeply steeped the story is in scientific lore. For instance, in the Prince's stories of his home, his exploratory space travels and the Aviator's comments about them, you can find an astounding array of serious scientific topics.

Bird Migration: The caption in the frontispiece tells us that the narrator believes the Prince took advantage of migrating birds to make his escape from his home asteroid.

Geography: While the Prince is not impressed with the callousness of the Geographer's treatment of the ephemerality of volcanoes and flowers, it is nevertheless the Geographer's advice that initiates the Prince's visit to Earth.

Geology: The Prince's home asteroid has one dormant (or maybe extinct) and two active volcanoes. The Prince discusses the avoidance of volcanic catastrophe in terms of maintenance requirements for the slow and gradual release of sub-surface pressure to prevent violent eruptions.

Biology: The Prince discusses natural selection pressures and evolution in terms of the Rose. She has thorn mutations evolved, over generations, in response to predation. She also finds herself in competition with invasive species for habitat.

Astronomy: Sunsets and their frequency on the Prince's, the King's, and the Lamplighter's asteroids are all discussed in terms of the axial spin velocities of asteroids and planets.

Geometry and Mathematics: Saint-Exupéry illuminates his prose with delightful aquarelles executed with his own hand. Among them are visual images of the geometry of circles, cones, triangles, and one almost complete pentagram, along with the mathematical sigils of algebra, trigonometry, and differential calculus.

Scientific Bias: The International Astronomical Congress initially rejects the Turkish Astronomer's claim to have first discovered the Prince's home asteroid B-612. This is because "no one had believed him on account of the way he was dressed."

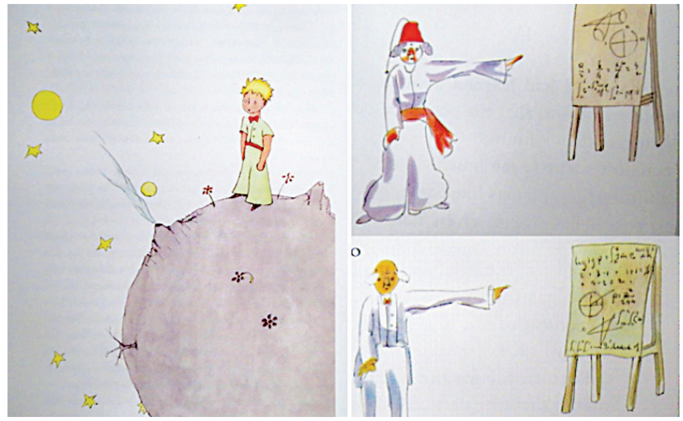


Figure 2 — Examples of the superb aquarelles, done in Saint-Exupéry's own hand, illustrating astronomy, volcanism, plant biology, geometry, mathematics, and scientific bias.

Toxicology and Pathology: To make the final voyage home, the Prince must abandon his body. He recruits the collaboration of the Snake to provide the required toxins and to inject him by means of a venomous bite.

Cognitive Science and Information Theory: The Prince finally departs Earth for home, leaving the reader to understand that the Prince somehow survives the death and abandonment of his earthly body. Evidently, this is how ETs travel, leaving the reader to wonder about how it works. This ends the story by planting the seeds of ideas such as mind-body independence, of mind as information rather than matter, and of translocation of mind as a signal. A deep frisson of insight recalls the opening metaphor of the crate—a mere repository for the imagination and the mind. Your own mind reels in appreciation of the fact that Saint Exupéry's little ET anticipates James Cameron's *Avatar* by over two-thirds of a century.

In spite of this cornucopia of seriously treated scientific elements, you will find it very difficult to see *The Little Prince* ever mentioned by reviewers and critics in the context of serious science fiction. This defies common sense and is an oversight of monumental proportions. For example, in our latest repository of popular culture, *Wikipedia*, you will find a variety of reasonably well-researched Web pages on the subject of science fiction. There are comprehensive lists of science fiction authors and books. Nowhere, at time of writing, could I find *The Little Prince* or Saint-Exupéry even mentioned on any of these pages. Evidently, the people who classify and award niches for these things have a blind spot of some kind or some sort of bias. This is especially surprising considering *The Little Prince* has a plot line primarily about ET space exploration. Moreover, the book is currently reported to have sold over 140 million copies, ranking third (after *A Tale of Two Cities* and *Lord of the Rings*) for the all-time worldwide best-selling single-volume book. The Saint Exupéry Foundation also reports it to be the world's most translated book, second only to *The Bible*. Whether these claims are exaggerated or not, the sci-fi cognoscenti can certainly not claim that people do not know the story.

Excluding it from the sci-fi category is even more surprising, considering to what degree serious scientists and engineers have drawn inspiration from the story. Evaluating its impact in these areas after 70 years of uninterrupted popularity reveals a level of influence that may surprise many.

Several real asteroids have formal names and designations that honour the story of *The Little Prince*. A main-belt asteroid discovered by Tamara M. Smirnova on 1975 November 2 is officially named 2578 Saint-Exupéry. Another is designated 46610 Bésixdouze (1993 TQ1), which is French for "Bsixtwelve." The number 46610 becomes B612 in hexadecimal notation. In 2003, a small asteroid moon was named (45) Eugenia I Petit-Prince, in part after *The Little Prince*. It is the larger, outer moon of asteroid 45 Eugenia, discovered in 1998 by astronomers at the Canada-France-Hawaii Telescope on Mauna Kea, Hawaii.

The B612 Foundation, named in honour of the little Prince's home, is a privately funded not-for-profit enterprise created to track asteroids that might pose a threat to Earth. It will fund, build, launch, and operate a deep-space mission called *Sentinel*—a space telescope to be placed in orbit around the Sun. Current reports describe the mission, estimated to cost in the order of several hundred million dollars, as being in an advanced state of preparation. The B612 Foundation has assembled a technical and scientific leadership team that is among the most experienced in the world. The preliminary spacecraft and mission designs are complete. Ball Aerospace has submitted a firm, fixed-price proposal to B612 for the telescope. This company's team of players previously built the *Kepler Space Telescope*, *Spitzer Space Telescope*, *Deep Impact* mission, and *Hubble Space Telescope* instrumentation. The B612 Foundation also signed a *Space Act* agreement with NASA in June 2012, under which NASA will provide communications, tracking, and technical support for the *Sentinel* mission. The NASA Advisory Council and the National Research Council, in their report on asteroid hazards, have both formally endorsed *Sentinel*'s mission strategy.

Let us pose a question and not let go of it. What is the qualifying criterion for classification as serious scientific literature, if it is not a requirement to inspire serious scientific thought and to change people's lives? I know what my answer would look like. I could even draw you a picture. Luckily, I don't have to. Saint Exupéry has already done it—superbly.

Oh, and if you happen to be one of those who make it their duty to tend the street-lamps of on-line encyclopedias, you may want to trim your wikis accordingly. ✶

The Little Prince in French is available in a new printing based on the original edition, from Gallimard Edition Jeunesse ISBN 2-07-051578-8. A fine new English translation by Richard Howard is also available from Harcourt ISBN 0-15-202398-4. Both are complete with all of Saint Exupéry's original aquarelles.

Richard J Legault is retired and not quite grown up in Ottawa, where he knows many who might benefit from a trip to planet Earth.

ISON—It Is Alive!

by Dave McCarter

To be, Or not to be, That is the question.

I have thee not, and yet I see thee still.
Art thou not, fatal vision, sensible to feeling
as to sight?
Or art thou but a comet of the mind, a false creation,
proceeding from this star light starv'ed brain?

I see thee yet, in form as palpable as any in my 'scope.
Thou marshall'st me the way that I was going;
And such an instrument I was to use.

Mine eyes are made the fools o' the other senses,
Or else worth all the rest; I see thee still,
And on thy orbit form clouds of light,
Which was not so before. There's no such thing:
It is the bloody business which informs
Thus to mine eyes.

(Apologies to Will) ✶

ISON speeds toward the Sun in this November 16 photo. Image: J. Anderson, 23×1 minute, ISO 1600, Canon 60Da on a 65-mm f/6.5 refractor.

The Dunlap Institute's 2013 Summer School

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

Modern-day astronomy and the design of cutting-edge instrumentation have much in common for scientists working in the field of astronomical research. The two areas—astronomy and instrumentation design—have evolved a symbiotic partnership over the years, as scientists continue looking deeper into space and father back in time, searching for new knowledge of the Universe.

So, it does not come as a surprise that both an appreciation and understanding of this symbiotic relationship are a professional "must," for aspiring scientists, say educators and practitioners of professional astronomy.

Forty senior undergraduate and graduate students from Canada, the United States, Europe, and Australia experienced an opportunity in August 2013 to learn about the importance of instrumentation design in the field of astronomy during a five-day Summer School at the University Toronto (U of T). Organized and sponsored by the Dunlap Institute of Astronomy and Astrophysics, the workshop was entitled *Introduction to Astronomical Instrumentation – Tools and Techniques for Pioneering Astronomers*. It was the second one held to date, following an inaugural one in the summer of 2012.

The Summer School featured both lecture and interactive laboratory activities. The overall learning objectives were specifically focused on giving participants an understanding of instrumentation for current and future telescope facilities. These objectives included:

- Basic principles of astronomical instrumentation;
- How telescopes work;
- How long- and short-wavelength detectors work;
- How high-precision spectrographs work;
- Hands-on experience with Fourier Transform Spectrometers; and
- Hands-on laboratory activities working directly with optics and mechanical equipment.

Supporting lecture topics provided up-to-date information on such questions as:

- What are the latest and upcoming innovative instruments and telescopes?

Figure 1 — James Graham of University Of California, Berkeley, makes an instrument adjustment during his introduction to a spectrometer lab while students look on.

- How are we discovering extra-solar planets?
- How do we discover and weigh supermassive black holes?
- How and what do we see at the edge of the observable Universe?
- How do we measure the growth of structure in the Universe?
- How will future instruments discover the first stars and galaxies?
- How will new millimetre-wave telescopes reveal shrouded sites of star formation?
- How and why do we use adaptive optics on ground-based telescopes?

The Dunlap Institute recruited professional astronomers to work with lab instructors and lecturers, many of whom were

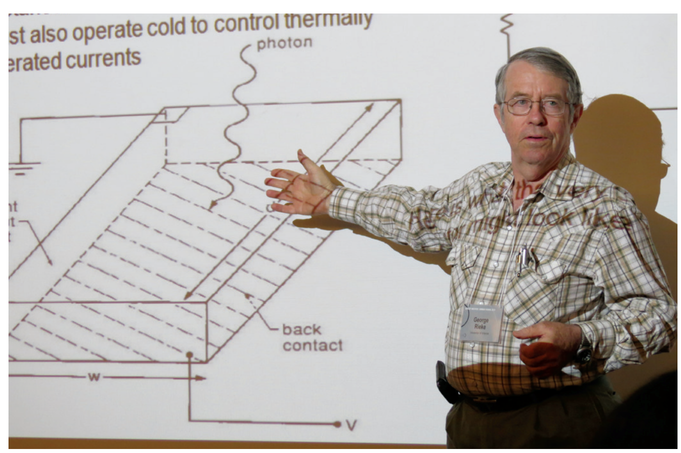


Figure 2 — George Rieke of the University of Arizona explains an optical concept during his lecture and discussion on the properties and detection of light.

known as advanced thinkers, cutting-edge researchers, and specialists in the development of astronomical instruments. The institute supplemented the teaching complement with its own Dunlap Institute lecturers, while inviting the guest scientists to address current developments, issues, and to share their passion for astronomical research. These included:

Matt Dobbs—McGill University: Dobbs has built experiments that use the Cosmic Microwave Background as a tool to probe the early Universe; he continues to construct and perform measurements with cutting-edge instrumentation.

Debra Fischer—Yale University: Fischer discovered the first known multi-planet system in 1999 and led an international consortium from 2003 to 2008 that detected more than 50 new exoplanets; she serves as Principal Investigator for CHIRON—a new high-resolution, fibre-fed spectrometer mounted on the 1.5-metre telescope at Cerro Tololo Inter-America Observatory (CTIO); Fischer is developing next-generation exoplanet detection instrumentation.

James Graham—University of California, Berkeley: Graham is the former director of the Dunlap Institute; he acts as Project Scientist for the Gemini Observatory's Gemini Planet Imager, a new adaptive-optics system to image planets orbiting nearby stars.

Olivier Guyon—University of Arizona and the Subaru National Observatory: Guyon is developing adaptive optics and coronography techniques for imaging exoplanets; he is also working closely with NASA to develop technologies for future exoplanet imaging missions.

Jamie Lloyd—Cornell University: Lloyd has expertise in infrared detectors and instrumentation, adaptive optics, interferometry, coronography, and high-contrast imaging, wavefront sensing, and precision radial-velocity measurements. He currently serves as Principal Investigator on Cornell's UNP-4 and UNP-6 nano-satellites, *CUSat* and *Violet*.

David Naylor—University of Lethbridge: Naylor established an internationally recognized research program in experimental astrophysics that specializes in the design and use of infrared and submillimetre Fourier-transform spectrometers and radiometers for astronomical applications. He is currently involved in the ESA's *Herschel/SPIRE* mission and the SCUBA-2 project, as well championing a Canadian role in the JAXA/ESA *SPICA* mission.

George Rieke—University of Arizona: Rieke's research focuses on infrared astronomy, ranging from the study of the impacts of Comet Shoemaker-Levy into Jupiter to galaxies at a redshift of 7. He was the Principal Investigator of the Multiband Imaging Photometer for the *Spitzer Space Observatory* and is science lead for the Mid-Infrared Instrument for the *James Webb Space Telescope* (JWST), which has a planned launch date in 2018.

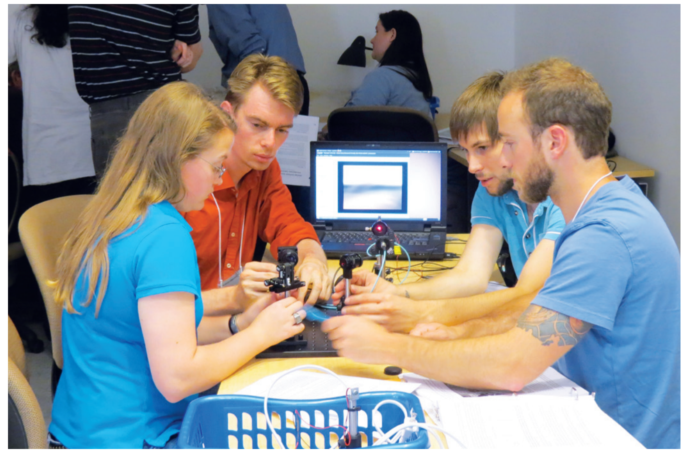


Figure 3 — Students conduct a hands-on optical exercise during a lab session.

David Wilner—Harvard-Smithsonian Centre for Astrophysics, Harvard University: Wilner's main research interests are circumstellar disks, the formation of planets, and the development of aperture-synthesis techniques. He makes use of the Submillimetre Array near the summit of Mauna Kea, Hawaii, in his research work.

The *Journal* asked two of the invited scientists to share, from their perspective, the importance of their own participation as Summer School guest lecturers.

"There are few opportunities for students to learn that designing and developing new astronomical instrumentation is a viable research path in astronomy," said James Graham of the University of California, Berkeley. "Indeed, a fundamental physics-based understanding of how our instruments work is necessary for any astronomer wishing to exploit existing facilities to their fullest," he noted.

On the other hand, Olivier Guyon of the University of Arizona and the Subaru National Observatory, recalled his days as a university student. "The summer school content is exactly what I valued as a student with a strong interest in astronomical instrumentation: a mix of lectures and laboratory activities with plenty of interaction between students and with lecturers," said Guyon. "Participating in the summer school is, therefore, very important for me."

And what are some of the future pressures or challenges that the new generation of astronomers expect to face when studying the universe once they graduate?

"Astronomy is immensely competitive—even more so in an era of reduced funding (fewer projects, fewer opportunities)," said Graham. "It's necessary to acquire a broad portfolio of skills (especially analytic and quantitative skills) as a graduate student."

Figure 4 — Peter Hiscocks (front, left), a member of RASC, relives his student days while working on an optical design lab with a fellow student at the Dunlap Institute's 2013 Summer School.

Figure 5 — David Naylor (standing) of the University of Lethbridge conducts a wave-front sensor lab with students at the 2013 Summer School.

Guyon underscored that astronomy relies heavily on new technologies and instruments, which are getting quite complex. "The link between astronomy and technology is critical: scientists need to have a very good instrumentation background to be able to come up with concepts for new instruments that can answer big-science questions, and they need to understand very well the instruments they use to extract and recognize the faint signals they are looking for," he noted.

"Maintaining a sharp knowledge and skills in both observational/theoretical astronomy and astronomical instrumentation is very challenging but ultimately essential to astronomy's success," added Guyon.

One of the "students" attending the 2013 Summer School was Peter Hiscocks, Emeritus Professor, Electrical and Computer Engineering, Ryerson Polytechnical University and a long-time member of the RASC (currently 1st Vice-President of the Toronto Centre). Although outside the norm of the student body at the Summer School—his university student days are long past—Hiscocks noted that what he enjoyed most about the school were the "excellent lectures on state-of-the art science goals and instrumentation."

"It was nice to get up-to-date on this stuff, for example, the transition-edge sensor, which I didn't know about. I didn't know it was possible to measure the velocity of a dust disk around a star. Some of the information that was presented was really cutting edge and pre-publication," he said. "The informal conversations in the hallway and over lunch were pretty interesting. The lab was challenging, but I learned something about optical design from the exercises and the session on computer-based optical design."

And why did Hiscocks decide to participate at his stage in life?

"I actually considered a career in astronomical instrumentation after graduating from engineering. I was told at the time that you had to be an astrophysics graduate to do useful work in the field. So I did other stuff for 30 years. Interestingly, apparently many of the students in the class were in engineering or had at least some engineering background. So I guess things have changed." From Hiscocks' perspective, the Dunlap Institute "gets a lot of credit for taking the long view, that these students will be the people to design the next generation of instruments. That was said by several people and, I think, it's the main reason that some of the instructors were there."

Hiscocks added that all this "ties in with the notion that you don't buy these instruments off the shelf, you have to design them to accomplish the science goals." *

Andrew I. Oakes is a contributing editor of the Journal. *He attended the Dunlap Institute's Summer School 2013 as an observer representing the* Journal.

Rainbow Modification by a Partial Solar Eclipse

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Astronomers sometimes curse the first few miles of our atmosphere. However, its rain, clouds, mists, dust and temperature inversions produce a whole host of visual optical effects.
–Les Cowley

Abstract

Rainbows photographed shortly before and during the pre-totality partial phase of the 2013 November 3 solar eclipse are compared. An appreciable decrease in the sagittal width and enhanced spectral resolution were evident in the primary rainbow as a consequence of the Moon partially occulting the solar disk.

Introduction

The rainbow is the most famous atmospheric optical phenomenon. Rainbows usually involve sunlight, and sometimes moonlight, interacting with raindrops. Rainbows have attracted the attention of natural philosophers over the centuries, including Aristotle, Descartes, and Newton (Bishop 1981). Detailed accounts of the history and nature of the rainbow are available (Minnaert 1940, Greenler 1980, Boyer 1987, Lee and Fraser 2001). A concise description of the physics of the rainbow appears in the *Observer's Handbook* (Bishop 2013). See also: www.atoptics.co.uk and www.philiplaven.com/index1.html.

One of us (Dyer) viewed the 2013 November 3 hybrid (annular/total) solar eclipse from within the path of totality. Dyer was on the four-masted barquentine *Star Flyer* in the Atlantic Ocean near latitude 17°N, longitude 37°W, approximately halfway between Africa and Barbados. See: http://eclipse.gsfc.nasa.gov/SEatlas/SEatlas3/SEatlas2001.GIF. At that position, the brief (44 s), total phase of the eclipse occurred at 11:30 UTC (08:30 standard time in the ship's time zone, or 09:18 sundial time).

On the day of the eclipse, Dyer photographed a rainbow at 09:27 UTC, 46 minutes before the partial phase of the eclipse began (Figure 1). He photographed another rainbow at 11:11 UTC, at which time the Moon was occulting about three-quarters of the Sun's diameter (Figures 2 and 3).

Discussion

The rainbow is often cited as the paragon of a white-light spectrum. However, five factors make the rainbow spectrum inferior to that produced by a laboratory spectroscope.

1) The minimum property of the stationary angle that produces a rainbow spreads the light of each wavelength over larger angles, resulting in some overlap of the spectral colours.

2) The Sun is not a point source of light. The 0.5° angular spread of its rays impinging on a raindrop smears the rainbow spectrum.

3) Sunlight reflected from the front of the raindrops, and skylight from behind, dilutes the colours, making them less saturated.

4) The increase in the minimum angle of deviation associated with aerodynamic drop distortion (significant for drop diameters of 0.5 mm and larger) causes additional spectral smearing in the upper part of a rainbow.

5) Diffraction broadening results in further overlap of the spectral colours, particularly for small raindrops.

A partial solar eclipse reduces the second of the five negative factors, cited above, that affect the rainbow spectrum. The extent of that improvement varies along the arc of a rainbow because of the crescent shape of the partially occulted Sun. Figure 3, from the planetarium program *Starry Night*, shows the solar crescent and its orientation relative to the horizon at the time of the photograph in Figure 2. The 10° clockwise tilt of the solar crescent resulted in the portion of the rainbow 10° *counter*clockwise from the top of its arc being least affected by the angular spread of the Sun's rays. The eclipse magnitude (the part of the solar diameter obscured by the Moon) was 0.75, corresponding to an obscuration (the part of the solar surface area obscured) of about 70 percent, and a decrease in the Sun's illuminance to about 27 percent of its unobscured value (Können and Hinz 2008).

The colour perceived in a photograph is influenced by many things: the design of a camera's CMOS sensor chip; camera electronics; the spectra of the LEDs in a display monitor; printing technology and dyes; and human physiology. Fortunately, the photographs in Figures 1 and 2 were taken with the same camera, on the same morning, from almost the same location, and with the same lens, f-stop, ISO setting, exposure bias, and white balance. Hence any difference in the rainbows recorded in the two photographs likely is due mainly to the eclipse-induced, different angular spreads of the sunlight striking the raindrops.

An obvious difference in Figures 1 and 2 is that the rainbow in Figure 2 is lower, closer to the sea. That is merely because the Sun's altitude had increased from 13° to 34° during the 104-minute interval between the two photographs. A primary rainbow lies at an angle of about 42° from the anti-solar point. Thus the top of rainbow was 42°– 13° = 29° above the horizon in Figure 1, and 42°–34° = 8° above the horizon in Figure 2.

Figure 4a (top) compares a short segment of the brightest portion of the rainbow in Figure 1 (near its left-hand end) with a segment of the rainbow in Figure 2 taken 10° counter-clockwise from its top, where the solar crescent provided the least spread in the light rays in a plane perpendicular to the rainbow, the *sagittal* direction. Both segments have similar backgrounds (a dark cloud), and have been adjusted in size to correct for the differing focal lengths of the camera zoom lens (10 mm and 18 mm for Figures 1 and 2, respectively). Also, the two segments have been rotated into a horizontal position and adjusted vertically, so that the middle (yellow) portion of the two spectra align. Figure 4b is similar, but with a gamma adjustment to enhance the colours. The narrower width and better spectral resolution of the eclipse rainbow are obvious.

In Figures 4a and b, a dark *Mach Band* likely appears adjacent to the top edge of each rainbow segment. See: http://en.wikipedia.org/wiki/Mach_bands. Also, the right-hand rainbow segment has a more-pronounced, light-grey band immediately beneath the dark blue. That light-grey band is probably a faint supernumerary bow, although the Mach Band physiological phenomenon likely is enhancing it.

Just before totality, the solar crescent still spans about 180 degrees of the solar limb, for a minimum effective angular width of not much less than 0.2°. Thus the width and spectral resolution of a rainbow at such times would not be appreciably different from those features shown in Figure 2 and in the right-hand portion of Figures 4a and b, albeit dimmer. A point-like light source would yield the best-defined rainbow. On his Web site www.atoptics.co.uk/fz28.htm, Les Cowley shows a simulated rainbow such as might be "lit by a distant point source of light, perhaps the diamond ring of a solar eclipse or a nearby supernova explosion."

We are not aware of any other photograph of a rainbow taken during the partial phase of a solar eclipse. A photograph of a "rainbow during total solar eclipse" appears on the Web site www.panoramio.com/photo/19252524, but the lighting indicates that it is mislabelled. Another Web site shows a "Rainbow over Easter Island before the [2010 July 11] eclipse," but there is no indication that it was taken during the partial phase. Können and Hinz (2008) address the visibility of rainbows during solar eclipses, but not the structure of rainbows.

Although not related to the eclipse, another feature of the rainbow in Figure 1 is worthy of note. Its two "ends" are different. The right-hand side is as bright above the horizon as it is for some distance below the horizon. The brightness of the left-hand side is not only greater than that of the right-hand side, but it decreases dramatically only a short distance below the horizon. The rain contributing to the right side of the rainbow must have been near the ship, whereas most of the rain contributing to the left side was much further away, and contained more raindrops. See Bishop (2013) for an explanation of the non-intuitive geometry of a rainbow. A rainbow is not what it seems.

Summary

Compared to the "normal" rainbow, the rainbow that occurred during the partial solar eclipse displayed better resolution of the spectral colours, and its width in the sagittal direction defined by the solar crescent was narrower. Both features are consistent with the change in the solar disk caused by the Moon. ✶

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Figure 1 (top) — Rainbow 46 minutes prior to the solar eclipse of 2013 November 3 (Alan Dyer photo)

Figure 2 (right) — Rainbow 104 minutes after the rainbow in Figure 1 and 58 minutes into the partial phase of the solar eclipse with the Moon covering 75 percent of the solar diameter (Alan Dyer photo)

Figure 3 — The solar crescent at the time of the photo in Figure 2 (Starry Night simulation)

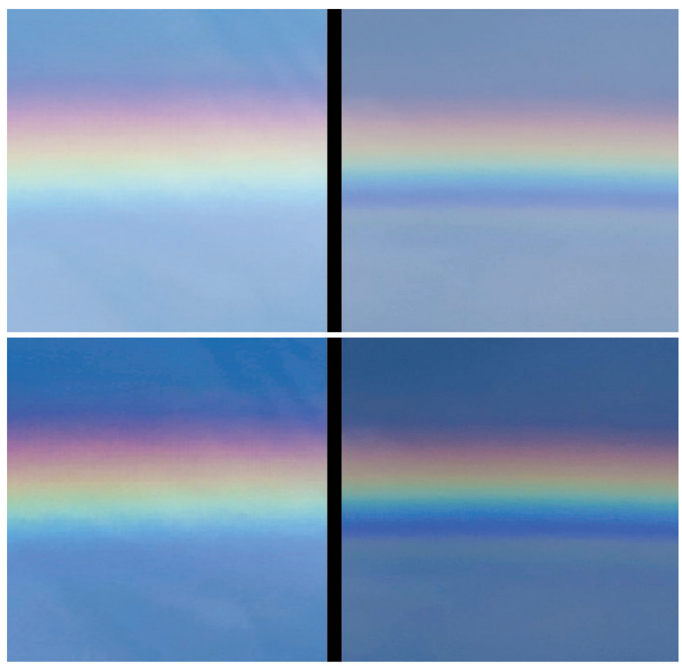

Figure 4 — Top (a): On the left, a segment of the rainbow in Figure 1. On the right, a segment of the rainbow in Figure 2. Bottom (b): a colour-enhanced version of the top images.

Figure 1 — The Saskatoon Centre's Tenho Tuomi caught Comet C/2013 R1 Lovejoy last November 30 as it was gradually brightening toward its early December maximum. While overshadowed by expectations for Comet ISON, Lovejoy put on a far more impressive show. Tenho assembled this image from 11 2-minute exposures using a Canon T5i camera on a SkyWatcher 80 mm ƒ/5 refractor.

Figure 2 — Michael Watson used a Nikkor 80-400-mm lens mounted on a Nikon D800 camera body at 400 mm, ƒ/4.5, and ISO 1600 to photograph the Double Cluster in Perseus, one of the most appealing objects in the northern sky and a favourite target at star parties. The image is a stack of 3 frames, each 2 minutes in length.

Figure 3 — Venus and the crescent Moon put on a two-day dance last December when the planet was at its maximum magnitude. Dave Chapman used a new Canon Digital Rebel SL1 zoomed to 115 mm to take this handheld image, capturing the two objects as they set in the west. Exposure was 1/40 s at ISO 800 and ƒ/4.5.

Pen & Pixel

Figure 4 — Charles Banville provides us with this image of the open cluster NGC 6939 and galaxy NGC 6946 in Cepheus, acquired during a photographic expedition to the Dominion Astrophysical Observatory outside Victoria, B.C., last June. The cluster is at a distance of 4000 light-years; the galaxy's light reaches us from 10 million ly distance. Charles used a Canon EOS 5D Mark III on a Tele Vue NP-127 refractor at ƒ/5.2; exposure was 12×300 s at ISO 800.

Figure 5 — Sheila Wiwchar of the Winnipeg Centre braves even the −40 °C weather for a good sky shot. In her words, "After hearing 'aurora alert,' I headed to Beaudry Park to check it out. I think I missed the initial flare up of spikes and such but did take in a couple hours of slow dancing on a clear winter's night. It was difficult to find a comfortable, good composition spot as I ran to the car many a time to defrost."

An Astronomer's View of Climate Change

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Abstract

This paper describes some of the astronomical effects that could be important for understanding the ice ages, historic climate changes and the recent global temperature increase. These include changes in the Sun's luminosity, periodic changes in the Earth's orbital parameters, the Sun's orbit around our galaxy, the variability of solar activity, and the anticorrelation of cosmic-ray flux with that activity. Finally, recent trends in solar activity and global temperatures are compared with the predictions of climate models.

1. Overview

In successive sections, this article will discuss the stability of the Sun's luminosity, how long-term changes ($\gtrsim 10^4$ yr) in the Earth's orbit around the Sun and through the Milky Way Galaxy can affect global temperatures, and how shorter-term changes ($\lesssim 10^4$ yr) in the luminosity or the solar magnetic field through the modulation of galactic cosmic rays can also be important. Later sections compare global temperature measurements with the predictions of the General Circulation Models (GCM) from the Reports of the Intergovernmental Panel on Climate Change (IPCC 2007, 2013).

2. The Stability of the Solar Luminosity

The simplest explanation of the ice ages and other climate changes is variations in the Sun's luminosity. The relevant quantity at the Earth is the solar constant or total irradiance—the integrated flux over all wavelengths outside the Earth's atmosphere at the mean distance of one astronomical unit. There has been much effort for nearly two centuries to measure the luminosity, but calibration difficulties have led to large uncertainties, and even satellite instruments recording the whole spectrum since 1978 have had their inconsistencies. With the NASA *Solar Radiation and Climate Experiment* (SORCE), Kopp and Lean (2011) found the value to be 1360.8 ± 0.5 Wm^{-2} during the 2008 solar minimum and similar values for the previous two minima, slightly less than the 1365.4 ± 1.3 Wm^{-2} adopted by most climate models. Note that the models actually use 1365.4/4 = 341.35 Wm^{-2}, which is the flux per unit surface area of a spherical Earth.

The new calibration is not expected to have a significant effect on the climate simulations. The mean peak-to-peak change in total irradiance over three solar cycles since 1978 is about 0.12 percent with occasional extremes up to 0.34 percent that could be partially compensated by unseen parts of the Sun. The associated change in global temperature during a cycle is approximately 0.1 °C, so the 0.5 °C warming during the past 35 years cannot be due to an increase in the irradiance.

Were larger variations possible in earlier times? The Sun is a spherical ball of gas in hydrostatic equilibrium with a central temperature of 1.6×10^7 K, hot enough for nuclear energy generation by converting hydrogen into helium. During an evolutionary time of 8×10^9 yr on the main sequence, the models of Bahcall *et al.* (2001) show that the luminosity of the Sun will increase gradually by about a factor of two. The lower luminosity in earlier years implies an Earth temperature below the freezing point of water more than 2×10^9 yr ago, while geological evidence suggests that liquid water has been present for the past 4×10^9 yr. Extra water vapour or CO_2 to trap the heat seems insufficient, so Sackmann & Boothroyd (2003) considered a Sun starting at 1.07 solar masses. Their model produces acceptable temperatures but requires a wind with a thousand times more flux than now to dissipate the extra mass.

On shorter time scales, there is the added complexity of the Sun's magnetic field and the internal mass motions of a dynamo to generate that field as well as turbulence and a convective outer envelope that carries the energy to the surface. Li *et al.* (2003) included these effects in simple models of the solar interior and found the luminosity could vary by the observed 0.1 percent. Much larger fluctuations seem unlikely, but further analysis with more realistic models is needed for a clearer answer. Meanwhile, it is instructive to examine other contributors to the Earth's climate.

3. Long-term Astronomical Effects $\gtrsim 10^4$ Years

The Serbian scientist Milankovitch (1941, 1969) investigated the slow variations in the parameters of the Earth's orbit around the Sun as the cause of the ice ages. The semi-major axis and the length of the year are very stable, but changes in other elements due to perturbations by the Moon and planets affect the insolation and its seasonal and geographical distribution. The direction of the Earth's pole precesses with a period of 26 kyr (1000 × year), while the orbital axis precesses over 112 kyr in the opposite direction for a combined period of about 22 kyr. The obliquity of the ecliptic oscillates over 41 kyr, and the orbital eccentricity has periods of about 100 and 413 kyr. Since the ^{18}O isotope is enhanced in ocean sediments and shells during colder intervals, it is a useful temperature proxy. When the first three Milankovitch periods were found in seabed cores, there was general acceptance that this orbital forcing could explain the ice ages. However, as seen from Figure 1, there was an unexpected change in the dominant period from 100 kyr to 40 kyr about 800 kyr ago and the 22-kyr signal is less significant, even though the precession term was expected to be the strongest. Furthermore Wunsch (2004) concluded that the Milankovitch terms could explain at most 20 percent of the observed temperature changes.

Alternative explanations have considered the Sun's orbit around our galaxy and where supernovae would be most frequent, because the associated cosmic rays could seed clouds that reflect more sunlight. Shaviv & Veizer (2003) estimated

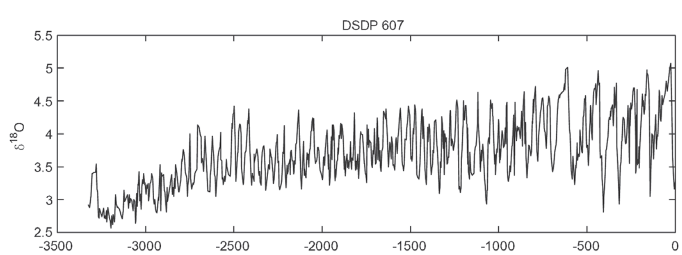

Figure 1 — Plot from Wunsch (2004) of the ^{18}O temperature proxy for the past 3.3 Ma from a subpolar North Atlantic seabed core. Increasing ^{18}O implies colder temperatures. The dominant periods are about 100 kyr during the past 800 kyr and 40 kyr for earlier times rather than the expected 22 kyr from the basic Milankovitch theory.

the times when the Sun passed through spiral arms, while Svensmark (2012) looked at close approaches to young clusters. Both studies found coincidences of the strongest cosmic-ray fluxes with colder temperatures indicated by ^{18}O enhancement, but significant differences in the two results prevent definite conclusions. These interesting ideas deserve further investigation as our knowledge of galactic structure improves.

4. Short-term Astronomical Effects ≲10^4 Years: Radiation and Sunspots

Again in consideration of orbital effects, there is the 2400-year period of the oscillation of the Sun about the barycentre (centre of mass) of the Solar System due to planetary perturbations. Since the barycentre usually is within two solar radii, the fractional variation in insolation is about ±10^{-4} or only 1/10 the mean variation over the solar cycle.

As the Sun rotates with an average period of about 27 days, various active regions come into view from the Earth. The total irradiance can vary by ± 0.34 percent and the ultraviolet (UV) and X-radiation as well as the solar wind and its perturbations of the Earth's magnetosphere can change by larger amounts in a random way. Thus the rotation can add brief spikes to the measurements of these indices.

The principal short-term effect is the ~11 year sunspot cycle discovered by the amateur astronomer Heinrich Schwabe in 1843. Actually, it is a ~22 year period because the new spots appearing at the maximum of a cycle reverse their magnetic polarity each ~11 years. At the peak of solar activity, the 0.1-percent reduction in solar irradiance by the dark spots is more than compensated by 0.2-percent increase from bright faculae or other regions of the solar surface.

In an important paper reviewing the history of sunspot observations, Eddy (1976) described how Rudolf Wolf began a systematic counting soon after Schwabe's discovery and estimated the numbers back to 1700 by searching old records. Later, Gustav Spörer and Edward Maunder extended these historical investigations, demonstrating a real absence of spots and aurorae from about 1645 to 1715. During some decades in this interval, spots were so infrequent that an astronomer could write a paper if he saw one. Galileo and others with early telescopes first reported spots in 1610. Forty years later, they might have missed them altogether. Figure 2 plots the sunspot numbers since 1610 showing what Eddy called the Maunder Minimum and a later one from about 1800 to 1820 now known as the Dalton Minimum.

The Maunder and Dalton minima are especially interesting, because they occurred when global temperatures were unusually cold. During the Little Ice Age from about 1430 to 1850, glaciers advanced in the European Alps, while canals in Holland and the Thames River in London froze during

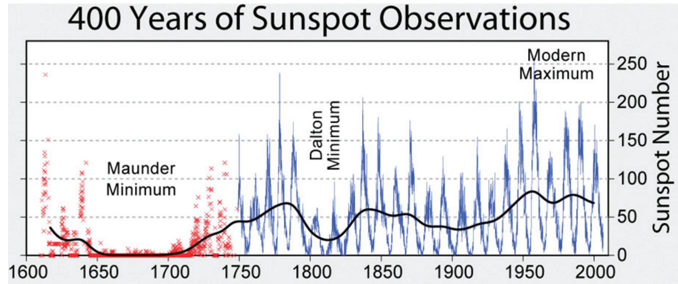

Figure 2 — This plot from the U.S. National Oceanic and Atmospheric Agency shows sunspot numbers since their first observation with telescopes in 1610. Systematic counting began soon after the discovery of the ~11 year cycle in 1843. Later searching of old records provided the earlier numbers.

some winters. Grove (2001) concluded from the radiocarbon dating of trees felled by advancing ice around the world that the Little Ice Age was a global phenomenon and began in the 13th century in many places.

Further historical investigations have revealed earlier warm intervals now referred to as the Roman (250 BC-AD 400) and Medieval (950-1250) Maxima. The latter matches the Norse settlements in Greenland and the explorations of the east coast of North America at least as far south as L'Anse-aux-Meadows in Newfoundland and a grape-growing region called Vinland. The following colder interval must have contributed to the abandonment of these settlements. All of these dates with warm and cold designations are rather imprecise and have regional differences.

In Switzerland, there is a mountain pass at 2756 m called Schnidejoch between Lenk on the north and Sion on the south side of the Bernese Alps. It was blocked by ice and snow year round and never considered a route joining these towns until an exceptionally warm summer in 2003 opened it to hikers and then archeologists. The carbon dates on 73 artifacts found there ranged from a Neolithic 4800 BC to a Medieval AD 1000 with gaps from 4300 to 3700 BC and 1500 to 200 BC, when ice probably closed the route (Hafner 2012). Temperatures warm enough to melt the ice on Schnidejoch occurred before modern industry and transportation began adding CO_2 to our atmosphere. The present recession of glaciers in much of the world confirms we are in another warm period.

It is possible to estimate past temperatures from the growth of tree rings, corals, and ocean sediments, or from deuterium or ^{18}O isotopes in these deposits because $HD^{16}O$ and $H_2{}^{18}O$ condense faster than normal $H_2{}^{16}O$. Mann, Bradley, & Hughes (1998, 1999) used some of these proxies to derive their "hockey stick" plot of Northern Hemisphere temperatures for the past 1000 years. It indicated a gradual decrease with some fluctuations for the first 900 years and then a steep rise beginning in 1900. The absence of the Medieval Maximum and the Little Ice Age raised immediate questions. Canadians Stephen McIntyre of Toronto and Ross McKitrick of the University of Guelph (McIntyre & McKitrick 2003) demonstrated that flawed statistics were used to construct the graph. (See also Essex & McKitrick 2007). Recently Ljungqvist *et al*. (2012) and Christiansen & Ljungqvist (2012) examined a variety of Northern Hemisphere proxies for the past 2000 years. They found that the magnitude of 20th-century warming is within the range of variability over the past 12 centuries, though the present rate of warming has been exceptionally fast. Relative to the interval AD 1880 to 1960, they found a Medieval Warm Period with a peak of +0.6 °C between AD 950 and 1050 and a Little Ice Age cooler by 1.0 °C between AD 1580 and 1720.

One objective measure of solar activity is the radio flux that is Canada's contribution to solar monitoring. Beginning in 1947 in Ottawa, Arthur Covington at the National Research Council (NRC) began a systematic, calibrated measurement of the solar flux at 10.7 cm. This happened to be the band of his war-surplus radar equipment, but it has turned out to be very suitable for studying the Sun. Ken Tapping (2013), at NRC's Dominion Radio Astrophysical Observatory near Penticton, B.C., has continued this monitoring with support from the Canadian Space Agency and participation by Natural Resources Canada. Figure 3 shows the variation in this radio flux over six 11-year cycles. There is no direct effect on the Earth, but the radio emission is a good measure of the ultraviolet flux around 120 nm and it correlates well with the sunspot number, giving a consistent measure of solar variability since 1947 and providing a definite measure of activity when there are no spots. At the 2009 minimum, the monthly average 10.7-cm flux was 4 percent lower than the previous minima. Note also the extra breadth of the last minimum and the weakness of the maximum just past. The sunspot count shows a similar pattern, possibly implying that the Sun could be heading for another Dalton or even a Maunder Minimum.

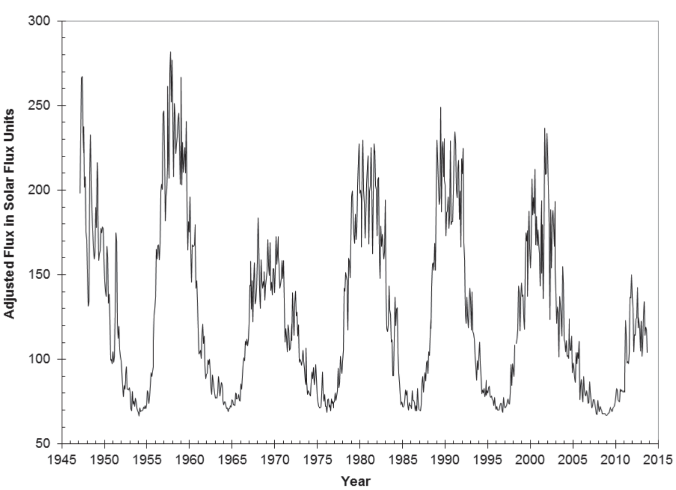

Figure 3 — Monthly averages of the 10.7-cm solar radio flux measured by the National Research Council of Canada and adjusted to the mean Earth-Sun distance. A solar flux unit = 10^4 Jansky = 10^{-22} Wm^{-2} Hz^{1}. The maximum just past is unusually weak and the preceding minimum exceptionally broad. Graph courtesy of Dr. Ken Tapping of NRC.

5. Short-term Astronomical Effects ≈10^4 years: Cosmic Rays

Protons, electrons, ionized atoms, and the attached magnetic field in the solar wind stream out from the Sun at velocities of a few hundred km/s to form the heliosphere. Beyond the orbits of Neptune and Pluto, this wind establishes a pressure balance with the interstellar medium in a region called the heliopause. Any direct effect of the wind on the Earth's climate remains uncertain, but the Sun's magnetic field, with its modulation of cosmic rays reaching the Earth, could be an important astronomical variable influencing climate. This field, which changes polarity every ~11 years and is distorted by the Earth's field and the Earth's motion through the interstellar medium, provides a variable shield against galactic cosmic rays, which can cause mutations in living cells, and and can seed nuclei for clouds. The incident protons (≈87 percent), alpha particles (≈12 percent), and heavier nuclei (≈1 percent) (Sherer *et al*. 2006) collide with atoms in our upper atmosphere to produce a large variety of secondaries including rare isotopes such as ^{2}D, ^{13}C, and ^{18}O, which can be proxies for temperature. The Sun also emits cosmic rays, but they are weaker and are partly shielded by the Earth's magnetic field.

Reaction	Half life (yr)	Product
$n + {}^{14}N \rightarrow p + {}^{14}C$	5730	^{12}C
Spallation of 14N, 160 → ^{10}Be	1.51×10^{6}	^{8}Be
Spallation of $^{40}Ar \rightarrow {}^{36}Cl$	3.08×10^{5}	^{35}Cl

Table 1 — The Cosmogenic Nuclides

Especially useful among secondaries are the radioactive nuclei ^{10}Be and ^{14}C, formed by the processes summarized in Table 1. The ^{14}C combines with atmospheric $^{16}O_2$ to form $^{14}C^{16}O_2$ that circulates for about 5 years before photosynthesis deposits it as ^{14}C in annual tree rings. The ^{10}Be isotope attaches to aerosols (any liquid or solid particle suspended in air) that precipitate after about a year. In polar regions, the snow becomes compressed in annual layers of ice. Thus we have two useful histories of the cosmic-ray flux reaching the Earth and the associated solar activity. Solanki *et al*. (2004) found from 11,400 years of ^{14}C data that the Sun has been exceptionally active over an unusually long duration from 1940 to 2000. The previous comparable activity was more than 8000 years ago.

Figure 4 from Frölich & Lean (2004) shows how these records correlate with the sunspot numbers—high flux during the Dalton Minimum and even higher during the Maunder Minimum. The ^{14}C variations are well known as the de Vries Effect in the dating of organic samples, because it is an important correction to the assumption that the flux is constant in time. The ^{14}C and ^{10}Be data also show earlier fluctuations with peaks on either side of the Medieval

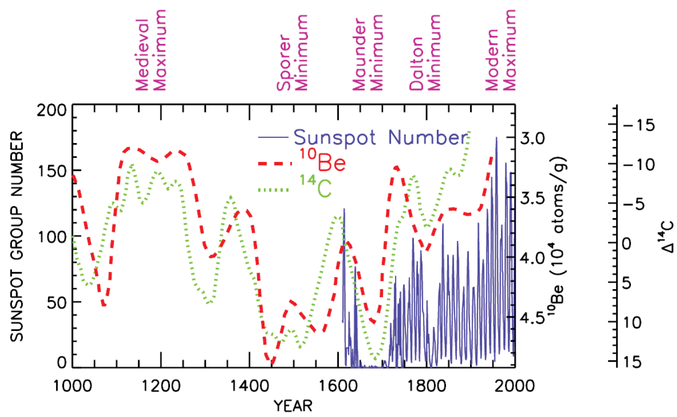

Figure 4 — The ^{10}Be and ^{14}C indices (increasing downward) show the variation in the strength of galactic cosmic rays reaching the Earth and their anticorrelation with sunspot number. The graph is reproduced from Frölich & Lean (2004).

Maximum and a broad peak from 1420 to 1570 named after Spörer. Except for an interval around 1600, the cosmic-ray flux was particularly strong from 1400 to 1700, coinciding with much of the Little Ice Age.

A remarkable correlation of ocean temperature and cosmic rays follows from the analysis of cores of layered sediments in the North Atlantic by Bond *et al*. (2001). Icebergs carrying debris from glaciers in Canada and Greenland drifted south until they melted at latitudes dependent on the water temperature, leaving signals in the sediments. Figure 5 shows the correlation of this temperature proxy with the ^{14}C and ^{10}B fluxes. Meanwhile, the concentration of atmospheric carbon dioxide changed by less than 8 percent.

How can cosmic rays affect global temperatures? Many years ago, Ney (1959) suggested that cosmic rays could provide condensation nuclei to help form clouds. This was a direct extension of the principle of the cloud chamber invented by C.T.R. Wilson, a meteorologist interested in cloud formation, to track ionizing particles. Svensmark & Calder (2007) have described the development of this idea and experiments to test it. When the solar magnetic field is weak, more cosmic rays reach the Earth. Ionization by secondary galactic cosmic rays with 10-20 GeV energies assists in the formation of aerosols of sulphuric acid and water with radii of 2-3 nm. Some of these are hypothesized to grow into cloud condensation nuclei with radii greater than 50 nm that enhance the formation of low-altitude clouds. These clouds reflect sunlight, letting the Earth cool. Laboratory tests at CERN with a pion beam support the first step of this process (Kirkby *et al*. 2011), and experiments in Copenhagen with gamma-ray and natural ionizing sources support the second step (Svensmark, Enghoff & Pedersen 2013). Research is continuing to determine whether these effects are sufficient to influence climate. During the present solar maximum the cosmic-ray fluxes at neutron monitors in Greenland and Finland have been exceptionally strong.

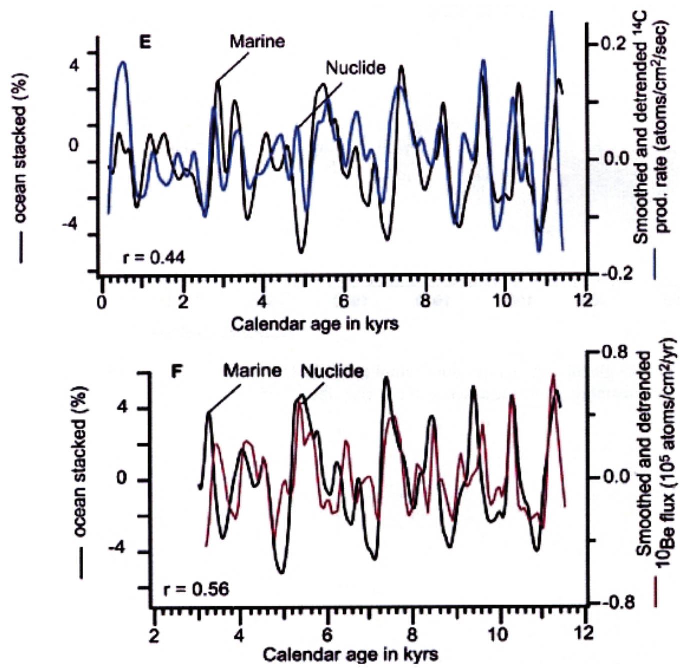

Figure 5 — Cores of layered ocean sediments indicate the latitude where ice floes melted leaving debris from northern glaciers. In this figure from Bond et al. (2001), the latitude of melting increases towards the top, so temperature increases downwards. Thus stronger cosmic-ray fluxes measured by the ^{14}C and ^{10}Be isotopes correlate with cooler North Atlantic temperatures.

Of course, it is possible that the past cold intervals resulted entirely from a reduced solar irradiance either at visible or UV wavelengths, so that a stronger flux of cosmic rays is just an indicator of an inactive Sun with lower total luminosity. However, the amplitudes of the fluctuations required for the ice ages seem greater than expected for the Sun, so alternative explanations such as the cloud-seeding hypothesis deserve further investigation.

Another possibility is a variation in the ultraviolet solar flux. From minimum to maximum in recent solar cycles, the radiation near 200 nm that produces ozone (O_3) from oxygen in the stratosphere increased by as much as 6 percent, and between 240 and 320 nm in the O_3 absorption bands, by up to 4 percent, while the total flux increased by only 0.12 percent. Gray *et al*. (2010) describe current research into mechanisms for coupling this heating into the lower atmosphere. Thus temperatures could go up and down with solar activity with minimal change in the total irradiance.

6. Current Global Temperature Trends and the Atmospheric Models

Since the recent pattern of solar activity suggests a cooler Earth, it is interesting to examine what has happened to the global temperature. Several institutions have produced graphs of changes in global annual temperatures by calculating the anomaly, the difference from a long-term mean at each location and averaging over continents, oceans, and seasons.

Canadians Christopher Essex of Western University and Ross McKitrick, already mentioned, have raised serious questions about both the physical significance of a mean temperature for a nonequilibrium Earth and the variability of the results, depending on the choice of the statistical procedures. Essex & McKitrick (2007) also discussed the inadequacies of the modelling process, but this paper will continue to refer to these temperatures and models, because they are central to the IPCC reports.

Figure 6 is one such plot of the mean temperature. The recent rise, beginning about 1977, continued until 1998 with no significant increase since. Already in 2009, the change in slope was a concern. At that time, Knight *et al.* (2009) asked the rhetorical question "Do global temperature trends over the last decade falsify climate predictions?" Their response was "Near-zero and even negative trends are common for intervals of a decade or less in the simulations, due to the model's internal climate variability. The simulations rule out (at the 95% level) zero trends for intervals of 15 yr or more, suggesting that an observed absence of warming of this duration is needed to create a discrepancy with the expected present-day warming rate."

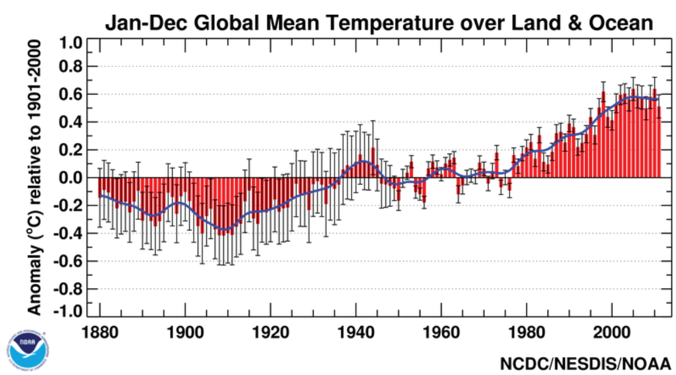

Figure 6 — Recent history of the global mean temperature anomaly compiled by the U.S. National Oceanic and Atmospheric Administration. Note the absence of any rise since 1998.

Now we have 16 years with no indication of increasing global temperature, while the atmospheric concentrations of CO_2 and other greenhouse gases shown in Figure 7 continue to rise. Figure 8 compares temperature observations with the predictions of an average of 42 models. By the 15-year criterion, the IPCC models have failed the test of predicting the temperature. Some climate scientists now are saying that 15 years is too short a time for a test, but if that is the case, the rise over 21 years also could be an aberration. The critical test of any scientific theory or model is whether it makes correct predictions; simply fitting a model to existing data does not validate it for future trends. Unfortunately, a lot of public policy is based on those unsuccessful predictions.

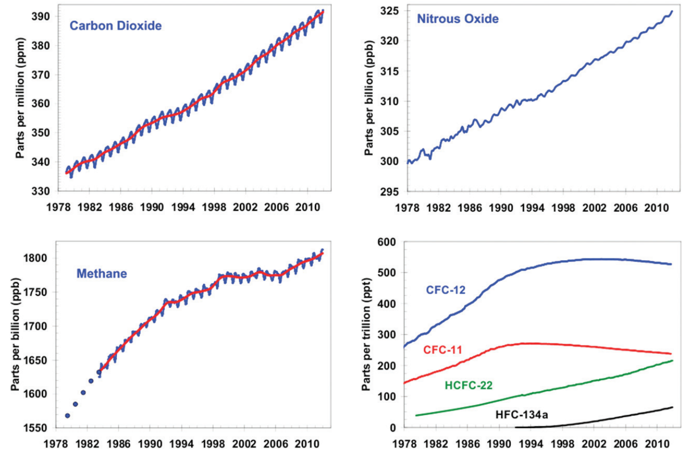

Figure 7 — Measured concentrations of the greenhouse gases CO_2, CH_4, N_2O and the four most abundant chlorofluorocarbons, all from the global air sampling network of the U.S. National Oceanic and Atmospheric Agency. Increasing uptake of CO_2 during Northern Hemisphere spring and summer produces the annual oscillations. However, the worldwide slowing of economic activity following the 2008 recession had no discernable effect.

Although other observations such as sea levels indicate continued warming, it is important to understand the surface-temperature hiatus, because environmental advocates and government policies emphasize it and have proposed a goal of limiting the rise to 2 °C. The extent of polar sea ice is less useful: the Arctic is notoriously variable; a previous major retreat occurred in the 1930s; and most of Antarctica has continued to cool.

The IPCC climate models are among the most sophisticated of all computer simulations. Nevertheless, something seems to be missing. The usual explanation of climate begins with a solar flux of 340 Wm^{-2} (on the surface-area scale noted in Section 2) incident on an Earth with no atmosphere that produces a mean temperature of -18 °C. Then, with an atmosphere, the water vapour along with small additional contributions from the so-called greenhouse gases (GHG)—carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), ozone (O_3), and chlorofluorocarbons —absorb about 240 Wm^{-2}, heating the Earth to a mean of about +15 °C and reradiating thermally in proportion to the fourth power of the temperature from near unit optical depth into the atmosphere. The remaining 100 Wm^{-2} is reflected from clouds and the surface. Such backwarming is well known to astronomers, who call it line blanketing in their calculations of stellar atmospheres (Mihalas & Morton 1965). This heating by gaseous absorption is well understood, so any explanation of the present constancy of global temperatures must include compensation for the expected continuing warming from increasing concentrations of the greenhouse gases.

Note, however, that absorption is not the cause of heating inside a glass house. Instead the air becomes hot from contact with the heated ground or plants and remains so because it

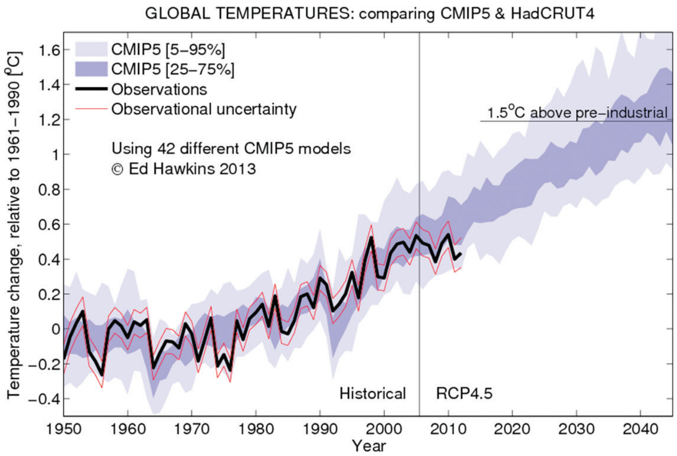

Figure 8 — Comparison of the average of 42 models from the Coupled-Model Intercomparison Project (CMIP) with the HadCRUT3 mean of global temperatures compiled by the Hadley Centre of the UK Met Office. Graph courtesy of Dr. Ed Hawkins (2013), Dept. of Meteorology, University of Reading, U.K.

does not circulate with external air that has not been heated. Greenhouse operators often increase the CO_2 concentration, because the plants will grow better with extra food!

Since the Industrial Revolution, global temperatures have been rising along with increased concentrations of CO_2 and the other greenhouse gases. Although coincident behaviour is not proof of a physical connection, the IPCC models made the plausible assumption that CO_2 has been the primary cause of the warming. Reflections by clouds and other aerosols approximately cancelled the effects of the other gases. However, the backwarming by CO_2 produced only about half the temperature rise, so the models needed to include amplification by a positive feedback caused by hotter air holding more water vapour, which absorbs more radiation. The computer simulations approximated this feedback and many other effects through adjustable parameters to match the observed temperature rise and produce a range of future scenarios. Essentially the feedback has been calibrated by the past rise in temperature; if it is no longer rising, the effect of more CO_2 will be less serious.

7. The 2013 Report to the IPCC

The latest report IPCC (2013), which was released on 2013 September 28 after the completion of this paper, changes little. The writers recognize the 15-year absence of warming and speculate it is part of natural variability in climate and is biased by a warm El-Niño event in 1998. (Until this explanation was required, the 1998 peak was just another example of warming by CO_2.) The report also suggests the deviation from the simulations could be due to heat being absorbed in the oceans or that some models overestimate the effect of greenhouse gases and notes that models can have decade-long intervals of near-constant temperature. The changes in slope for the curves for CH_4 and two of the chlorofluorocarbons in Figure 7 also could be contributing, as proposed by Estrada, Perron, & Martinez-Lopez (2013). The IPCC report broadens the range of the predicted temperature increase to 1.5 to 4.5 °C from the previous 2.0 to 4.5 °C for a doubling of the CO_2 concentration, thus allowing for a little less warming while retaining the alarming upper limit. Otherwise, the report ignores the change in slope of the temperature curve and a possible clue to some overlooked physics of climate change. If there is a heating bias in some models, why did the upper limit on temperature remain the same? Regrettably, there is no recognition of the significant decrease in solar activity during the last decade.

Also in September, Canadian scientists Fyfe, Gillet, & Zwiers (2013) at the University of Victoria published an important paper confirming the discrepancy between the models and temperatures. The authors averaged only model temperatures at locations coincident with observations and found a predicted rise of 0.21 ± 0.03 °C per decade since 1998 compared with an observed 0.05 ± 0.08 °C. As these authors have noted, there is much work ahead to identify the causes of the discrepancy, construct new models, and see how well they predict temperatures in coming decades.

8. Summary and Viewpoint

In summary, at this stage of our understanding, the most important contributors to climate change in order of decreasing time scales are:

a) the gradual evolutionary brightening of the Sun over almost $5\times10^{\wedge 9}$ yr,

b) changes in the total solar irradiance, with limitations to be determined from satellite measurements and further solar modelling,

c) a change in the ultraviolet irradiance,

d) changes in cloud formation due to galactic cosmic rays, both in the long term, depending on the proximity of supernovae in the Sun's galactic orbit, and on shorter time scales, depending on the strength of the Sun's magnetic shield, and

e) changes in the concentrations of absorbing gases, both water vapour and the greenhouse gases.

This astronomer's view includes the following thoughts:

1) The present climate models have predicted rising global temperatures that actually have been constant since 1998.

2) Like the astrophysical models described above, climate models can be helpful to test hypotheses and understand physical processes. However, more development is needed before the models are reliable enough for future planning. Without a clear understanding of the temperature plateau, it is impossible to decide how much reduction in anthropogenic greenhouse gases is needed to limit the temperature rise to 2 °C.

3) As we increase the concentration of CO_2 and other anthropogenic gases, temperatures could rise again, or they could decrease if the weak solar activity leads to another Maunder Minimum.

4) We should avoid claiming that climate science is settled or that we know how to control the climate.

5) We must beware of science by consensus. There once was general agreement that the ether was necessary for the propagation of light in a vacuum. Science progresses by skepticism and the comparison of theory with experiments and observations.

Acknowledgements

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A Telescope Comes Home

by Rick Saunders, President, London Centre
(ozzzy@bell.net)

Figure 1 — Peter Jedicke and Rick Saunders pose with the Kingston telescope.

In 1921, Dr. Harold Reynolds Kingston came to Western University from the University of Manitoba and assumed the position of Head of Mathematics and Astronomy. The following year, the London Centre of The Royal Astronomical Society of Canada was founded, a consequence of the increase in public awareness of astronomy stemming from Dr. Kingston's public lectures. Dr. Kingston remained at Western for the remainder of his career, retiring in 1954. He passed away in 1963 at the age of 77.

Fast forward to 2011.

One of the first projects I undertook after being elected president of London Centre in 2011 was to re-open communications between the Centre and Mr. John Kingston, Dr. H.R. Kingston's grandson. Previously, he had made known to us that he still had his grandfather's brass refractor and would like to see it repatriated to London for display at Western. With that goal in mind, I started to make some inquiries.

Getting the refractor from Seattle, the home of Mr. Kingston and his family, to London was going to take a bit of work and, I assumed, a bit of money. Mr. Kingston said that the telescope was about 1.2 m long and that the tripod would be about twice that length—not a small package. My brother Robert, who resides in Vancouver, offered to bring the telescope back from Seattle on one of his trips south to visit his wife's family in Oregon. He was able to do this in June 2012; the first step on the voyage was complete.

Leigh Cummings of Vancouver Centre picked up the telescope for the next part of its voyage home. He arranged, through his business, to first have the optical tube and tripod properly crated and then shipped to the workplace of Craig Levine in London. It arrived without a scratch, apparently being handled with kid gloves by the trucking company. Once in London, it was put on display at the London Centre's annual banquet, a gala that was attended by Mr. Peter Snell of the Kingston family, who also presented London Centre with Dr. Kingston's old silk top hat. Along with the telescope came an envelope containing documentation on Dr. Kingston's career, newspaper clippings from the time, and even his original high-school diploma. These have been placed into the Centre's archives.

While Dr. Kingston's telescope was waiting for a permanent home at Western, Joe O'Neil of the Centre "borrowed" it to put it on public display at Eldon House in London. Eldon House is the oldest existing home in London and has been turned into a museum.

In October 2013, Western was finally ready to accept delivery of the telescope. It was packed up and driven over to the campus where Peter Jedicke and I toted it up to the boardroom and set it up. After many decades in time and many kilometres in distance, Dr. Kingston's fine brass refractor has come home. ✶

Imager's Corner

Controlling Star Bloat

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

This month, our discussion will deal with "masked stretching" to control star bloat. When processing images of faint nebula, especially those embedded in the rich star fields of the Milky Way, the stars bloat and quickly rob detail as you stretch the image. The image of the Veil below shows the effect.

The image in Figure 1 was brightened with an arcsine stretch in *Images Plus*. This stretch already does a reasonable job of controlling star bloat. The idea behind masked stretching is to

Figure 1 — Veil showing star bloat robbing detail

come up with a mask that has no stars. This has the effect of limiting or eliminating the stretch applied to the stars and thus controlling the bloat.

For this column I'm going to move away from a more general-purpose image-processing package to a more astro-specific package, *Images Plus*. Using the new feature "mask tool" in the latest release of the package, we get the mask shown in Figure 2.

The mask has had all the stars removed and there are only a few of the larger halos left. The detail of the nebula is not blurred as happens when you generate the mask using more general-purpose image processors. The nice part about the tool is that it only takes a few mouse clicks to generate the mask. In

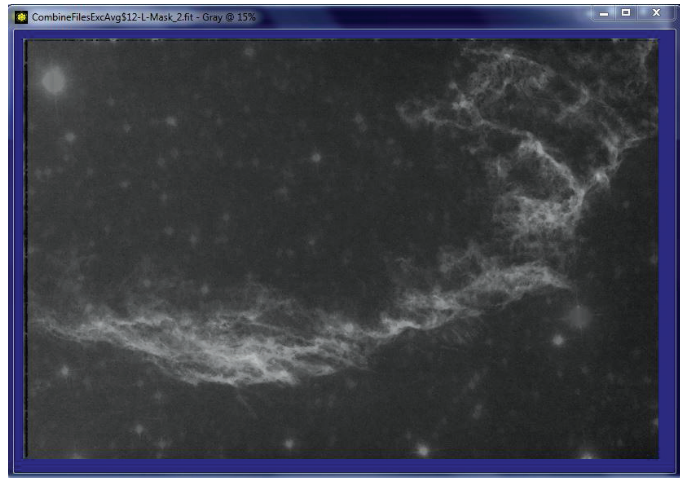


Figure 2 — Mask used during the mask stretch

actual fact, it can generate a full-colour starless image and a separate star-only image suitable for split-star processing (a story for another time).

Now that we have the mask, let's apply the same arcsine stretch that produced Figure 1. This gives us the image in Figure 3.

Figure 3 — Initial masked stretch

Already we can see that the stars are much smaller, have more colour, and the nebula is more visible, as it is not hidden in a field of white stars. The stretch leaves the image a little muted, as the mask limits the stretch over the entire image and more so over the stars. To rev up the image, we increase the saturation followed by a gentle S curve, both using the same mask. This produces the image below in which the nebula is substantially more colourful and not hidden by large, numerous stars.

The image clearly shows more detail and there is more star colour. The problem is that it takes a lot of tedious work to generate good quality masks using a general-purpose image processor. More dedicated packages like *Images Plus* or *PixInsight* have tools that greatly simplify the effort required to generate a wide variety of masks that can be used to tailor

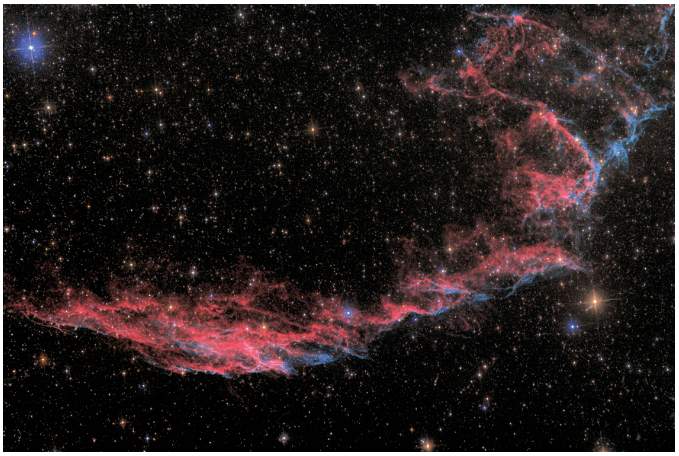


Figure 4 — Final masked stretched image

the processing to specific areas of the image. In the next installment, we will compare techniques for generating the masks used in masked stretching.

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

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

Rising Stars

Constellations You Can Salute

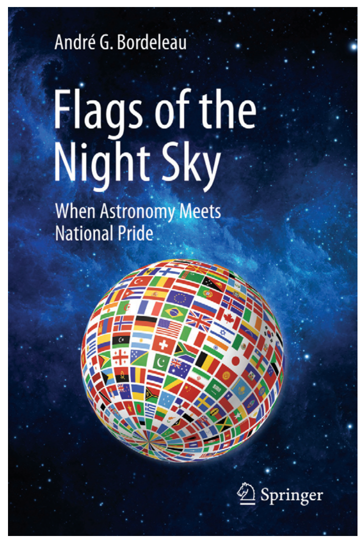
by John Crossen (johnstargazer@xplornet.com)

We've all seen national flags with images of the Sun, Moon, and stars. Some represent astronomical objects such as constellations; others are just designs. Though the flag of the United States sports 50 stars, they represent only the number of states and have no astronomical significance. On the other hand, Brazil's national flag is almost a chart, depicting stars such as Canopus in Carina and Spica in Virgo along with complete constellations. What's more, they are shown as they would appear above Rio de Janeiro, on 1889 November 15, the date of the proclamation of the Republic.

Don't worry if you can't recognize them immediately. Like many of the star charts from the 16th through 18th centuries, they are shown on the celestial sphere as they would appear when viewed from the outside.

The national flags of Australia and New Zealand are less of a brain twist to decipher, because both show the stars that form the Southern Cross from an earthly point of view. But, what about flags that feature a crescent Moon? Could it be an eclipse of the Sun that hasn't reached totality?

André Bordeleau's new book *Flags of the Night Sky (When Astronomy Meets National Pride)* digs into the astronomical origins of nearly 40 different national flags. It is written with the authority of a man who has done his homework very thoroughly. But, of equal importance, it immerses the reader



in a seemingly endless river of fascinating facts and intriguing details.

Country by country, Bordeleau takes us on a 220-page guided tour through time to show how national flags evolve as history and countries change. Sometimes the modifications reflect significant political events, the addition of new provinces, or changes in geographic boundaries.

Some flags come to life as new nations are born. At other times, changes are made simply to assure that the flag could not be mistaken for that of another country. For example, other than being green and yellow, the Brazilian flag once wore stars and stripes in almost the same design as the American flag.

The name for the study of flags is vexillology and the subject may seem a tad obscure at first. But, read a couple of paragraphs of *Flags of the Night Sky*, and you'll say "betcha didn't know that..." to the next person you encounter.

The seeds of *Flags of the Night Sky* were planted in 2008 in the form of a four-page article that Bordeleau had written for *The Planetarian* magazine. He wanted to take the idea farther—a lot farther. A friend and professor at the University of Chicago suggested that Bordeleau talk with the Editor at Springer Publishing whom he though might be interested in such a book. Bordeleau emailed him the same four-page article, to read on the plane while travelling. As the fates would have it, the publisher was travelling to Brazil the following day to look into opening an office there.

Fortunately for all of us, Springer found the article fascinating and Bordeleau's four-page article has since morphed into a nicely illustrated book. Says André, "I made the winning touchdown in the last seconds of the game. It was like a Hail Mary pass in football."

Flags of the Night Sky is now available on Kindle and as a paperback via Springer Publishing. If you have $29 left after the Christmas buying binge, the paperback is available at Amazon and belongs on your bookshelf. Kindle readers will only have to find $20 to enjoy the same read.

If you have been to the Montreal Planetarium, chances are you have heard André Bordeleau speak. Mr. Bordeleau has been involved in astronomy since he joined the University of Guelph Physics and Astronomy Club in 1982. At Guelph, he was heavily involved in astronomy outreach activities, giving observatory tours and presentations to schools and the public. By 1987, he had done so much for the club and its public outreach programs, that he was given a lifetime membership. Though he earned a Master's Degree in Political Science, astronomy was and is his passion and his job. Currently, he has been a planetarium lecturer for over 20 years.

Since 1987, he has been active in the fight to eradicate light pollution, and has written several articles in both French and English on the subject. Bordeleau has also translated five astronomy books from English to French.

From 1978 to 1990, he was a member of the Canadian National Moving Target Rifle Team and competed in the 1984 and 1988 Olympic Trials. While he didn't make it to the Olympics, André won the Ontario Target Rifle Championship in 1984. Did he hit the bull's eye with this book? You bet! ✶

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

Cosmic Contemplations

How to Throw a Proper Planetary Eyepiece Shootout Party

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

I recently caught the visual-observing eyepiece bug. After reading many online reviews and forum threads, I came to the rather dubious conclusion that evaluating an eyepiece is like evaluating fine wine. No doubt, the eyepiece connoisseur who collects $1500 CZJ[1] Monocentrics can see much more than I'll ever be able to. As a man of science, I was particularly dismayed at how eyepiece comparison studies are conducted. The winner always appeared to be a foregone conclusion.

One of the problems with eyepiece comparisons is that there is no control for operator bias. Tests need to be conducted as a single-blind study so that the viewer has no knowledge of the eyepiece identity. Unfortunately, a true blind test cannot be engineered because even the most casual amateur astronomer knows the difference between a classical Plössl design and a modern multi-lens design like a Tele Vue Nagler just by the size of the eyepiece, its comfortable eye relief, and its apparent field of view (AFOV).

Perhaps the only way to ensure a true single-blind study was to recruit complete astronomy novices. Fortunately, my family throws a large Thanksgiving party every year and, after being plied with drink and fowl, our guests could be persuaded into volunteering for this study!

Figure 1 — A planetary eyepiece lineup (between 4-6 mm focal length).

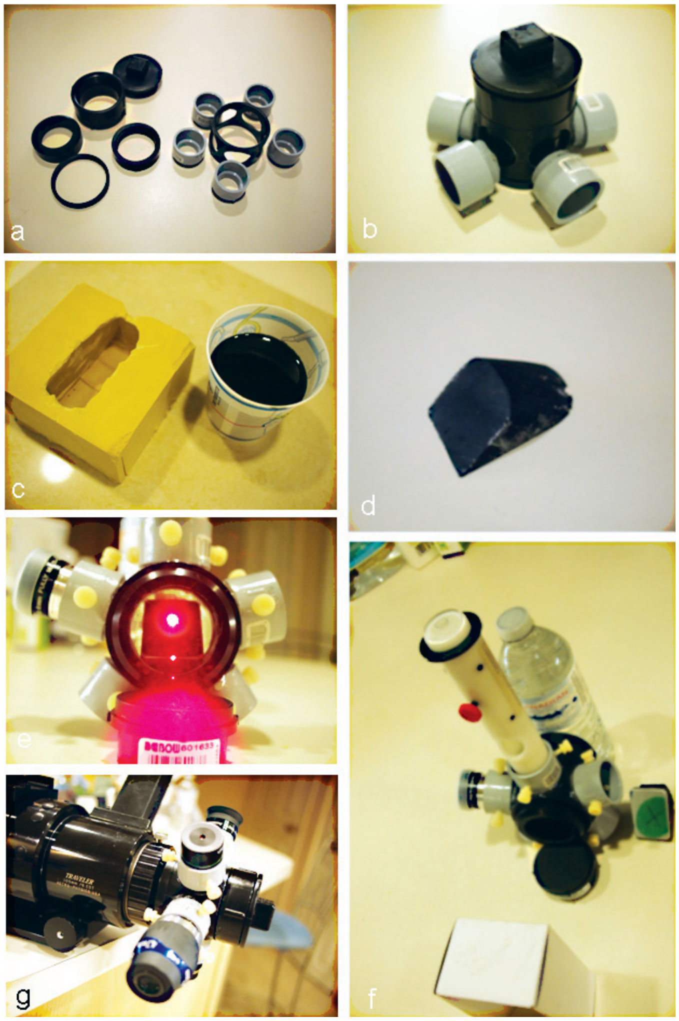


Figure 2 — Fabricating an eyepiece turret: a) the ABS rings; b) the assembled eyepiece turret; c) preparing the mold; d) the molded mirror support; e & f) laser collimation; g) the eyepiece turret in use.

The target was the Moon, approaching its apogee in the south on Thanksgiving night under good seeing conditions. We viewed it with a four-inch Astro Physics Traveler refractor that was polar aligned and pier mounted at a comfortable standing height. A five-eyepiece turret was used in which all eyepieces[2] were carefully prefocused so that the viewer could rapidly shuffle through the selection. This was a very important consideration, as it increased the likelihood that the viewer was observing with all eyepieces under the same seeing conditions (which can change from moment to moment) by eliminating the time-consuming task of removing, reloading, and refocusing each eyepiece. I believe it also reduced visual fatigue, since it was easier to recall what the other four eyepieces looked like when you could quickly shift from one to the next.

This latter factor is a critical parameter often missed by earlier eyepiece studies: they made no attempt to control the seeing conditions. Such studies are sometimes conducted over several nights when not all the eyepieces were available at the same time! While only an indoor bench test can truly reveal subtle differences between eyepieces, a rapid method of changing eyepieces in the outdoors ensures, at least, that they are all being subjected to similar seeing conditions. This made an eyepiece turret a necessity and not a luxury. Turrets are perceived to be the latter, since they can be difficult to manufacture and expensive to purchase[3]. As a budget-minded amateur astronomer, I was determined to find another way.

Figure 2 at left details how one can easily fabricate a five-eyepiece turret using two-inch black ABS plastic plumbing fittings, electrical conduit couplers, and nylon thumbscrews. The heart of the system is a mirror flat, rescued from a 1.25-inch diagonal secured to a cast-polyurethane resin mount whose angle of incline has been fine tuned with a targeting laser.

The eyepieces under consideration are labelled with a number designation in Table 1 below.

The less glass in the path of an image, the less the degradation in brightness and contrast it experiences, as there are internal reflections that occur at every glass-to-air interface. Modern antireflection coatings are very good at minimizing transmission losses at these interfaces and all eyepieces tested were fully multicoated. That said, the preferred eyepiece layout used by planetary observers tends to be the classical, simpler designs, since fewer groupings of elements means fewer glass-to-air interfaces. The orthoscopic design features a stack of

	Eyepiece Name	AFOV	Eye Relief	Elements/Groups	Design	Price (used)
#1	Meade 4.7 mm Series 5000 UWA	82°	14 mm	7/4	proprietary	$80
#2	Pentax SMC 5.2 mm XL	65°	20 mm	7/5	proprietary	$170
#3	Pentax SMC 3.8 mm XP	42°	2.7 mm	5/3	ortho	$175
#4	University Optics (UO) 6 mm HD	43°	4 mm	4/2	ortho	$70
#5	Smart Astronomy 6 mm	52°	5 mm	4/2	Plössl	$13

Table 1

three elements followed by a simple planoconvex eye lens. The modern-day Plössl is a mild variation of the original design and features two identical aplanatic doublets with their crown biconvex elements facing inwards.

An orthoscopic eyepiece has four glass-to-air interfaces and if uncoated, can cause a 4-percent light loss at each interface, yielding a final value of 0.96 × 0.96 × 0.96 × 0.96 = 0.85; a 15-percent light loss. An uncoated modern seven-element/four-group eyepiece would be subject to nearly 40-percent light loss. Fortunately, modern multicoatings can reduce losses to as little as one-tenth of a percent.

The eight subjects (n=8) were randomized, as was the eyepiece turret position. The observer's final eyepiece selection was communicated privately to me so as not to influence the opinion of those who came later. All eyepieces were thoroughly cleaned. Medium magnification of 50-100× was used, far below the 60×/aperture-inch rule. The eyepieces were tested the night before for the amount of in-travel focus required; the UO HD eyepiece required the most in-travel and that was brought to focus using the refractor's focuser. The other eyepieces' foci were then set by slightly unseating them from their holders.

The purpose of the test was not to rank the eyepieces but to simply choose one overall best eyepiece. The astro-community consensus is that the Pentax 3.8 mm XP is one of the finest eyepieces ever produced, featuring a nearly unheard of 98-percent overall transmission rate, extra-low-dispersion glass, and lanthanum glass elements. It is only marginally surpassed by the Zeiss Abbé orthos (ZAO) and TMB Monocentrics. If this eyepiece were to be blindly chosen as the best performing eyepiece by the group, it would legitimize the price differential of such high-end optics.

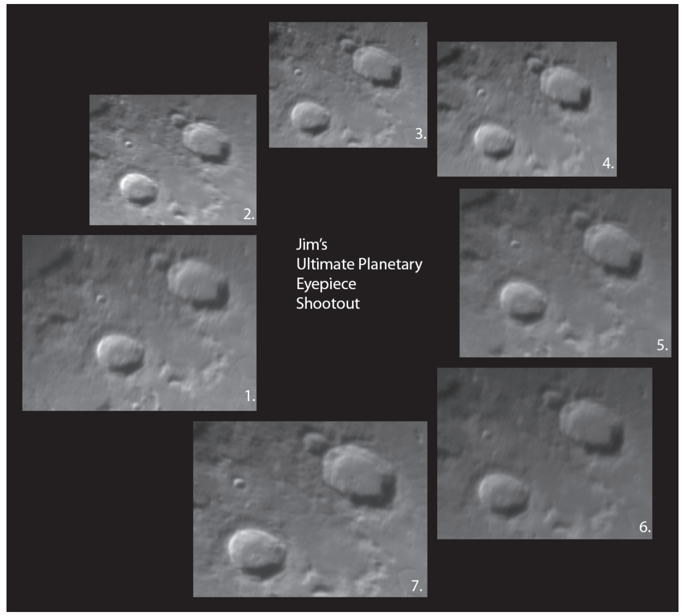


Figure 4 — The image selection produced by videocamera for evaluation. Which one to you think is the sharpest?

Since the focal lengths were not identical, I instructed the viewers to disregard the differences in AFOV and brightness and to simply choose the one that they felt gave the best view in terms of on-axis sharpness. None of the eyepieces exhibited a "kidney bean" exit pupil or glaring internal reflections. Similarly, I chose to concentrate on on-axis performance and ignore any aberrations likely to be present off-axis. I did not want to evaluate contrast, because the AFOVs of the eyepieces were not equal, and the brain could be fooled by the darker background surrounding the Moon in those eyepieces that were able to show the entire half Moon against its setting.

Overwhelmingly, the Meade was the first choice (n=6), followed by the Pentax XL (n=2).

Interestingly, the subjects who chose the Pentax XL were torn between it and the UO HD and were also significantly older than the median age of 22. Is it possible that age confers a more discerning nature?

After the guests left, I spent some time observing crater Plato located on the Moon's mid-northern limb. I could detect no significant differences in sharpness or detail from the cheapest to most expensive eyepiece.

I began to have misgivings about the design of the study. Was it possible that the group of novices was distracted by the wide-field views

Figure 3 — The eyepieces used for eyepiece-projection imaging with a Flea CCD camera.

and comfortable eye relief of the Meade UWA, making them feel it was the sharper and better eyepiece? There is a biological effect at work, since larger fields of views tend to excite the nervous system, possibly influencing pupillary dilation, and I can attest that astronomy novices were easily excited! I could install field stops in the modern eyepieces and reduce their AFOVs, but the differences in focal lengths would still exist, and images of a smaller scale always tend to look sharper. I concluded that the only method to normalize these differences, and the effect of eye relief, would be use a small-sensor CCD to record and evaluate the eyepiece image via eyepiece projection.

Using plumbing fittings, I quickly made two different-sized eyepiece-projection C-thread camera adaptors. This was necessary because of the large size of some of the modern eyecups and the need to be compatible with my 640×480 Point Grey Research Flea2 CCD camera. This small camera put no strain on the eyepiece and could be placed very close to the eyelens to minimize the magnification that eyepiece projection tends to produce. To facilitate this, the eyecups were screwed to their lowest position or rolled down. Single 1/30th-second frame captures of each eyepiece image were made, and these were either reduced in scale or cropped to equalize focal length and AFOV. No other image processing was performed, and each image was clearly subject to the seeing of the moment—those mild manifestations of turbulence that seem to be edited out by the visual cortex in real time. I debated capturing conventional streams of images, selectively stacking and then sharpening them, as this would normalize seeing conditions and make comparisons easier, but I thought that all that processing might introduce other differential factors.

A new total of seven eyepieces was tested (those listed in Table 1 and those in Table 2, below). RASC members were invited to participate through the Yahoo group forum by viewing the images online[5]. These experienced observers were blind to the eyepiece identity when they chose the best and worst images. The waning gibbous Moon was very high in the southern sky at 5 a.m. when data were collected, with seeing as good if not better than Thanksgiving night. The images were acquired over a 20-minute interval. The craters in the image are identified as Aristoteles (right) and Eudoxus (Figure 4).

The consensus among the 17 respondents was that the best eyepiece was the Speers-Waler 5 mm and the worst was Smart Astronomy's 6 mm Plössl (two chose the BO/TMB). Again, the Pentax ortho[4] was not favoured, but four respondents did mention it as a close second. Refreshingly, the cheapest eyepiece turned out to be the worst, and the eyepiece with the most elements (9!) performed the best on planets.

Eyepiece Name	AFOV	Eye Relief	Elements/ Groups	Design	Price (used)
Speers-WALER 5-8 mm	84°	12 mm	9	proprietary	$180
Burgess Optical/ TMB 4 mm	58°	16 mm	6/4	proprietary	$ 60

Table 2

The conclusion I reached is that when eyepieces are compared on a level playing field, most modern optics with good coatings perform very well indeed. Expensive eyepieces may be either more comfortable to use, such as the Tele Vue Delos or the Pentax XWs, or are classical designs produced in small numbers but made to the very best quality so that they reveal very subtle and nuanced detail. However, to appreciate the ZAOs and TMB Monocentrics, the observer must have excellent seeing conditions. The reason why the ZAO eyepieces deliver both in this performance and in price is that Zeiss spends more than twice the standard time in polishing their lens elements to eliminate the subsurface damage within the fine-ground surface that will turn hazy after the coatings are baked on. Zeiss also multicoats each lens surface with specific regard to its unique refractive index rather than subjecting all elements to the same treatment. High-index glass requires upwards of five coats. Zeiss eyepieces can never benefit from economies of scale, as only cheaply manufactured eyepieces can ever be offered at popular prices, and because they serve a highly specialized niche market. Aside from collectors who covet their eyepieces merely as acquisitions, you get what you pay for in this hobby, with diminishing returns at the top end. Luckily for the majority of us, very good performance can be had for very reasonable costs. ✶

Endnotes

1 Carl Zeiss Jena

2 Keen-eyed readers will observe that I initially had seven eyepieces to test. The two I deleted from the study were the Canadian-manufactured and widely acclaimed Speers-WALER 5-8 mm zoom and the Burgess Optical/TMB 4 mm Super Planetary eyepiece. I have owned both for many years. I had fabricated a seven-eyepiece turret using 4-inch white PVC drainpipe and a Televue 2-inch diagonal flat, but many eyepieces couldn't come to focus, because it was too large.

3 The $1500 Van Slyke billet aluminum six-eyepiece turret comes to mind. www.observatory.org/turret.htm

4 Critics defending the reputation of the Pentax orthos will insist the evaluation would have been fairer if I had purchased a Pentax O-6 eyepiece instead. I agree, the larger focal length would have yielded better transmission and AFOV, but my budget was for eyepieces less than $200 and Pentax O-6 is well in excess of $300, used.

5 https://dl.dropboxusercontent.com/u/4852049/Eyepiece-Shootout.jpg

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

Second Light

Boom!

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

On 2013 February 15, about 9:20 a.m. local time, a meteoroid exploded just south of Chelyabinsk, Russia, a city of about a million people that lies 1500 km almost due east of Moscow. It was the largest impact since the 1908 Tunguska event. In a pair of papers, Jiří Borovička of the Academy of Sciences of the Czech Republic and Peter Brown of Western University report on an analysis of the properties of the bolide, its trajectory, and its energy, in part based upon studying amateur videos of the path of the meteoroid (see the November 14 issue of *Nature*).

The Tunguska explosion has been estimated to be the equivalent of 5-15 megatons of TNT, with the most recent estimates at the lower end of the range. Most people have seen photos of the flattened forest, although according to Mark Boslough of Sandia National Lab, those famous photos do not show that the damage was less widespread than originally thought, with the worst damage on slopes facing the explosion (from a talk at the recent meeting of the Division of Planetary Sciences (DPS)). Still, even a 5 MT explosion over your own city would make for a very bad day.

Peter Brown and his collaborators estimate that the energy of the Chelyabinsk burst was about 500 kilotons—a factor of ten less than the low end of the Tunguska range. Even so, over 1500 people were injured, mostly by flying glass from the thousands of windows broken. The main explosion occurred at a height of about 30 km, about 50 km south-southwest of Chelyabinsk. An 8-m-diameter hole was found in the ice of Lake Chebarkul (about 70 km west of Chelyabinsk), and although it was unclear at the time whether that hole was related to the meteoroid, Borovička's reconstructed path for the largest remaining fragment puts it on the ground just a few hundred metres from the hole in the ice—well within the uncertainties of the projected path.

Borovička's reconstruction has the meteoroid "entering" the atmosphere at a height of 95 km with a speed of 19 km s^{-1}, which is typical for a near-Earth body hitting Earth. Twelve seconds later, two main explosions occurred, at heights of 32 and 30 km, with many small fragments spread over the projected path. The small fragments were slowed and/or ablated within a few seconds, with the largest fragment—a rock with an estimated mass of about 450 kg—hitting the lake with a speed of about 230 metres per second about 60 seconds after the main break-up explosion. Based upon the trail in the sky and the heights at which detonations occurred, Borovicka concludes that the main body was probably a "fractured rock," not a "rubble pile," and traced it back to the near-Earth asteroid 86039 (1999 NC43), though that is not entirely settled at the present time.

Figure 1 — an image of the track of the Chelyabinsk bolide. Credit: Alexander Vazhenin. The video from which the montage was made is at www.youtube.com/watch?v=BaxMeEEl4zA.

A 600 kg rock was recovered from Lake Chebarkul in early October and is believed to be the largest surviving fragment. Brown estimates that when the meteoroid first hit the atmosphere, its diameter was 17-20 m. Much of the mass was lost to ablation as it sped through the atmosphere at highly supersonic speeds, with Borovička putting the main fragmentation events between 40 and 30 km height, after which there were about 20 boulders left. These in turn fragmented at 24 to 22 km, with the largest ("main body") gone by a height of 17 km. Interestingly, the largest surviving fragment, the one that hit the lake, did not come from the main body but rather from a rapidly decelerated boulder from which it separated at a height of 25 km.

Brown's modelling of the explosion revealed some good news and some bad news. On the good side, it appears that the effects of nuclear explosions typically used to estimate damage from impact events overestimate the damage considerably, mainly because in an impact, the energy is dissipated over a path length many km long, while a nuclear burst deposits all the energy in single point.

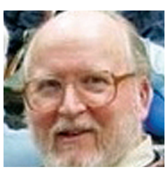
The bad news is that there seem to be many more of these small bodies than would be expected based upon an extrapolation of the observed numbers of near-Earth asteroids of diameter >1 km—about 90 percent of which have been discovered by the Spacewatch project and whose orbits have been determined. Based upon those extrapolations, the Tunguska event should be a once in a thousand year occurrence, while the Chelyabinsk one should happen about once every hundred years. Brown estimates frequencies that are higher for both types of events—those with the energy of Chelyabinsk will have an impact rate 3 to 5 times higher than suggested by telescopic data.

Before Mark Boslough's talk at the DPS meeting, I asked him what size of body he would classify as potentially harmful to human life, and he put the Chelyabinsk body at the low end of threatening. To date, only about 500 near-Earth asteroids with diameters of 10 to 20 m have been found (they are very difficult to see with telescopes), out of an estimated population of 20 million or so. In about 100 years, the frequency of these intermediate-sized impacts will be known with much greater precision. Let's hope that during that time we do not suffer much damage from these smaller airbursts. In the meantime, if you see a track like in Figure 1, move away from the windows. ✶

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.*

Through My Eyepiece

Looking Forward



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

As I write this, we have just watched The Comet ISON Show (complete with surprise ending), and I find myself closing that chapter and looking forward to the coming year. The *Observer's Handbook 2014* is in my hands, and that is always exciting and invigorating.

I inevitably go first to the section on eclipses to see what special treats the year has in store. It looks like there will be two lunar eclipses, but both are after midnight in Eastern and Central Canada, making them poor candidates for outreach events—mark April 15 and October 8 on your calendar anyway. There will also be a late-afternoon partial solar eclipse, a better outreach opportunity, on October 23. That eclipse is best seen in Western Canada, and the farther north, the better (page 146 in the 2014 Handbook). Be sure to lay in supplies of eclipse glasses early.

Because of health issues, bad weather, and other distractions, I have not been doing as much observing this past year. I hope that that will change this coming year. Basically, I am in need of a new "project" around which to focus my observing energies.

In recent years, much of my observing has centred on variable stars. However, I'm beginning to see the writing on the wall regarding visual observations of variable stars. Much as I enjoy this activity, I can see its dwindling importance in astronomical research. I've thought of switching to using a photometer or a CCD camera to observe variables, but that honestly doesn't appeal to me.

I often think of devoting more attention to astrophotography, but again, the technical side of it doesn't interest me. I spend most of my days working on computers; I have no desire to spend my nights hovering over a monitor. Instead, my greatest astronomical pleasures lately have been what I call "revisiting old friends." As I've written here before, I enjoy using my scope's GoTo feature to look at a variety of deep-sky objects, mostly from Messier's catalogue. It's amazing how much pleasure can be mined from those old, familiar objects.

For better or for worse, most of my astronomical energy nowadays goes into what I call "cyberastronomy." I get great pleasure in answering beginner's questions, on Yahoo!Answers and on our own AskRASC service. My request for additional help with the latter brought a couple of new volunteers, including the indefatigable James Edgar. I received enormous assistance from my mentors in the RASC, ALPO, and AAVSO over the years, and it gives me great pleasure to pay it back by helping others just starting in this great adventure. ✶

Geoff Gaherty received the Toronto Centre's Ostrander-Ramsay Award for excellence in writing, specifically for his JRASC column, Through My Eyepiece. *Despite cold in the winter and mosquitoes in the summer, he still manages to pursue a variety of observations. He recently co-authored his first iBook with Pedro Braganca:* 2012 Venus Transit.

John Percy's Universe

Galileo Galilei and *The Galileo Project*

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

In 2009, we celebrated International Year of Astronomy (IYA2009), the 400th anniversary of Galileo's development and first use of the astronomical telescope. With it, he made observations that changed our understanding of the Universe. IYA2009 was spearheaded by the International Astronomical Union (IAU), the world organization of professional astronomers, supported by UNESCO, and sanctioned by the UN General Assembly.

IYA was celebrated in 148 countries around the world—twice the number that belong to the IAU and twice the number in which astronomical research is done. In most countries, IYA2009 was driven by amateur astronomers and astronomy educators. In Canada, it was an overwhelming success, thanks to inspired leadership by Jim Hesser and the effective pro-am partnership between CASCA, FAAQ, and RASC (Hesser *et al.* 2010). We organized over 3600 events, and delivered almost two million "Galileo Moments"—moments of personal astronomical discovery, either intellectual or emotional or both.

Why Celebrate Galileo?

Why celebrate Galileo? Why is he "one of the top ten people of the millennium" and one of the top ten Italians of all time? Why is his name known by most educated people?

Galileo Galilei was born in 1564 in Pisa, the son of a musician, and he grew up in Florence. He had several younger siblings to support (and later three illegitimate children), so money was always an issue. He was educated initially in medicine, but switched to mathematics; he apparently never finished his degree. He would have been schooled in the Aristotelian model of the Universe, with the Earth at the centre, and in Ptolemy's mathematical version of that model, which was capable of predicting the positions of the Sun, Moon, and planets as accurately as they could be measured at the time. But he would also have been aware of Copernicus's Sun-centred model, which was simpler and more elegant, but lacked evidence in its favour. In 1589, he became a professor of mathematics at the University of Pisa. In 1592, he became professor of mathematics and astronomy at the University of Padua (at twice the salary). In 1610, he received an additional appointment at the court of the Grand Duke of Tuscany. See Drake (1980) for a short but excellent account of his life and work.

His talents were broad and deep: mathematics and science, theory and experimentation, engineering and technology, drawing and writing. What was it about his upbringing that made him such a prodigy? Perhaps it was because of his father's innovative approaches to music theory and experiment. Early in his career, Galileo developed a compass (for measuring, not for finding direction) that had considerable military and commercial application. He sold many of them to his colleagues and students, and (for a price) taught them how to use it. For us, his most important invention was the astronomical telescope, a significant improvement on the recently invented Dutch "spyglass." It provided the light-gathering power, resolving power, and magnifying power needed for astronomical use. The telescope also had military and commercial application, and Galileo sold (or gave away) dozens of them to influential people.

In 1609, he turned his telescope on the Moon, and found it Earthlike, in that it had mountains and valleys. Using shadows and mathematics, he could determine the heights and depths of these. This and his observations of sunspots (previously observed by others) showed that the heavenly bodies were not perfect and unchanging "quintessence" as Aristotle had proposed. He discovered and studied the four "Galilean" satellites of Jupiter, showing that there were objects that definitely did not revolve around the Earth. This also contradicted Aristotelian philosophy and the Ptolemaic model based on it. Indeed, it demonstrated that objects could revolve around a moving object—hard to understand, given the physics of the time. In the Copernican model of the Solar System, the Jupiter observations showed that the Earth was not the only planet with a moon. Galileo observed the phases of Venus, and they were not what the Ptolemaic model predicted, but instead supported the Copernican model (or Tycho Brahe's hybrid model, in which the planets revolved around the Sun, and the Sun revolved around the Earth). And, might the moons and planets be habitable? Or inhabited? He also observed countless faint stars, especially in the Milky Way, and concluded that the stars must be very distant, which explained why they did not show the parallax that would be expected if the Earth was revolving around the Sun.

Throughout his career, he was also interested in motion—of pendulums, projectiles, and planets. He needed to understand how the Earth could revolve and rotate without us feeling it, wwork that became the basis for Isaac Newton's laws of motion.

It is said (by Einstein, Hawking, and others) that Galileo is the father of modern science. He didn't develop it single-handedly, but he certainly advanced the notion of a science based on experimental and observational evidence, as well as on a solid theoretical foundation, rather than on pure reason and logic as in Aristotelian philosophy.

Figure 1 — The musicians of the Tafelmusik Baroque Orchestra memorized the entire score of The Galileo Project*, so they could move about and interact on the circular stage.*

Galileo was a skilled lutenist, and this brought him much joy, especially in later life. He was a competent artist, as his drawings of the Moon and Sun demonstrate. He was a compelling writer, especially in his *Dialogue on the Two Chief World Systems*, a short excerpt of which is given below. His discoveries and ideas spread surprisingly rapidly, both through his books and letters, and through word of mouth via academic and diplomatic channels.

But why are some scientists known by the public? In my experience, it's not just because of their achievements, but because of something extra—in Galileo's case, for his interactions ("conflicts") with the Catholic Church. He was a devout Catholic, a friend of cardinals and popes, and conversant with the scriptures. The Church allowed him to publish his evidence for the Copernican model—initially if he specified that it was a hypothesis only, and later if he gave the Aristotelian model "equal time." The *Dialogue* did this, but only superficially. And, it was written in Italian, in powerful language, so it was a best-seller. In 1633, he was forced to recant his views, which he did (sort of), and spent the rest of his life under gentle house arrest. He died in 1642, but only in 1737 was he buried in sacred ground. In 1992, the Vatican issued a formal apology.

A problem is that Galileo is usually seen, by the public, to represent the "conflict" between science and religion. Such a conflict only arises if science and religion are interpreted in an inflexible way. Otherwise, they can be independent; they can be in dialogue with each other; or they can be mutually supportive—depending on one's interpretation of each. Galileo has been portrayed in novels, plays, and movies, and the depiction of his "conflict" varies with the times.

One portrayal of Galileo is in Tafelmusik Baroque Orchestra's *The Galileo Project*. It does not dwell on the "conflict," but on the deep connections between science, culture, and the arts.

Tafelmusik's *The Galileo Project*

In addition to national and local IYA2009 projects, Canadian astronomers were encouraged to dream up personal projects, especially ones that would bring astronomy to new audiences. I've described some of mine elsewhere (Percy 2012). My wife and I have followed and supported Toronto's Tafelmusik Baroque Orchestra since their beginning in 1979, and watched them develop into "one of the world's top baroque orchestras" (Gramophone magazine). I was aware that their double-bass player Alison Mackay had developed some outstanding multi-disciplinary, multi-media programs, so I suggested to her that she might want to develop an astronomy-themed program in honour of Galileo, as an IYA project. She took it from there. I was the astronomy advisor, but had little to do, other than sit back and marvel.

The Galileo Project[1] combines music, images, narrated text from a variety of sources (including Galileo himself), and choreography such that the result is much greater than the sum of the parts. The images are projected on a large circular screen that brings to mind the view through a telescope. The screen is mounted in an ornate, Renaissance-style frame. The stunning images come from both professional telescopes on the ground and in space, and from skilled amateur astrophotographers, notably Alan Dyer—views that you yourself might see under a clear, dark sky.

The fusion of science and culture is broad and deep, starting with excerpts from Phaeton, through music from the time of Galileo (when modern opera was being developed by *e.g.* Monteverdi), Kepler, and Newton. Remarkably, the musicians memorized the entire score, so they are free to move and interact on the stage (Figure 1). They are joined by actor Shaun Smyth who reads from sources both profound and not ("The Astronomical Drinking Song"). The highlight, for me, is the last few minutes in which two Bach compositions—the gentle "How Brightly Shines the Morning Star" and the brilliant Sinfonia BWV 29—frame Galileo's tribute to the inventor of the alphabet, from the Dialogue:

1 www.tafelmusik.org/media-room/galileo-project/galileo-overview

But above all these was the sublime mind who realized that, with twenty characters upon a page, we could communicate across mighty barriers of time and place. That, with a few lines and drops of ink, we could share our deepest thoughts, our most important ideas, and our most profound creations with those who are not yet born, and will not be born for another thousand years.

Alison Mackay also created an educational version of *The Galileo Project*, which has been experienced by thousands of children around the world. Happily, in Ontario in grade six, astronomy is part of the science curriculum, and baroque music is part of the music curriculum. Alison's program, which immerses children in sound, sight, motion, and thought, shows how well science and the arts can connect. It demonstrates that science can have both an intellectual and emotional dimension, and that science is truly part of culture.

The Galileo Project has been a smashing success by all the usual criteria: full houses, standing ovations, rave reviews, and invitations to tour the world. It has travelled across Canada, and to the U.S., Mexico, China, Malaysia, Australia (where it won the *Helpmann Award* as the year's best chamber concert), New Zealand, Japan, and Korea, delivering tens of thousands of "Galileo moments." In Asia and "down under," appropriate references to local indigenous astronomy were added, to remind us that Western astronomy is not the only astronomy. Alison Mackay won Orchestra Canada's Betty Webster Award in 2013 for this and her other creations. Through the efforts of David Balam, Jim Hesser, and me, the IAU named asteroid 197856 Tafelmusik in honour of *The Galileo Project*. A DVD of the program can be ordered from tafelmusik.org; it's superb, especially on a big screen. It brings a new dimension to the concert experience. ✶

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Drake, S. (1980). *Galileo: A Very Short Introduction.* Oxford: Oxford University Press.

Hesser, J.E. *et al.* (2010). An Initial Retrospective on the International Year of Astronomy 2009 in Canada. *JRASC, 104*, 51.

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Society News

by James Edgar, Regina Centre
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I'm happy to report that the Society Board has approved and adopted the Strategic Plan 2014-2016. Much of what must be done to attain the goals in the plan happens at the Centre level, so the many Centre executive and council members are encouraged to read up on the details and timelines involved. The Strategic Plan is posted in the Members Only page at www.rasc.ca/system/files/private/RASCSP_2014_16.pdf

Watch for some important news in the new year about the new Fellow of the RASC award.

At the National Advisory Council meeting in November, a working group was formed to explore the possibility of including or inviting committee chairs, editors, the Honorary President, and the Past President to attend NAC meetings. The group's report will be forthcoming before the next NAC meeting in mid-March 2014.

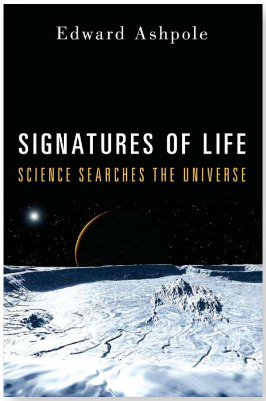
People around the world got caught up in the media hype associated with the "Comet of the Century"—wishful thinking, at best, as Comet ISON sputtered out before it could journey through the Sun's hot corona. Apparently, all that came out the other side was dust, but no comet. It's a caution to all that we should be wary of over-hyped predictive announcements of objects that can be as skittish, and unpredictable, as a cat!

Speaking of comets, were there any camera-happy astronomers out there photographing Comet Lovejoy (C/2013 R1)? If so, we'd like to see the pictures.

Even though it's cold out there, spring isn't far away, so plan to grab that new scope or lens and make good use of the dark skies, wherever you are. ✶

Reviews / Critiques

Signatures of Life, Science Searches the Universe, Edward Ashpole, pages 227, 16 cm × 23.5 cm, Prometheus Books, New York, 2013. Price $26.50 CAD, hardcover (ISBN: 978-1-61614-668-9).



Edward Ashpole is a science writer who has covered the life sciences for numerous publications in Britain and abroad. He is author of *The UFO Phenomena: A Scientific Look at the Evidence for Extraterrestrial Contacts* and *Where Is Everybody?*

In this latest book by Ashpole, he urges an open-minded view by scientists and laypeople to all credible and scientific-method tests that weed out fantasy in the search for hard evidence of extraterrestrial intelligence, particularly within our local reach.

For a moment, ponder the book cover and consider Ashpole's book title. Those elements set the stage for a viewpoint of the Universe that substitutes looking over and pondering our pale blue dot rather than a traditional myopic search for the proverbial E.T. It is from this vantage point that he launches off towards a major hypothesis in human history: *that life and intelligence are universal phenomena*. Ashpole decrees this hypothesis "the Grand Hypothesis, because they don't come any grander."

Indeed the term grand is most fitting. Hardly a week goes by without new exciting revelations of life as we know it here on Earth and evolutionary transformations of past epochs. Head on, Ashpole walks readers through relevant aspects of both our carbon/oxygen terrestrial evolution, while at the same time contrasting it with other theoretical life forms. Delving deeper, he explores the four key chemical bases in our own DNA and the role that environment can play in defining life. If his conclusions are correct, there are important implications for life within the Universe.

As for intelligence, Ashpole follows an evolutionary path for the development of sentience. He builds a compelling case for evolutionary opportunities and pathways that lead to biological intelligence. While he skirts issues of how an extraterrestrial may differ, he challenges us to wonder where life-form development can or must lead to avoid our current intellectual limits. In that vein, he unquestionably accepts that curiosity is a *quid pro quo* of intelligence.

As for aliens, where are they, indeed? The mere mention of UFOs limits serious publication and has ended careers. Ashpole attacks the deadly three-letter initialism with fervour, lashing out at UFOlogy on one side and the head-in-the-sand science community on the other. No camp is allowed to hide under cover of opinion, tradition, comfort, or complacency.

After discussing the astronomical odds (literally) of identical human/alien DNA, Ashpole repeatedly and unceremoniously pleads for a tiny alien body part—any body part. A hair, a scale—it need not be an entire dead or alive alien! He focuses hard on testable evidence and rightly so. Hearsay, opinions, and *Ad Populum* arguments need not apply.

The science community largely dismisses extraterrestrial reports. Popular discussions are rebranded as SAC—Strange Aerial Craft—to provide cover for authors to prevent them being labelled UFOlogists. However Ashpole claims to have sensed some changes within the community, most obviously by the acceptance and growth in SETI. His Grand Hypothesis can only be tested through the application of the scientific method and that requires an open-minded and engaged scientific community.

For full disclosure, I have been a SETI@Home participant from the beginning. I do agree the SETI programs make highly debatable assumptions, as Ashpole points out. Nevertheless, he concedes that SETI has contributed scientifically, as well as given credibility to discussions about detecting extraterrestrial intelligent life. Yet he presents strong points for the need to look elsewhere and in particular within our local reach.

Ashpole argues that alien development and curiosity must progress to the search for pale blue dots like ours. He shows that there has been sufficient time and opportunity for such development. Given the success of our developments in robotic technology, its relatively fast pace, and superiority in space travel, Ashpole offers a convincing thesis that it is time to apply science to local phenomena and actively search for signs of our being the subject of interest of extraterrestrial intelligence. In his mind, confirming the Grand Hypothesis may be within our current reach.

While in the general science genre, the presentation style is almost textbook-like, frequently repeating the main themes. The book is engaging and a quick read. I would have liked to have seen some visuals: charts, diagrams, and photos. There is a short "Notes and Reference" section. Interestingly, Ashpole provides mostly Internet references, which makes casual follow-up easy. Is there a TV mini-part series in the future—pity!

Overall, interesting and engaging, one for which I'm glad to have taken the time. ✶

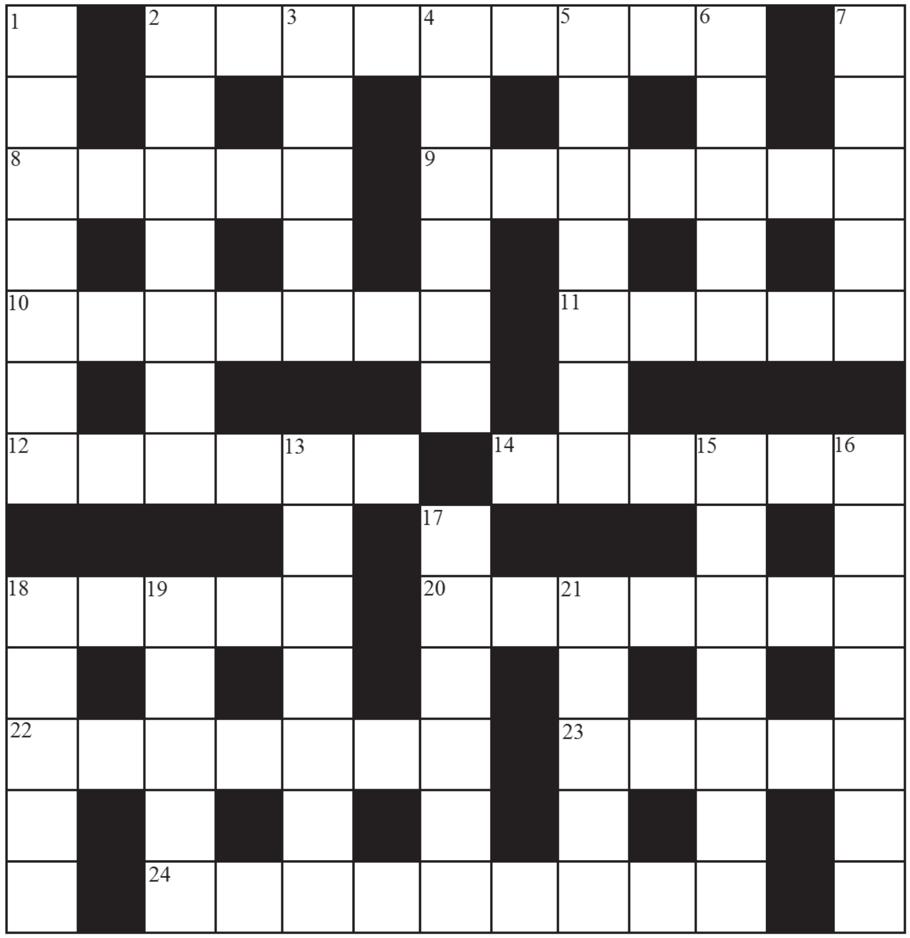
Ken Metcalfe is a member of RASC Winnipeg with additional interests in cosmology: life, the Universe, and everything!

ACROSS

2. A great comet finder manoeuvred the kayak around university (9)
8. Where first magnitude stars face the worst light pollution (5)
9. Lopped off right after a shift in frequency (7)
10. Spectroscopist found helium in Trojan's sentry position (7)
11. What is this hare star doing in a circumpolar nebula? (5)
12. Toady finally, finally locates Mensa in disarray (3-3)
14. Commercial heat began at the Altar in the Big Dog (6)
18. Where cones concentrate in the field of view, half of each (5)
20. Lunar formation theory made California erupt wildly (7)
22. An odd present for Ophiuchus to hold (7)
23. Open spaces highlight the Southern Triangle (5)
24. CoRoT orbits toward loud source of comets (4,5)

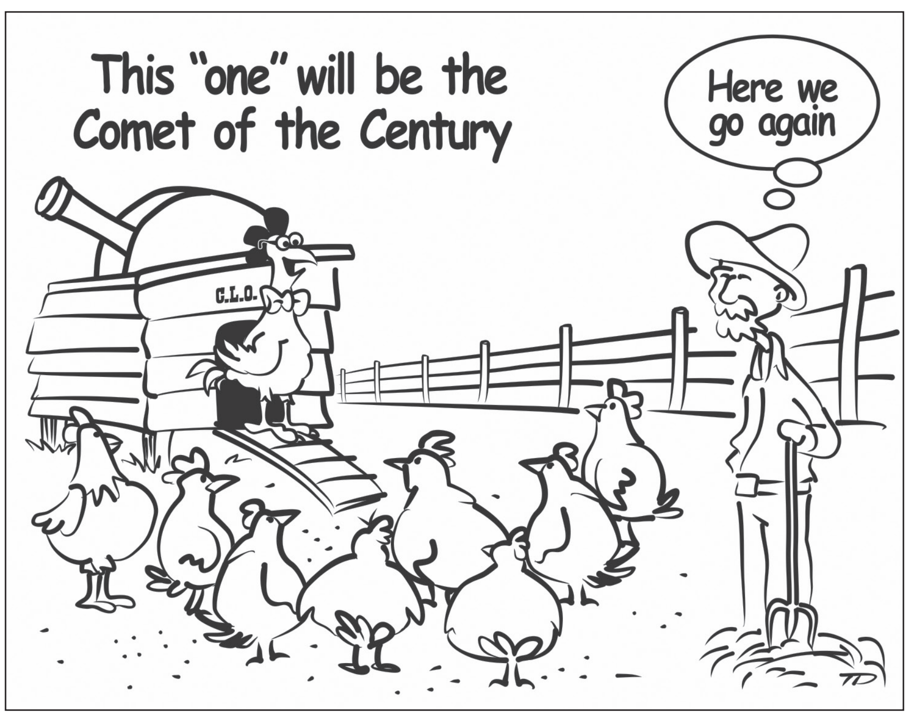
DOWN

1. Adoration and elation for a comet hunter (7)
2. Sun spins back to retro 1957-8 after hydrogen appeared in a lunar crater (7)
3. Orbital position shifts westward in quasi-space (5)
4. It is partly found in a family of asteroids (6)
5. The first research and development highlight in Hydra (7)
6. Meteorite Millie appeared in a Bonestell engraving (5)
7. Star with a right ascension in Corona Borealis or in Scorpius (5)
13. Brew a rum/tea blend for a hobbyist astronomer (7)
15. A question you text before dry summer shower (7)
16. Normal ones who see Vega are screwed up (7)
17. Alpha Ceti with carbon acid (6)
18. Planetary trench carved back in mostly soft, partly salty soil (5)
19. Six Romans go for the maiden (5)
21. Italian river flows around the latitude of a prominent crater (5)



It's Not All Sirius

by Ted Dunphy



THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

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Journal

Great Images

The Orion Nebula is a familiar object at this time of year, but most photographers have a difficult time handling the wide range of brightness when imaging this object. Halifax Centre's Blair MacDonald used his processing talents to suppress the bright core of the nebula while making the faint outlying parts visible. Even the four Trapezium stars can be seen in the centre of the nebula.