The Journal of The Royal Astronomical Society of Canada

Journal

Le Journal de la Société royale d'astronomie du Canada

PROMOTING ASTRONOMY IN CANADA

June / juin 2016
Volume/volume 110
Number/numéro 3 [778]

Inside this issue:

Sulawesi Eclipse

The Best of Monochrome.

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

The Jellyfish Nebula (IC 443) in the constellation Gemini was photographed from Joel Parkes's observatory in Meaford, Ontario, using a Takahashi TOA 130-mm ƒ/7.7 refractor fitted with an ST8XME CCD camera from Santa Barbara Instrument Group. Exposure through an Astrodon 5-nm Hα filter was for 1 h and 20 min and the data processed using MaxIm DL and Photoshop.

Journal
June/juin 2016 | Vol. 110, No. 3 | Whole Number 778

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

contents / table des matières

Feature Articles / Articles de fond

Columns / Rubriques

Departments / Départements

Judy Anderson shot this eclipse image from Sulawesi, Indonesia (Lat. 1° 08.8′ S, Long. 119° 55.3′ E). She used a Canon EOS 70D at ISO 640 with a Canon EF 100–400-mm zoom lens (1:4.5-5.6 L IS) set at 400 mm and ƒ/10. Exposure was 1/8000s on live view and silent mode.

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.

His Excellency the Right Honourable **David Johnston**, C.C., C.M.M., C.O.M., C.D., Governor General of Canada, is the Viceregal Patron of the RASC.

The *Journal* of The Royal Astronomical Society of Canada is published at an annual subscription rate of $93.45 (including tax) by The Royal Astronomical Society of Canada. Membership, which includes the publications (for personal use), is open to anyone interested in astronomy. Applications for subscriptions to the *Journal* or membership in the RASC and information on how to acquire back issues of the *Journal* can be obtained from:

The Royal Astronomical Society of Canada
203 – 4920 Dundas St W
Toronto ON M9A 1B7, Canada

Email: nationaloffice@rasc.ca
Web site: www.rasc.ca
Telephone: (416) 924-7973
Fax: (416) 924-2911

Canadian Publications Mail Registration No. 09818
Canada Post: Send address changes to 203 – 4920 Dundas St W, Toronto ON M9A 1B7

Canada Post Publication Agreement No. 40069313
We acknowledge the financial support of the Government of Canada through the Canada Periodical Fund (CPF) for our publishing activities.

 ISSN 0035-872X

President's Corner

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

As I form these words (can we call it "writing," if it's done on a computer?), I reflect that only a few short weeks remain in my 2nd term as President. It has been a great two years, and we have accomplished much. Our Society is on a good footing to progress on into the future, with strong leadership on the Board of Directors and at the Society Office. There's much for me to do, so I won't be fading into the background—just changing directions, again.

While we consider where we in the RASC are heading, take some time to look back on our past. We are nearing 2018, a year-long celebration of our beginnings—a 150th anniversary of the roots of the RASC in the Toronto Astronomical Club in 1868, which quickly became the Astronomical and Physical Society of Toronto. You would do well to set some time aside for our rich written history, *Looking Up* by Peter Broughton FRASC. If you can't get a printed copy, it's available at www.rasc.ca/sites/default/files/LookingUp-300-text.pdf or as a DJVU file.

Included in *Looking Up* is a narrative of our several National Offices, from the beginnings in 1893 on McGill Street to our present location at 4920 Dundas Street West. On the Encyclopedia Urania site, I count 10 addresses www.rasc.ca/national-office-rasc, but we have just moved down the hall on April 1 and kept the same address, which makes 11. How cool is that? The new digs give us much more room, opportunities for growth, and some degree of privacy, when needed. Whenever your travels find you in Toronto, drop by for a visit. The staff there always enjoy meeting our members in person.

There is much talk both for and against the notion of human-caused climate change and the implications of it, but I can tell you this for certain, there is more moisture in the atmosphere than ever before. When was the last time you actually got to see the sky? Night or day? I despair of these dreary days, with clouds, clouds, clouds. Not to worry, though, as warmer weather abounds, we look forward to getting the scope out of storage, dusting off the mirror, and doing some real astronomy. Yes!

Let's cheer on the Clear skies! ✶

News Notes / En Manchette

Compiled by Jay Anderson

Does TW Hydrae host Earth's twin?

Observations from the Atacama Large Millimetre/submillimetre Array (ALMA) have revealed details of a planet-forming disk around TW Hydrae, a nearby Sun-like star. The observations show an intriguing gap in the disk at the same distance from the parent star as the Earth is from our own Sun. Such gaps are usually taken as evidence that a proto-planetary body is clearing the dust and gas in that region, which in this case may be evidence of a younger version of our own planet or a more massive "super-Earth."

TW Hydrae is a young star—about 10 million years old—that lies only 175 light-years away. The dust-and-gas disk is seen face on, providing an undistorted view of the complete stellar disk.

According to Sean Andrews of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Massachusetts, "The new ALMA images show the disk in unprecedented detail, revealing a series of concentric dusty bright rings and dark gaps, including intriguing features that suggest a planet with an Earth-like orbit is forming there." The additional gap features lie at positions corresponding to the distances of Uranus and Pluto in our own Solar System, and are also likely the result of gravitational "sweeping" of material and the shepherding of nearby debris into well-defined bands similar to the processes at work in Saturn's ring system.

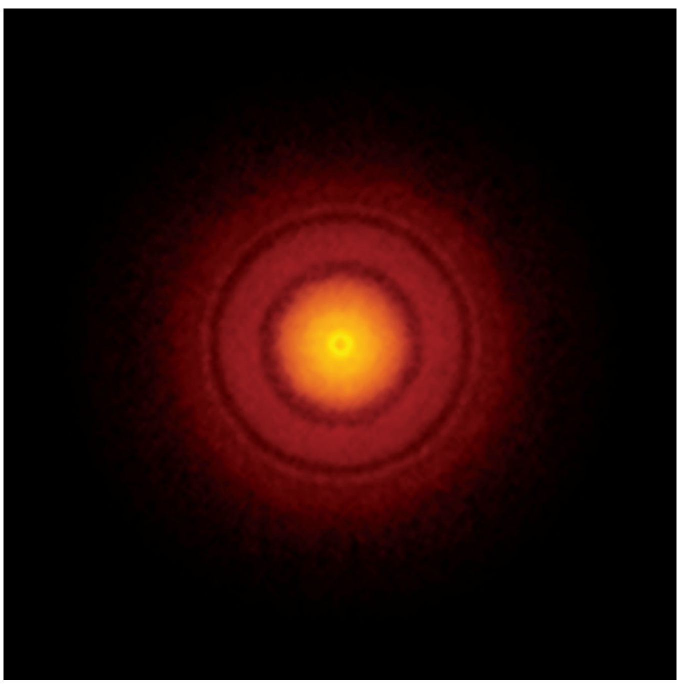


Figure 1 — This picture of the nearby young star TW Hydrae reveals the classic rings and gaps that signify planets are in formation in this system. TW Hydrae is a popular target of study for astronomers because of its proximity to Earth and its status as an infant (or T Tauri) star about 10 million years old. Its distance has been recently re-calculated to be as close as 38 pc. The star itself is slightly less massive than the Sun, spectral type K8IVe. Image: S. Andrews (Harvard-Smithsonian CfA); B. Saxton (NRAO/AUI/NSF); ALMA (ESO/NAOJ/NRAO).

The detailed observations were made possible with ALMA's high-resolution, long-baseline configuration. Because of its proximity to the Earth, ALMA was able to resolve details at TW Hydrae down to a scale of one AU (astronomical unit) in its long-baseline arrangement. "This is the highest spatial resolution image ever of a protoplanetary disk from ALMA, and that won't be easily beat going forward," said Andrews.

Earlier ALMA observations of another system, HL Tau, show that even younger protoplanetary disks—a mere 1 million years old—can display similar signatures of planet formation. By studying the older TW Hydrae disk, astronomers hope to better understand the evolution of our own planet and the prospects for similar systems throughout the galaxy.

This article was compiled from information provided by the Harvard-Smithsonian Center for Astrophysics and the European Southern Observatory.

The Heart of 3C 273

Space-based radio astronomy scored a news-making success recently with the Very-Long Baseline Interferometry (VLBI) observations of the quasar 3C 273 by the Russian spacecraft RadioAstron and four other Earth-based telescopes. VLBI techniques combine the signal from several telescopes to give an effective resolution equivalent to a telescope with a size equal to the separation of the individual components. Before space-based astronomy, the greatest resolution obtained was equivalent to an Earth-sized telescope, since the individual instruments could not be separated by more than the diameter of the planet. RadioAstron has an orbit that takes it as much as 360,000 km from the Earth, effectively creating a telescope of almost eight Earth diameters in size and obtaining an unprecedented resolution as small as 26 microarcseconds.

Supermassive black holes, containing millions to billions times the mass of our Sun, reside at the centres of all massive galaxies. These black holes can drive powerful jets that emit prodigiously, often outshining all the stars in their host galaxies. But there is seemingly a limit to how bright these jets can be—when electrons get hotter than about 100 billion degrees, they interact with their own emission to produce X-rays and Gamma-rays and quickly cool down. RadioAstron observations now call this limit into question.

"We measure the effective temperature of the quasar core to be hotter than 10 trillion degrees!" comments Yuri Kovalev (Astro Space Center, Lebedev Physical Institute, Moscow,

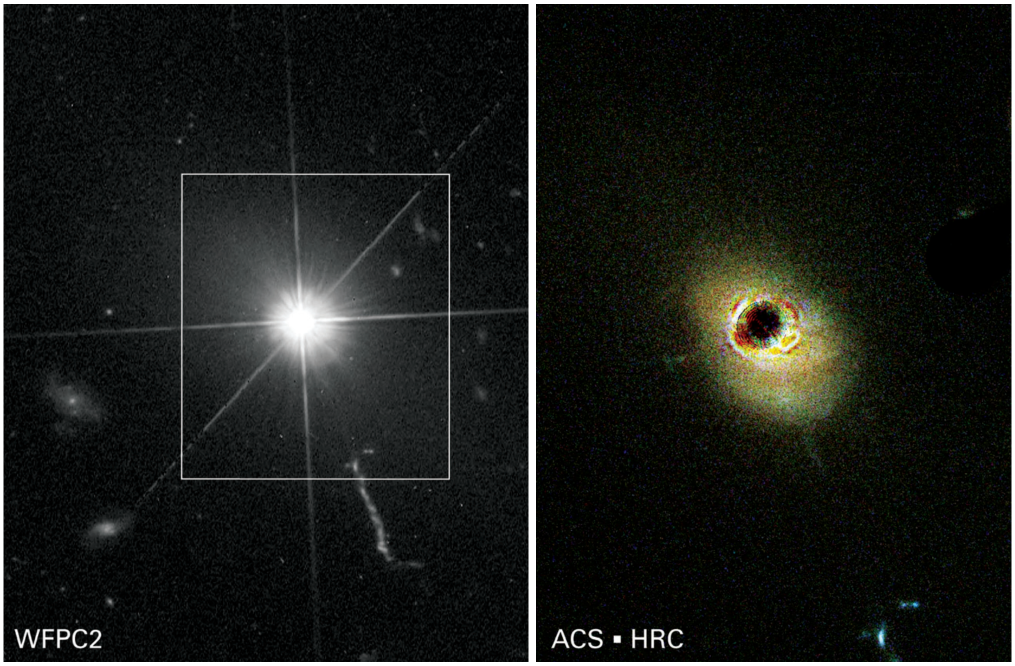


Figure 2 — The quasar 3C 273 is revealed in this pair of Hubble Space Telescope *images, one (left) acquired by the older Wide-Field Planetary Camera 2, shows the brilliant quasar but little else. The diffraction spikes demonstrate the quasar is truly a point-source of light because the black hole's "central engine" is so compact. The newer Advanced Camera for Surveys (ACS) coronagraph reveals features in the surrounding galaxy that are normally drowned out by the quasar's glow. The ACS reveals a spiral plume wound around the quasar, a red dust lane, and a blue arc and clump in the path of the jet blasted from the quasar. Previously known clumps of hot gas and the inner blue optical jet are now resolved more clearly. Image: NASA and J. Bahcall (IAS).*

Russia), the RadioAstron project scientist. "This result is very challenging to explain with our current understanding of how relativistic jets of quasars radiate." "The fact that RadioAstron has measured extreme brightness temperatures already in several objects, including the recently reported observations of BL Lacertae, these measurements indeed point out new underlying physics behind the energetic sources of radiation in quasars," states Andrei Lobanov, the coordinator of RadioAstron activities at the Max Planck Institute for Radio Astronomy (MPIfR) in Bonn, Germany.

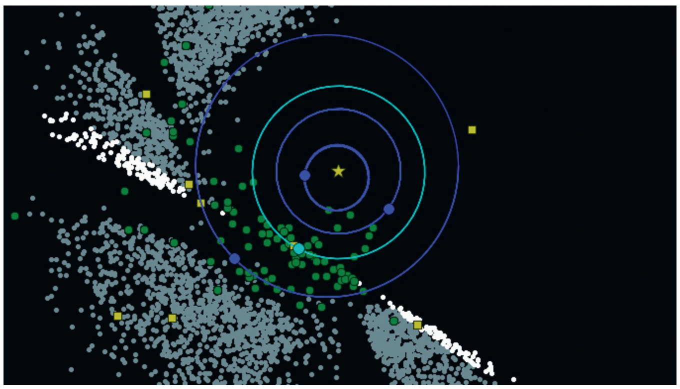
The incredibly high temperatures were not the only surprise the RadioAstron team has found in 3C 273. The team also discovered an effect never seen before in an extragalactic source: the image of 3C 273 has substructure caused by the effects of peering through the dilute interstellar material of the Milky Way. "Just as the flame of a candle distorts an image viewed through the hot turbulent air above it, the turbulent plasma of our own galaxy distorts images of distant astrophysical sources, such as quasars," explains Michael Johnson of the Harvard-Smithsonian Center for Astrophysics, who led the scattering study. He continues: "The amazing angular resolution of RadioAstron gives us a new tool to understand the extreme physics near the central supermassive black holes of distant galaxies and the diffuse plasma pervading our own galaxy."

Compiled from information provided by the Harvard-Smithsonian Center for Astrophysics and the Max Planck Institute for Radio Astronomy.

NEOWISE ups the threat level

NASA's *Near-Earth Object Wide-field Survey Explorer* (NEOWISE) mission has released its second year of survey data. The spacecraft has now characterized a total of 439 NEOs since the mission was re-started in December 2013. Of these, 72 were new discoveries (Figure 3). With the release to the public of its second year of data, NASA's NEOWISE spacecraft completed another milestone in its mission to discover, track, and characterize the asteroids and comets that approach closest to Earth.

Near-Earth Objects (NEOs) are comets and asteroids that have been nudged by the gravitational attraction of the giant planets in our Solar System into orbits that allow them to enter Earth's neighbourhood. Eight of the objects discovered in the past year have been classified as potentially hazardous asteroids (PHAs), based on their size and how closely their orbits approach Earth. One such body, Comet P/2016 BA14, passed by our planet on March 22 at a distance of 4 million km (Figure 4) and was imaged by ground-based radar.



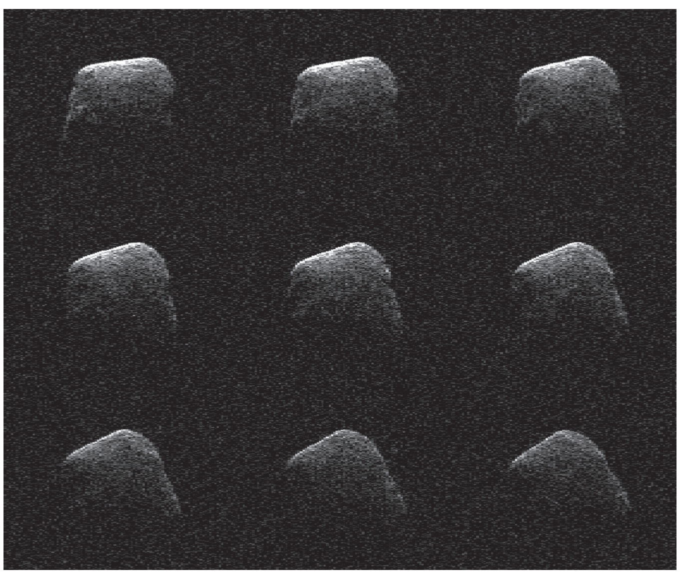


Figure 3 (top)— This "snapshot" of the inner Solar System shows asteroids and comets observed by NASA's Near-Earth Object Wide-field Survey Explorer *(NEOWISE) mission at one particular moment. Green circles represent near-Earth objects. Yellow squares represent comets. Gray dots represent all other asteroids, which are mostly in the main asteroid belt between Mars and Jupiter. The orbits of Mercury, Venus, Earth, and Mars are shown. Image: NASA/JPL-Caltech/UCLA/JHU.*

Figure 4 — Radar data of comet P/2016 BA14 taken over three days (2016 March 21–23), when the comet was between 4.1 million kilometres and 3.6 million kilometres from Earth. Radar images and data from the flyby indicated that the comet is about 3000 feet (1 kilometre) in diameter. Image: NASA/JPL-Caltech/GSSR.

Since beginning its survey in December 2013, NEOWISE has measured more than 19,000 asteroids and comets at infrared wavelengths. More than 5.1 million infrared images of the sky were collected in the last year.

"By studying the distribution of lighter- and darker-coloured material, NEOWISE data give us a better understanding of the origins of the NEOs, originating from either different parts of the main asteroid belt between Mars and Jupiter or the icier comet populations," said James Bauer, the mission's deputy principal investigator at NASA's Jet Propulsion Laboratory in Pasadena, California.

Originally called the *Wide-field Infrared Survey Explorer* (WISE), the spacecraft was launched in December 2009. It was placed in hibernation in 2011 after its primary mission was completed. In September 2013, it was reactivated, renamed NEOWISE and assigned a new mission: to assist NASA's efforts to identify the population of potentially hazardous near-Earth objects. NEOWISE also is characterizing previously known asteroids and comets to provide information about their sizes and compositions.

"NEOWISE discovers large, dark, near-Earth objects, complementing our network of ground-based telescopes operating at visible-light wavelengths. On average, these objects are many hundreds of metres across," said Amy Mainzer of JPL, NEOWISE principal investigator. NEOWISE has discovered 250 new objects since its restart, including 72 near-Earth objects and four new comets.

NASA defines Potentially Hazardous Asteroids (PHAs) as "all asteroids with an Earth Minimum Orbit Intersection Distance (MOID) of 0.05 AU or less and an absolute magnitude (H) of 22.0 or less are considered PHAs." That means asteroids that can come within 7,480,000 km of Earth and are at least 150 m in diameter.

Compiled with material provided by the Jet Propulsion Laboratory.

The Missing Brown Dwarfs

When re-analyzing catalogued and updated observational data of brown dwarfs in the solar neighbourhood, astronomers from Potsdam have found that a significant number of nearby brown dwarfs should still be out there, awaiting their discovery. The study by Gabriel Bihain and Ralf-Dieter Scholz from the Leibniz Institute for Astrophysics Potsdam (AIP) challenges the previously established picture of brown dwarfs in the solar neighbourhood.

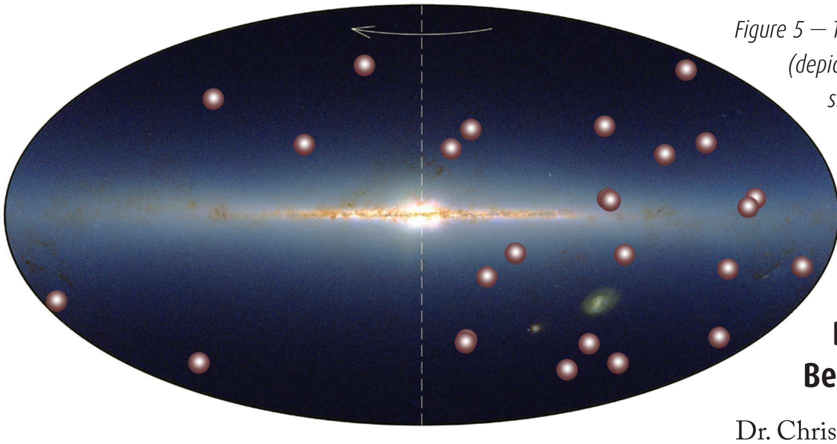


Figure 5 — The distribution of known nearby (d <6.5 pc) brown dwarfs (depicted as brown spheres) shown against the background of a sky panorama in infrared light. The arrow indicates the direction of the rotation of the Milky Way; the dotted line separates the two very differently populated hemispheres. Image: AIP/2MASS).

Brown dwarfs are objects that are too large to be called planets, yet too small to be stars. Having a mass of less than seven percent of the mass of the Sun, they are unable to create sufficient pressure and heat in their interiors to ignite hydrogen-to-helium fusion, a fundamental physical mechanism by which stars generate radiation. In this sense, brown dwarf are "failed stars." It is therefore important to know how many brown dwarfs really exist in different regions of the sky in order to achieve a better understanding of star formation and of the motion of stars in the Milky Way.

Gabriel Bihain and Ralf-Dieter Scholz have taken a careful look at the distribution of nearby known brown dwarfs from a point of view that was not looked at before. To their surprise they discovered a significant asymmetry in the spatial configuration, strongly deviating from the distribution of stars in the nearby Milky Way.

"I projected the nearby brown dwarfs onto the galactic plane and suddenly realized: half of the sky is practically empty! We absolutely didn't expect this, as we have been looking at an environment that should be homogeneous," Gabriel Bihain explained. Seen from Earth, the empty region overlaps with a large part of the northern sky.

The scientists concluded that there should be many more brown dwarfs in the solar neighbourhood that are yet to be discovered and that will fill the observed gap. If they are right, this would mean that star formation fails significantly more often than previously thought, producing one brown dwarf for every four stars. In any case, it appears that the established picture of the solar neighbourhood and of its brown dwarf population will have to be rethought. "It is quite possible that not only brown dwarfs are still hiding in the observational data, but also other objects with even smaller, planetary-like masses. So it is definitely worth it to take another deep look at both existing and future data," Ralf-Dieter Scholz concluded.

Compiled with material provided by the Leibniz Institute for Astrophysics Potsdam (AIP).

Dr. Chris Pritchet to receive the 2016 Beals Award from CASCA

Dr. Chris Pritchet of the University of Victoria has been selected as the 2016 recipient of the Carlyle S. Beals Award by the Canadian Astronomical Society (CASCA). The Beals Prize is awarded biennially "to a Canadian astronomer or an astronomer working in Canada, in recognition of outstanding achievements in research (either for a specific achievement or for a lifetime of research)."

Dr. Pritchet's interests lie in supernovae, galaxy formation and evolution, high-velocity clouds, image processing and data handling, stellar populations in nearby and distant galaxies, chemical evolution of galaxies, galaxy interactions and kinematics, galaxy luminosity functions, stellar coalescence, and the blue straggler phenomenon. He is the Principal Investigator of the Canadian Network for Astronomical Research, a CANARIE-funded cloud-computing project. ✶

Research Article / Article de recherche

Analyses of *Great World Wide Star Count* (GWWSC) and *Globe At Night* (GAN) Light-Pollution Data using Microsoft Excel Pivot Tables.

(Is Light Pollution Getting Better or Worse? Is More Light Making Our World Safer and More Secure?)

by James Cleland, President Astro Club Borealis, Edmundston, Member Administrative Committee Aster Observatory (jherbc@gmail.com)

Abstract

Data from Great World Wide Star Count and Globe at Night were used to determine if light pollution is increasing during the 8-year period of the surveys. It was also possible to look at various regions centred about some cities and determine if all areas are changing at the same rate. Worldwide light pollution increased during the 8-year period of the surveys, but not all areas changed at the same rate. Using murder rates per 100,000 as a proxy or index of violent crime, this data was compared with the amount of light pollution to determine if this measure of security and safety actually improved with higher amount of lighting used in various areas. A time study compared lighting use with murder rates in Canada from 1920 to 2014. Both sets of data show that increased use of lighting is not effective in reducing murder rate.

Today it is very difficult to be involved in astronomy without being concerned about light pollution. Lighting use is growing at an estimated rate of 5 percent to 7 percent per year (11, 13). This means that we are using 100 times more light than we did in 1920 and 50 times more light than we did in 1950. It is commonly assumed one of the reasons this is happening is that we need more light to be safe and secure—the perception that many business people have when asked if they could shut their store lights off after closing their stores. The common answer is "I need them for security." Today it is a common perception among members of the public that you need all these lights for security. A recent article about reducing light pollution in Hong Kong was quoted as saying, "However, some quarters fear that enacting laws against light pollution may affect commercial and tourism businesses and even have an impact on the safety of streets and neighbourhoods." [12] The reality is that Hong Kong's limiting magnitude is 2.2 and its murder rate is 0.4 per 100,000 compared to some cities, which are as high as 40.

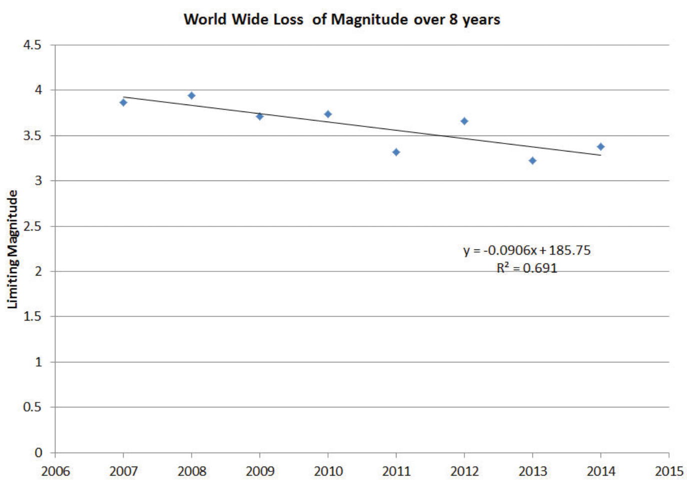
Great World Wide Star Count (GWWSC) and Globe at Night (GAN) surveys were both started in 2007. Each survey measures light pollution by having people look at a particular constellation to see how many stars are visible. Charts are used to determine what the limiting magnitude is for a given location and time. Magnitude is the way stars' relative brightness is measured. The brightest stars are approximately 1st magnitude. At a clear, dark site under good conditions, an observer with good eyes can see stars as dim as 7th magnitude. Numbers from these surveys range from 1 (extreme light pollution) to 7 (pristine, dark sky). Participating in these surveys can give someone a better understanding of light pollution, how it works and how pervasive it is. A person can see first-hand the effects of urban sprawl and how far from a city light pollution goes. After a few surveys you can learn that the light dome from this small city like Edmundston, New Brunswick, Canada, extends out for at least 100 km and that there is no pocket of good visibility available less than one hour away.

Excel is a powerful tool that can be used to analyze large amounts of data. Pivot tables are a convenient tool that allow data to be summarized and broken down so that trends and patterns in the data can be shown. Looking at both data sets from Globe at Night and Great World Wide Star Count gave a total of over 100,000 usable data points after eliminating all points that had no light-pollution reading because of less than clear skies. With such a rich source of data there should be a few good pieces of information in it.

Certainly there are issues with the data from these two surveys. It is collected by a variety of people with a variety of backgrounds. It is only collected to the nearest magnitude. The locations are chosen randomly so it is difficult to make comparisons in time. Huge areas of the inhabited world have only a few data points. Given these limitations, it was decided to work with the data set to see what could be learned from it.

In an effort to compare cities, or more properly, regions centred on cities, a 5-degree longitude by 5-degree latitude area was chosen. This is approximately the area influenced by the light pollution from large cities or a diameter of 500 kilometres. This size was also chosen because it gave several regions with relatively large amounts of data ranging from 500 to 7000 points. In blocks with many points, it was possible to look at year-over-year trends. Regions with smaller amounts of data could only be benchmarked as an average against other cities.

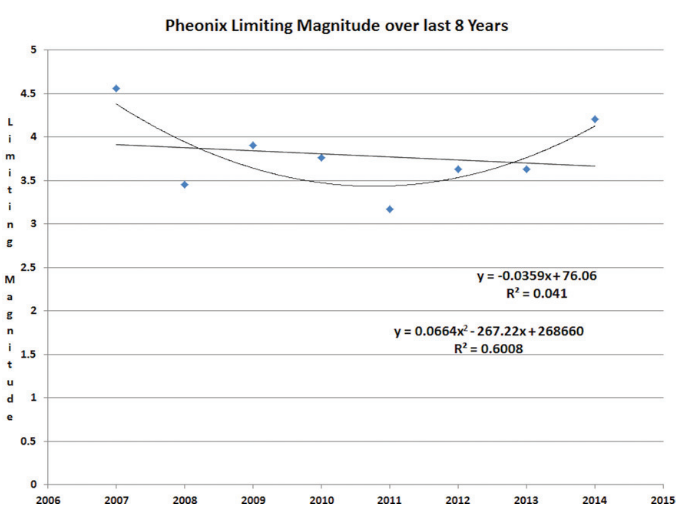
Both GWWSC and GAN have been going on since 2007. If you plot the eight annual world averages, it shows that light pollution has been steadily increasing. We are losing our stars at an alarming rate of 0.1 magnitudes per year. The difference between 2007 and 2014 is equal to 0.7 magnitudes in the 8 years of the survey. At the current rate of lighting increase, the world average limiting magnitude will hit 1 by approximately 2040. That means only 15 stars would be visible at the average site across the world.

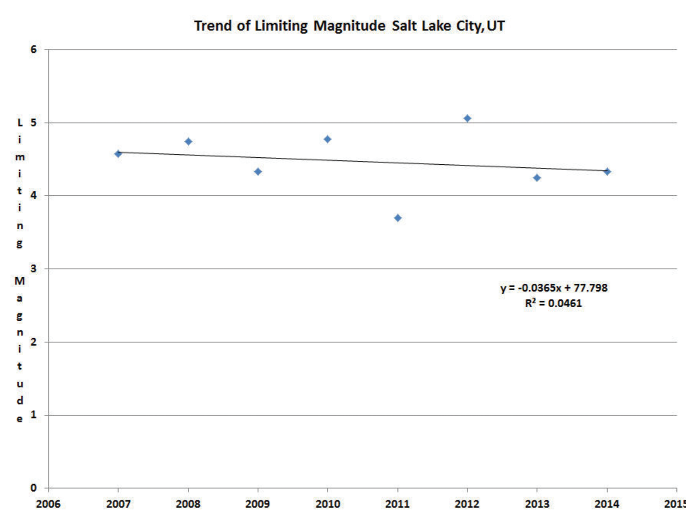


Graph 1

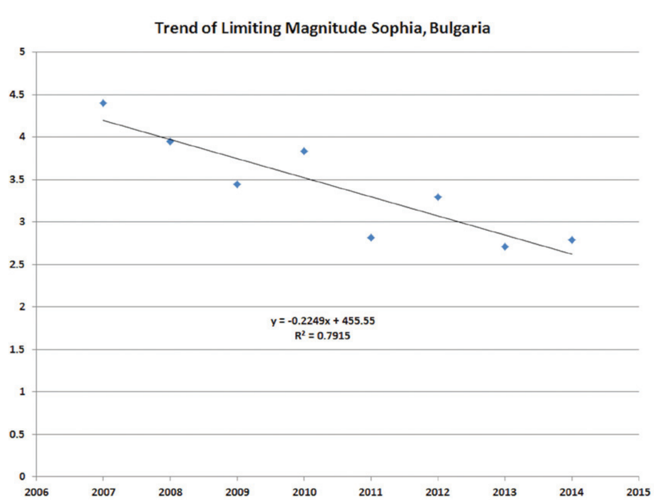
If you look at city region by city region, you have a more complex situation. Some areas are adding light at or above the world average pace. In other regions, there has not been a significant change in the 8-year period of the surveys. A few have reversed a trend of increasing lighting levels and started to reduce lighting. Still others have steadily reduced lighting levels over the 8 years in the study. Some examples are shown below and at right (graphs 2–6).

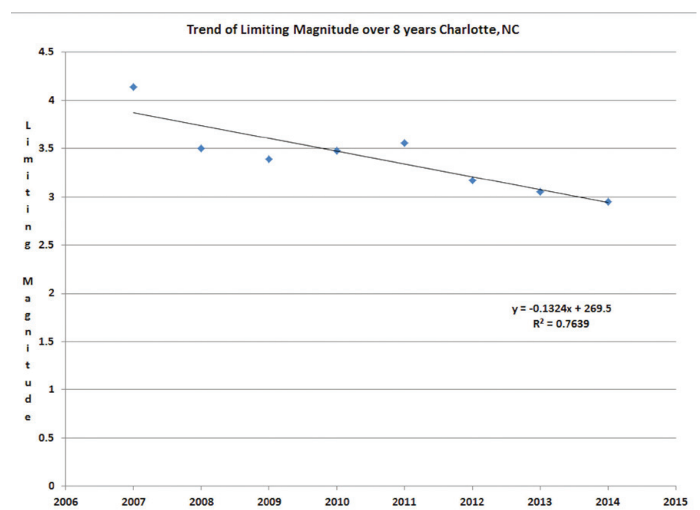
Various cities are ranked according to how fast they are increasing their lighting levels over the past 8 years based ona combination of GWWSCount numbers and GAN numbers. It can be seen that most cities are increasing their lighting levels very fast, about 20 percent of cities have been able to hold the line on lighting increases or even reduce their light levels. This kind of information can be used to gauge how effective efforts to reduce light pollution have been in various regions of the world. It is hoped that, once we know what approaches work to reduce light pollution, sharing of effective approaches will improve the results of light-pollution abatement efforts worldwide (graphs 7 & 8).



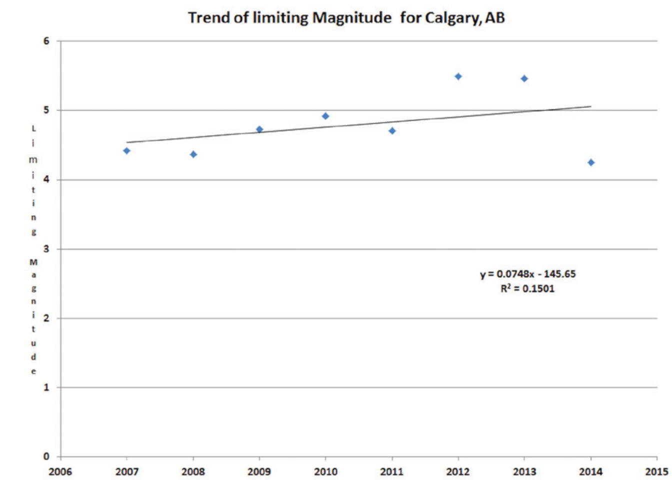


Graph 2 and 3 — Above are two examples of cities that have not increased lighting levels over the past 8 years.

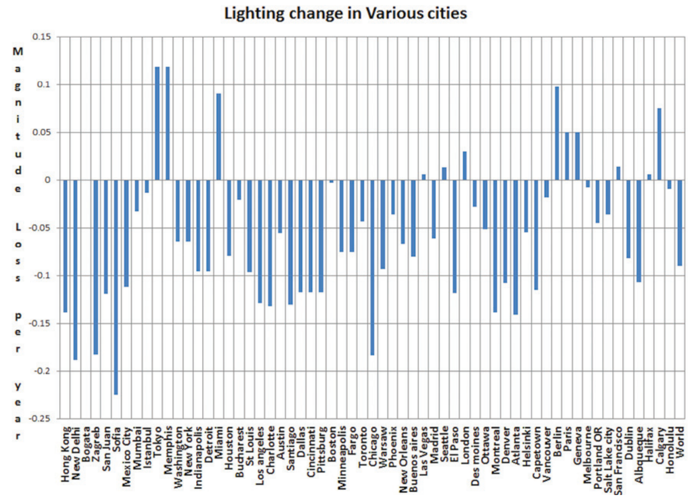




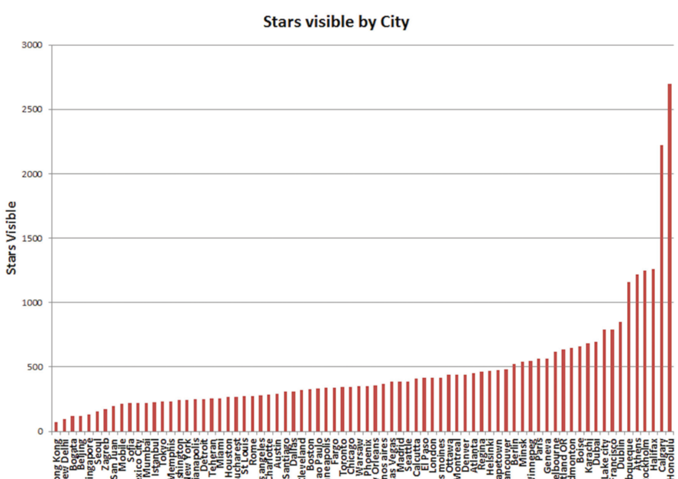
Graph 4 and 5 — Above are two examples of cites that have increased lighting levels at a rate faster than the world average of lighting increase.



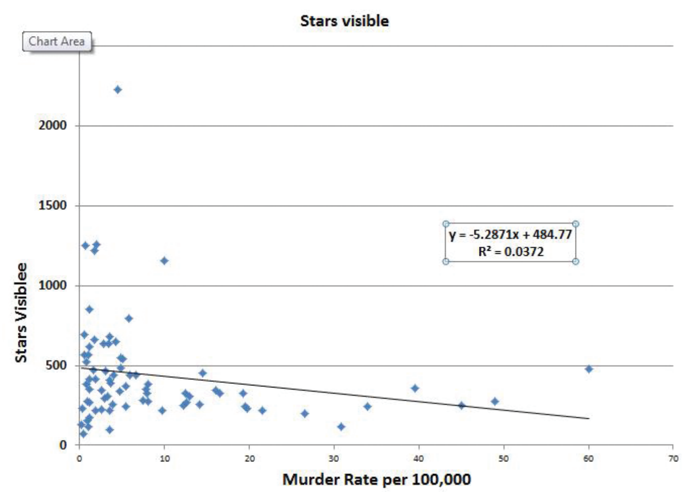
Graph 6 — Above is an example of a city that has been able to steadily reduce lighting levels over the past 8 years.



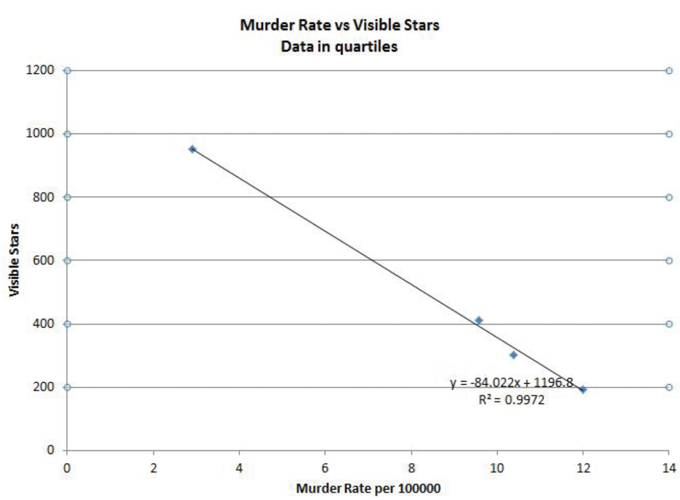
Graph 7



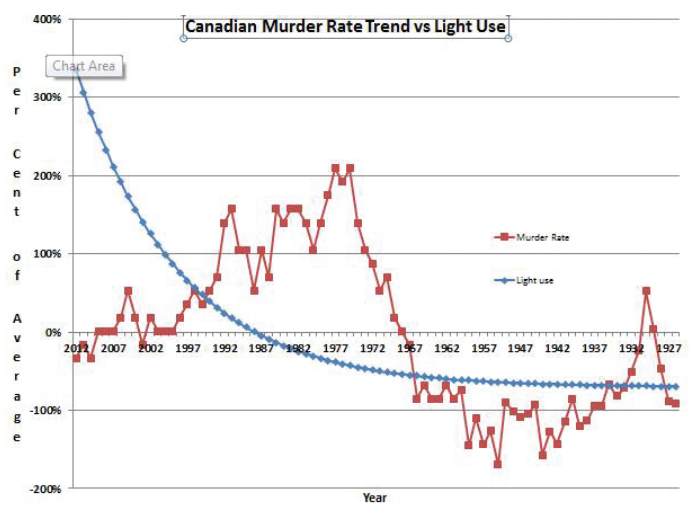
Graph 8 — Various cities are ranked by how intensely they are lit. You can see there is a large variation between cities where lighting is very intense and others that have much less intense lighting.



Graph 9



Graph 10



Graph 11

Using data from Statistics Canada, the FBI, and the WHO, it is possible to determine murder rates per 100,000 for all of the regions that have light-pollution data available. Murder rate was chosen as a measure of security and safety because it is reported more consistently over time and across regions than other measures of violent crime. Light-pollution data was plotted versus murder rate to see if, in general, cities with high levels of lighting were indeed "safer or more secure" as measured by their murder rate. Looking at the plot (Graph 9) there does not seem to be any relationship. The data was then grouped into quartiles to verify the conclusion. Surprisingly, there is a pretty good correlation between cities that are brightly lit and high murder rates, and conversely lower lighting levels and lower murder rates (see Graph 10).

Use of light has been growing at an estimated rate of five percent [11,13] per year, if this fact is taken and extrapolated back to 1920. Murder rates per 100,000 for Canada are available back to 1920 [3,4,5]. This plot (Graph 11) shows no correlation between murder rate in Canada and lighting level.

While this does not break the link between high lighting levels and safety and security, it certainly weakens the connection somewhat.

Conclusion

Even given the limitations of the database, it is still possible to draw some useful conclusions from this data. Overall lighting levels are increasing at an alarming pace. The data does show that this does not have to be the case, as some regions have been able to hold the line and some have actually been able to roll back lighting over the 8-year period studied. Benchmarking of light levels has been done across various regions. It shows that a lighting level giving a limiting magnitude of 5 is not impossible, not insecure, not unsafe, nor unreasonable. In fact, limiting lighting increase to no more than 2 percent [10] may be too conservative, when we know functioning well at or near limiting magnitude 5. A possible target could be to reduce lighting levels by 2 percent or possibly 4 percent per year. We know from animal studies that "artificial lighting generally does not seem to have any ecological benefits, especially in natural environments, and should therefore be reduced as much as possible to minimize ecological impacts and damage" [11]. It would not be unreasonable to assume that humans are affected negatively by light as well. An effort was made to show a link between lighting levels and security as measured by murder rates per 100,000 over time. Lighting levels in Canada have increased by over 100-fold since 1920. With this size of change. you would think that there would be an obvious change in the murder rate over this time that would correlate negatively with increasing lighting levels. This is not the case [Graph 11]. Another way to look at this issue is to compare murder rates in highly lit areas with murder rates in areas that are less highly lit. There is no relationship between murder rate as a measure of security and the amount of light that is used in a city [Graph 9].

Further work

It would be interesting to look at other aspects of safety and security versus light level, like auto accident frequency or violent crime rate. It is hoped that using the data from GWWSC and GAN would encourage wider participation in these surveys, especially in China, Russia, the Middle East, and the Southern Hemisphere. These types of surveys would help to hold political leaders to account for the money they spend on lighting and the energy wasted. The wide variation in lighting levels suggests that much of the money spent on lighting is being badly spent and is not achieving the results that were hoped for.

Compare results with satellite photos and attempt to digitize light pollution so that light use can be quantified. This would allow us to hold politicians, businesses, and individuals accountable for their expenditures in lighting. ✶

References

1. Dennis L. Ward, Copyright 2007, Globe at Night Maps and Data, University Corporation for Atmospheric Research, Light pollution Surveys Data 2007 to 2013, www.globeatnight.org/maps.php
2. Great World Wide Star Count, Windows to the Universe from the National Earth Science Teachers Association (NESTA), Light pollution surveys Data 2007 to 2014, www.windows2universe.org/citizen_science/starcount/results.html
3. Statistics Canada, Homicides and attempted murders, Canada, 1962 to 2013, Statistics Canada, Canadian Centre for Justice Statistics, Uniform Crime Reporting Survey, www.statcan.gc.ca/pub/11-630-x/2015001/c-g/desc2-eng.htm
4. Statistics Canada, Table Z15-20

   Murder, actual offences and persons charged, Canada, 1961 to 1975, for 1972 to 1975, Statistics Canada, *Crime and Traffic Enforcement Statistics*, (Catalogue 85-205); for 1962 to 1971, Statistics Canada *Crime Statistics (Police)*, (Catalogue 85-205); for 1961, Statistics Canada Judicial Division, unpublished figures, www.statcan.gc.ca/pub/11-516-x/sectionz/4147446-eng.htm
5. Wikipedia Population of Canada 1867 to 2014, Canada as a whole since confederation, https://en.wikipedia.org/wiki/Population_of_Canada
6. FBI murder rates by city 2012
7. Uniform Crime Rates: Murder: The Federal Bureau of Investigation FBI, Table 4 Crime in the United States by region, geographic division and state 2012-2013, www.fbi.gov/about-us/cjis/ucr/crime-in-the-u.s/2013/crime-in-the-u.s.-2013/violent-crime/murder-topic-page/murdermain_final
8. Nation Master, Crime > Murder Rate: Countries Compared, Copyright NationMaster.com 2003-2015, www.nationmaster.com/country-info/stats/Crime/Murder-rate
9. New Framework of Sustainable Indicators for Outdoor LED (Light Emitting Diodes) Lighting and SSL (Solid State lighting) – *Annika Jagerbrand, Sustainability 2015 7(1)* p. 1
10. New Framework of Sustainable Indicators for Outdoor LED (Light Emitting Diodes) Lighting and SSL (Solid State lighting) – *Annika Jagerbrand, Sustainability 2015 7(1)* p. 6, p. 17
11. New Framework of Sustainable Indicators for Outdoor LED (Light Emitting Diodes) Lighting and SSL (Solid State lighting) – *Annika Jagerbrand, Sustainability 2015 7(1)* p. 6
12. Task force suggests voluntary scheme to curb light pollution, Copyright 2013 Hong Kong Economic Journal Company Limited, www.ejinsight.com/20150423-task-force-suggests-voluntary-scheme-to-curb-light-pollution/
13. National park Service: Growth of Light Pollution, www.nature.nps.gov/night/growth.cfm 2013 November 13

Great Images

by Blair MacDonald

Blair MacDonald took this beautiful image of NGC 2359, an emission nebula surrounding a Wolf-Rayet star about 11,960 ly away. MacDonald used a Canon 60Da DSLR, on a 200mm SkyWatcher f/5 Newtonian reflector with Paracorr for a total focal length of 1150 mm and imaged from St. Croix, Nova Scotia.

What You Never Knew About Cleaning Optics

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

It's been over a year since I last had the pleasure of writing for the *Journal* as I've been a little preoccupied with another project. Still, I've been active in the local RASC scene, participating in an outreach program that involved speaking to seniors, the telescope maker community, and newly minted amateur astronomers. I wanted to share some insights on cleaning optics that I discovered while preparing for one of those talks.

We all want to preserve and maintain our expensive astronomical observing gear. Part of realizing that goal would be to keep the optics of that equipment clean. But what appears to be common sense would be wrong. Not only should we not be actively cleaning our optics, we are likely cleaning the wrong optics. And certainly in the wrong way!

In Harold Suiter's magnum opus *Star Testing Astronomical Telescopes*, he devotes the final section of Chapter Nine to the effect of dust and scratches on optical performance. Suiter refers to the accumulation of dust and other detritus as contributing to cosmetic errors much like the diffraction effects of spider vanes. There is a generalized scattering of light that has more of an effect on viewing bright objects like planets, where low-contrast details become washed out. In other words, the appearance of visibly dirty optics has a negligible effect on performance. His guideline is to ignore dirt that covers less than 1/10th of a percent of the optical surface area—say a pinch of salt thrown on the corrector plate of an 8″ Schmidt-Cassegrain.

In reality, you could probably throw an entire teaspoon of salt at that corrector plate and not notice any effect on visual performance, because only debris closer to the focal point will make its presence known. That means keeping eyepieces, diagonals, Barlows, focal reducers, and Newtonian secondary mirrors clean matters more than primary mirrors, corrector plates, and refractor objectives. A zeal for cleanliness is detrimental, because the cleaning process could cause damage by scratching the antireflective coatings of lenses or scratching the reflective aluminized surface of a mirror.

The best thing to do is ensure your optics are kept covered when not in use. Eyepieces can be stored in individual eyepiece bolt cases. Diagonals and Barlows can have both ends stoppered shut with plastic end caps. It's the formation of dew that deposits and seals atmospheric contaminants and dust onto refractor-lens objectives and corrector plates when it dries. This makes the cleaning process even more difficult, so the use of dew shields and anti-dew straps when operating the telescope is paramount.

When one ultimately reaches the point where cleaning is required, the first step is to debride the area of solid particles, which when wiped become the abrasive element for scratching optical or reflective coatings. Camera stores are a good source for soft bristle brushes and air bulbs with which to blow and swipe those particles away. Compressed cans of air should be avoided for a number of reasons. The cans themselves contain liquefied fluorocarbons (tetrafluorethane) as the propellant, which can often be expelled from a fresh can if not held perfectly vertical. In addition to contaminating the optical surface, these sprays sometimes contain antistatic chemical additives, which are sure to leave a residue when the fluorocarbon evaporates. While the propellant does technically have a freezing point below −100 °C, it's unlikely the cans are that heavily pressurized, so the propellant likely exists as a liquid closer to its boiling temperature of −27 °C. Indeed, I measured a stream of liquid propellant with a laser IR temperature reader at only −38 °C. This I believe debunks scenarios of −100 °C liquid thermal shock causing micro cracks in both optical coatings and glass elements. The cans should be avoided because there are simpler and better options that do not introduce residue.

Traditionally, optical coatings were singular in layer and were only a few molecules thick. The coating material is either

The Royal Astronomical Society of Canada

Vision

To be Canada's premier organization of amateur and professional astronomers, promoting astronomy to all.

Mission

To enhance understanding of and inspire curiosity about the Universe, through public outreach, education, and support for astronomical research.

Values

- Sharing knowledge and experience
- Collaboration and fellowship
- Enrichment of our community through diversity
- Discovery through the scientific method

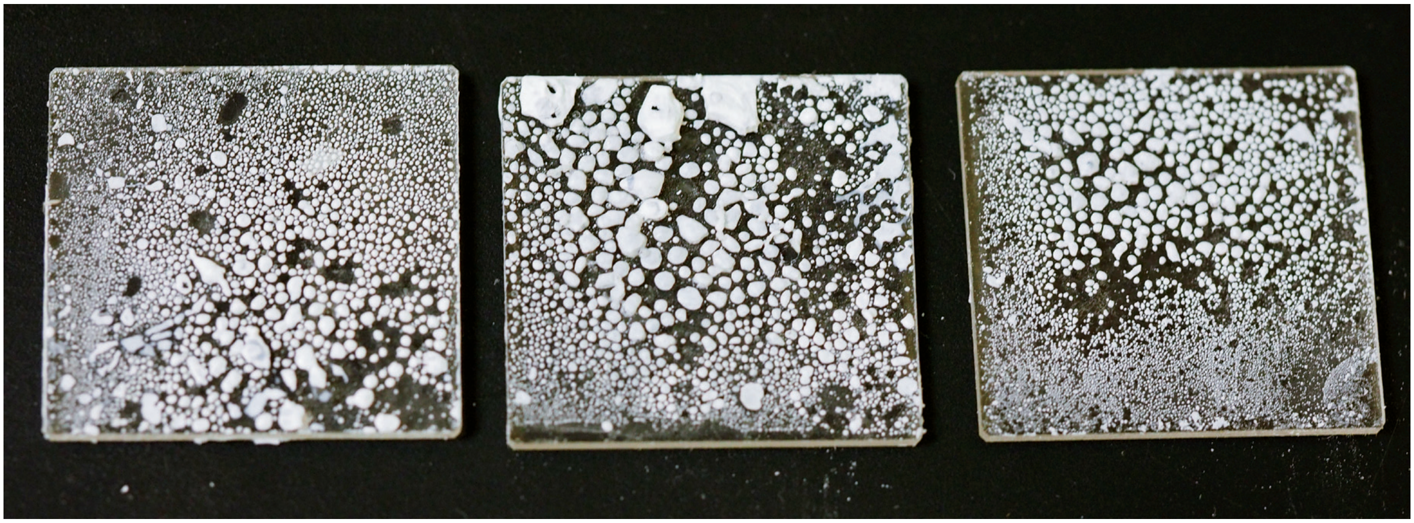


Figure 1 — Don't ever let your optics get this dirty—glass samples simulating deposit residue left by multiple dewing cycles.

heated resistively or applied through electron-beam bombardment until it vapourizes and passively settles on the optical surface being coated, forming a low-density, porous, and fragile coating that can absorb water. Optical coatings today are laid in multiple layers to provide better light transmission across a wider range of wavelengths, and the layers are much denser and better adhering due to processes like ion-assisted deposition and ion-beam sputtering. These processes accelerate heavy inert ions through a magnetic field into the developing coating layers and physically compress them. The resultant coatings are much more resistant to damage and are likely to be found on the eye lens of a modern eyepiece. Modern diagonals are also likely to feature very tough all-dielectric coatings that not only deliver near-100-percent reflectivity but are strong enough to withstand the repeated wiping action of a cleaning solution. Conversely, care should be taken if cleaning eyepieces, diagonals, refractors, and catadioptric telescopes made even late in the previous century. The reflective coating of primary mirrors still remains fragile, despite the introduction of overcoating the aluminized or silvered mirror surface with a simple dielectric layer of either silicon monoxide or titanium monoxide. The bombardment with a reactive-oxygen ion beam transforms the SiO to a tough quartz layer (SiO_2) able to withstand annual cleanings. So why not apply an all-dielectric mirror coating like those found in diagonal mirrors given how durable they are? Such coatings require as many as a hundred layers, which is thick enough to alter the final figure of the mirror if there is a variation as little as two percent in thickness. An all-dielectric mirror coating would also lack a metal bottom layer, which means the coatings cannot be simply stripped chemically but must be polished off if the mirror is to be recoated in the future—with further dire consequences to the figure!

I won't discuss the intricacies of cleaning methods or the different approach to cleaning refractive elements versus reflective surfaces. I will attempt to discuss the efficacy of a number of different commercially available cleaning solutions by testing them with quasi-scientific means. All of these formulations rely on some type of water-soluble organic solvent that is able to dissolve fingerprint or eyelash oil. They also require reagent-grade components, meaning chemicals that are at least 95 percent pure with no contaminants that could leave a residue. Acetone and any number of alcohols are very popular solvents and can be easily found at hardware stores or Canadian Tire, but they are all very impure. Likely the best source is from one of the big-name pharmacy chains that will often have 97-percent-pure isopropyl alcohol. Water is an important component since it's the water soluble contaminants in the air that deposit onto optical surfaces after repeated dewing cycles, and again the pharmacy is the best source for distilled water.

After a review of the most popular and reputable commercial optical cleaning solutions, I'm happy to advocate that you save your money and have some fun making your own. In this era of occupational safety and health legislation, all companies are required to accurately divulge the chemical composition of their products in a material safety data sheet (MSDS). Hence the Zeiss Lens Cleaner is simply four to six percent isopropyl alcohol and >94% water. Baader's Optical Wonder cleaning fluid is a mixture of ethanol and propanol alcohols. The only lone wolf is an interesting product from Purosol, which is advertised as an eco-safe organic plant enzyme extract that breaks the bonds that attach dirt to an optical surface, and reverses the surface charges to repel new deposits. The product found great success with military optics in the harsh environment of the Gulf Wars and with NASA in the oxygen-rich environments of spacecraft because of its lack of flammable ingredients. Indeed, its MSDS lists… nothing, because it has no hazardous components to disclose! Finally, the *Arkansas Sky Observatory* is well known to amateur astronomers because of the fine supercharging service that founder Dr. Clay Sherrod offers to owners of Meade Autostar telescopes. Dr. Clay also provides an online recipe for an optical cleaning solution that uses distilled water, isopropyl alcohol, Windex, and Photoflo. Photoflo is made by Kodak, is available from Henry's chain of camera stores, and is used as surfactant to reduce the surface tension of the optical cleaning solution and allow it to more easily wet surfaces, hence cleaning and evaporating more efficiently www.arksky.org/asoclean.htm.

I purchased some uniform 1-mm-thick optical window glass squares with antireflection coatings from *Surplus Shed*. I subjected these glass samples to the mist of an ultrasonic humidifier filled with a strong solution of magnesium sulfate (Epsom salts) to simulate the mineral deposits that would be left after multiple dewing cycles (figure 1). The transmission profiles across the visible spectrum, as measured by a spectrophotometer before and after the glass samples were immersed for five seconds in a cleaning solution, would be compared to measure the effectiveness of the cleaning solution.

You could buy a used student-level spectrophotometer for very little money but who has the room for yet more stuff? In this *Instructables* link, you can see how I designed and built an extremely simple and completely digital *Arduino* instrument using an RGB light-emitting diode: (www.instructables.com/id/Arduino-Spectrophotometer/).

All data is expressed as the mean value of six spectrophotometric measurements of each sample, and the standard deviation was too low to be worthy of being displayed as error bars for each data point. The drop in the blue-spectrum end of light transmission reflects the lower response of the cadmium-sulphide photocell to blue wavelengths. The results show that both Purosol and the ASO solution were very effective at removing all deposits very quickly without even physically

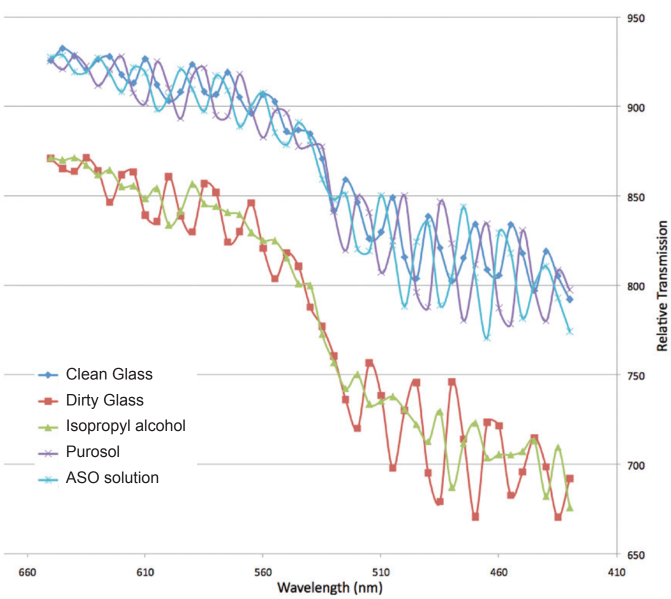


Figure 2 — Spectrophotometer measurements evaluating the cleaning abilities of several optical cleaners.

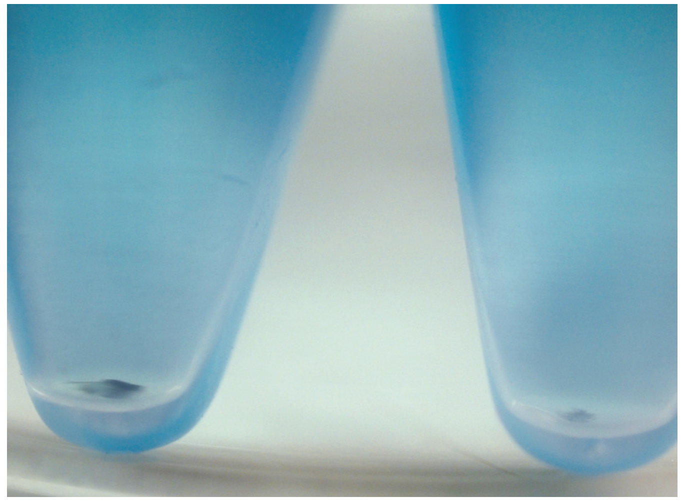


Figure 3 — Centrifuge tubes showing particulate matter present in Windex after being spun at 9000g for 10 minutes.

rubbing the glass surface. Straight alcohol (or any organic solvent) is ineffective at removing water-soluble deposits (even after minutes of exposure—see Figure 2).

So the ASO solution appears to be as effective as any commercial solution, but the use of *Windex* raises an interesting concern. ASO claims that all Windex is contaminated with insoluble residue that leaves streaks when it evaporates, as well as being a potential abrasive. I wanted to prove this Internet factoid for myself and built a Dremel-based swinging-cup centrifuge, which can also be accessed through this *Instructables* link www.instructables.com/id/Dremel-Centrifuge/.

I centrifuged some Windex samples at about 9000g of force for 10 minutes in my kitchen sink, which I figured was more than adequate because this regimen is able to precipitate mitochondrial fractions from cellular extracts. The image (Figure 3) above clearly shows some sort of black insoluble residue that is likely contamination from a dirty bottle-manufacturing facility, rather than a component of the Windex solution itself.

Just to prove that the residue does not come from the brand-new centrifuge tubes, I spun some distilled water and no precipitate was present. I also filtered Windex through two sheets of coffee filters, and no precipitate was recoverable after centrifugation, so this is a simple way to remove the offending material.

So, in conclusion, do not routinely clean the optics of your telescope. Do often clean the optics of your eyepieces and diagonals with a solution as simple as reagent-grade 6-percent solution of isopropyl alcohol in distilled water, especially if they are modern 21st-century eyepieces and diagonals, since they are designed to stand up to repeated and frequent cleaning. Store your equipment in a clean environment and practice anti-dew procedures scrupulously. Never use Windex to clean your optics!

Letter From Hungary

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

Given that the centennial of the First World War is currently being observed, it seems appropriate to reflect on the RASC's connection to that conflict. On the one hand, there is the example of the Society making a material contribution to the war effort by donating small telescopes for use in the trenches (Rosenfeld 2011, J.R.C. 1919). On the other hand is the letter from Hungary.

In 1921, the RASC received a letter from Professor Antal Tass (1876-1937), vice-director of the Hungarian State Observatory. Prof. Tass describes the devastation suffered by astronomical institutions in Hungary as a result of the Great War and pleads for assistance:

> *Thoroughly deprived of all literary resources, I beg to ask you above all to furnish us with the full series of the publications of your institute; besides we should be very grateful if you will let us have the duplicates of mathem.-physical works you can do without. Finally we most respectfully request you to send us lantern slides representing celestial objects and observatories (Tass 1921).*

So, how badly off was astronomy in Hungary during and immediately after the war years? And how did the RASC respond to Tass's request?

> *The only observatory belonging to the Hungarian State: the Astrophysical Observatory de Konkoly-Foundation in Ogyalla has been taken from us . . . (Tass 1921).*

This observatory was founded in Ogyalla, Hungary (now Hurbanovo, Slovakia) by the wealthy landowner Miklos Konkoly-Thege (1842-1916) in 1871 as a private observatory (Figure 1). Konkoly was a serious practitioner of astronomy having studied under Johann Enke in Berlin. Instruments included a 10-inch Browning reflector, 6- and 10-inch Merz refractors, a 3-inch Rheinfelder and Hertel refractor, a spectroheliograph, and spectroscopes. Sunspots, planets, stellar and cometary spectroscopy, and stellar photometry were included in the observational program. Konkoly was a very early practitioner of such spectroscopy and photometry. At the time of its founding, the observatory was the only remaining facility of its kind in Hungary. Having seen what generally became of private observatories after the passing of their founders, Konkoly took steps to preserve his legacy. In 1890, he donated the observatory to the state and it became the Royal Hungarian Observatory. Tass became an assistant. The main work of the observatory at this time was photometry of variable stars, the last published results of which appeared in 1918. In the meantime, Konkoly had died in 1916 and the Austro-Hungarian monarchy disintegrated in 1918. Borders were re-drawn and Ogyalla and its observatory found themselves in Czechoslovakia. Since the observatory was presented as a gift to the Hungarian people, there were strong feelings about repatriating whatever possible. The staff saved what they could such as the 6-, 8-, and 10-inch telescopes. Tass says he successfully protested the removal of the library and remaining instruments to Prague and that diplomatic efforts were underway to have them returned to Hungary. While the resident astronomers were promised that they could finish their work, the new authorities allowed the observatory to fall into disrepair and the building to be occupied by soldiers. Such instruments as were recovered formed the foundation of a new facility built in Budapest where observations began in the autumn of 1922. Tass was named director in 1923 and the main building completed by 1926, in which was eventually housed a 24-inch Heyde-Zeiss Cassegrain. More trials were to be faced, especially during the Second World War and communist-dominated years, but the staff persevered and both the original observatory and its modern descendant remain in existence in Czechoslovakia and Hungary respectively. The names of asteroids 1259 Ogyalla and 1445 Konkolya hearken back to the early

Figure 1 — The Konkoly Observatory as it appeared at the end of the 19th century (www.academia.edu).

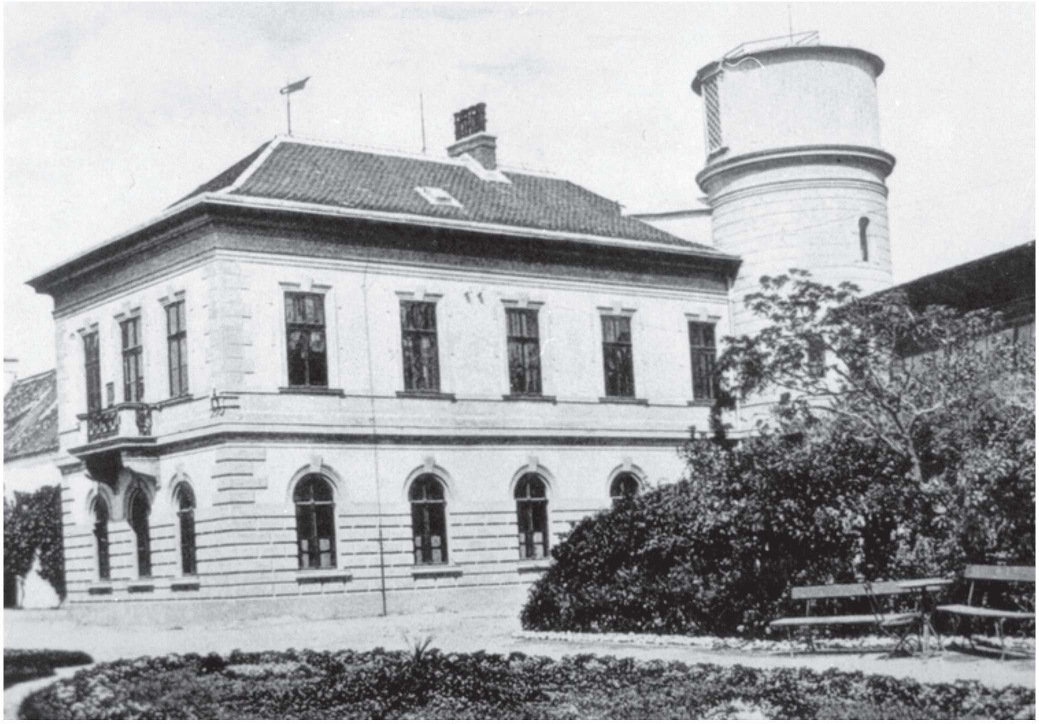


Figure 2 — von Gothard's mansion and the Hereny Astrophysical Observatory shortly after its completion (Vincze and Jankovics 2012).

years. (Balazs et al. 2009, Tass 1921, Vargha and Kollath 2000, Konkoly Observatory Home Page).

The Observatory of Hereny, erected by von Gothard, after the death of its founder, was partly sold, partly given away as a donation made by the heirs (Tass 1921).

Eugene von Gothard (1857-1909) founded his observatory in 1881 (Figure 2), at age 24, in Hereny where he did important work in photography and spectroscopy as well as experimenting with X-rays. His inspiration stemmed from a meeting and continued friendship with Konkoly-Thege. The main instrument was a 10-inch Browning-With telescope, manufactured in 1874, that he obtained from his mentor. To conduct his observations, von Gothard manufactured a number of his own instruments including spectroscopes, photometers, and cameras and, using them, became a (largely unsung) pioneer in the fields of spectral analysis and photography. He was, for example, able to establish through his observations a connection between novae and planetary nebulae and was the first to photograph the central star of the Ring Nebula. Although closing by war's end, the Gothard Observatory was re-established in 1992 at Hungary's Lorand Eotvos University and operates with a 24-inch Schmidt-Zeiss Cassegrain as its primary instrument. Many of von Gothard's instruments and records are preserved there (Jankovics et al.1994; Vincze and Jankovics 2012; Gothard Astrophysical Observatory homepage).

Figure 3 — Kiskartal Observatory (www.gothard.hu/gttak/archive-photos/categories/buildings/images/010.jpg).

The Observatory of Kiskartal, founded by and maintained by the Baron de Podmaniczky, was first plundered by the Communists in 1919 under the Bolshevist regime, later by the Roumanians, and is in ruin today (Tass 1921).

Baron Geza Podmaniczky (1839-1923) was a Hungarian landowner with an interest in astronomy sufficiently great that, with the encouragement of Konkoly-Thege, he founded the Kiskartal Observatory in 1884 (Figure 3). The main instrument was an 8-inch Merz-Cooke refractor; the extensive library contained 35,000 volumes. On 1885 August 22, the Baron was observing the Andromeda Galaxy with his wife when the Baroness claimed to see a bright object within its confines. The observatory's astronomer, Rado Kovesligethy, thought this was an illusion caused by the Moon. When it became known that something was there (what we now know as Nova S Andromedae) priority claims were advanced on behalf of the Baroness, but these never became firmly established. The observatory was demolished in the 1920s with the books and telescope going to Konkoly Observatory. Podmaniczky, Kovesligethy, and Kiskartal have asteroids (117712, 117713, and 117714 respectively) named for them (Schmadel 2003; Zsoldos and Levai 1999).

The Haynald Observatory in Kalocsa has for years ceased operations on account of insufficient means and urgently needs help in order to resume work (Tass 1921).

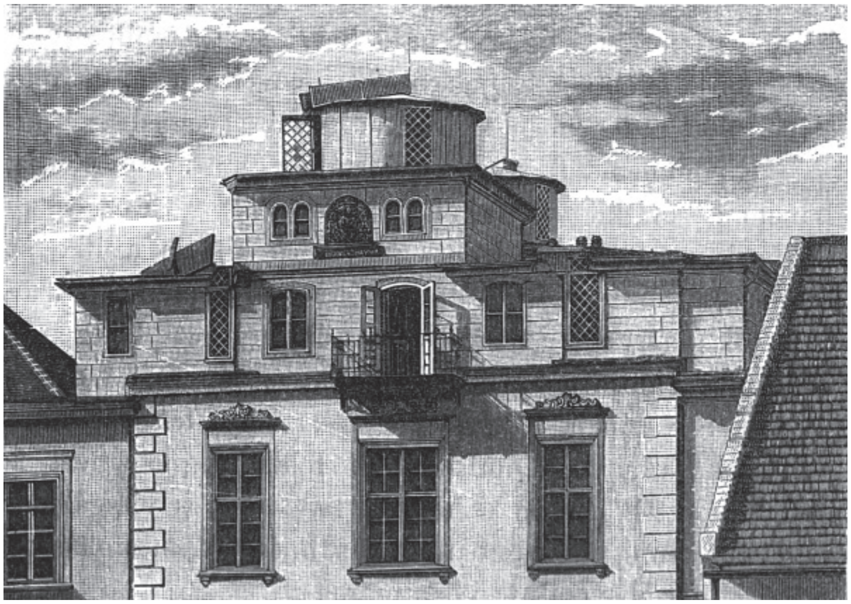


Figure 4 — Haynald Observatory (http://fenyi.solarobs.unideb.hu/Kalocsa/Figure%201.html).

The Haynald Observatory was founded in 1878 by Ludwig Cardinal Haynald, Archbishop of Kalocsa, once again with the help of Konkoly-Thege (Figure 4). It was equipped with a 7-inch Merz-Browning refractor equipped with a prominence spectroscope and a 4.5-inch Merz refractor with which photosphere observations were made. The observatory's greatest contribution is doubtless the series of photosphere drawings made by Gyula Fenyi S.J. on every cloudless day from 1886 to 1917, likely forming "the longest homogeneous series of prominence observation all over world" (and by one person, no less!). Bleak years followed the First World War, but the observatory did resume work under the direction of Jesuit Fathers until it was nationalized and closed in 1950. Asteroid 115254 and a lunar crater are named for Fenyi (Toth et al. 2002).

All told, the first half of the 20th century represented difficult times for Hungarian astronomy. How, then, did the RASC respond to the request for assistance? On this point the national archives are, unfortunately, silent. However, one may surmise an answer from a nearly contemporaneous incident. The following appears in the minutes of the National Council meeting for 1922 June 1:

> *"Dr. C.A. Chant read a telegram from Prof. W. Stratonov of Moscow, Russia to the effect that a central astrophysical observatory had been established at Moscow, and requesting the donation of complete volumes of the Society's publications. The General Secretary was instructed to communicate with Prof. Stratonov stating that his Observatory was being placed on the mailing list, and that the Society was not in a position to send the requested back volumes."*

It appears likely, then, that nothing was done. All the more remarkable that Hungarian astronomers were able to keep Urania alive and well. Kudos to them. ✶

Acknowledgements

Many thanks to Randall Rosenfeld for assistance in negotiating the archives in the RASC's National Office.

References

Balazs, L., Lajos, G., Vargha, M., Zsoldos, E., 2009. The First 50 Years of Konkoly Observatory, Cultural heritage of astronomical observatories: from classical astronomy to modern astrophysics; *Proceedings of the International ICOMOS Symposium in Hamburg, Oct. 14-17, 2008*. Berlin: Hendrik Bäßler Verlag, 2009. Edited by Gudrun Wolfschmidt; p. 151 - 163

Gothard Astrophysical Observatory homepage, www.gothard.hu

Jankovics, I., Kovacs, J., & Vincze, I.J., 1994, Digital Image Processing and CCD Imaging at Gothard Astrophysical Observatory, *Astronomy From Wide-Field Imaging, Volume 161*, International Astronomical Union

J.R.C., 1919, *JRASC, Vol. 13*, p. 243, 251

Konkoly Observatory Home Page, www.konkoly.hu/index_en.shtml

Rosenfeld, R.A., 2011, *JRASC, Vol. 105, No. 5*, p. 210

Schmadel, L., 2003, *Dictionary of Minor Planet Names*, Springer, p.1255.

Tass, A., 1921, The Hungarian State Observatory, *JRASC, Vol. 15, No. x*, p. 332

Toth, L., Mezo, Gy, and Gerlei, O., 2002. Haynald Observatory Photosphere Observations 1880-1919, *Journal for the History of Astronomy, Vol. 33, Part 3, No. 112*, p. 278

Toth, L., Mezo, Gy, and Gerlei, O., Historical Photosphere Observations of the Haynald Observatory from 1880 to 1919, Astronomy and Earth Sciences Research Center of the Hungarian Academy of Sciences, Konkoly Thege Astronomical Institute http://fenyi.solarobs.unideb.hu/Kalocsa/Kalocsa_E.html

Vargha, M. and Kollath, Z., 2000. The First Century of the Konkoly Observatory, *Astronomy and Geophysics, Vol. 41*, www.konkoly.hu/staff/kollath/thefirst.html

Vincze, I. and Jankovics, I., 2012. In Memory of Eugene (Jeno) von Gothard: A Pioneering Nineteenth Century Hungarian Astrophysicist, *Journal of Astronomical History and Heritage, Vol. 15(2)*, p. 105

Zsoldos, E. and Levai, Z.S., 1999, "Novae" Over Kiskartal, *Journal for the History of Astronomy, Vol. 30, Part 3*, p. 225

The RASC Board of Directors

by Chris Gainor, RASC First Vice-President

The RASC is now into its third year of governance under a new structure that includes a Board of Directors. In this article I will look at this new governance structure and how it serves RASC members.

Prior to the changeover at the 2013 General Assembly at Thunder Bay, the RASC was governed by a National Council consisting of representatives from RASC Centres, and between its infrequent meetings, by an executive consisting of a president, two vice-presidents, a secretary, and a treasurer.

As a long-time member of the RASC, I believed that the former system worked well, but changes were needed to respond to the challenges of a growing society and the need for more services. Since 2010, an executive director has assisted the executive and later the Board in the day-to-day running of the Society.

Our original system of governance provided strong representation for the Centres, but the executive was elected only by whoever came to the annual general meeting and those who went to the effort of casting a proxy. Most members did not have a direct vote for those who ran the Society.

The Canada Not-For-Profit Corporations Act, which was passed by Parliament in 2009, required that members vote for boards of directors running their not-for-profit societies. The law was probably passed with this provision to deal with other groups that haven't had the robust democratic tendencies of the RASC.

The RASC went through a transition to the new system in 2013 and 2014, when a Board consisting of the executive and three Board members elected by the membership took direction of the Society. The three new Board members were chosen in a contested election from five candidates, and members voted online or by mail ballot.

In 2014, all nine seats on the new RASC Board of Directors were up for election, but were filled by acclamation as only nine people stood for those seats. Starting in 2015, three seats became open each year. Only three people stood for the three seats in 2015, but the Nominating Committee is working hard to ensure that upcoming elections are contested.

The Board chooses members of the RASC executive from among its own membership, which means that some Board members require special skill sets—notably the treasurer. We seek to have Directors on the Board who represent members in terms of astronomical interests, skills, orientations, and backgrounds. We also hope to have the various Centres and the different regions of Canada represented at our Board table.

In the interest of staying representative, each Board member is restricted to serving no more than two full terms in succession.

In my opinion, experience on a Centre executive is an important asset for prospective Board members. The three RASC Boards that I have served on have all been aware of the importance of maintaining links to the Centres through the National Council and through visits by Board members to our Centres.

Since the RASC Board was first formed in 2013, we have usually met in person each year at the General Assembly and twice a year at an airport hotel near Toronto. At the GAs, we can hear from members from all over Canada, and at our Toronto meetings we can catch up on what is happening in the Society Office. We hold meetings in other months by computer or telephone conference.

Much of the work that Board members do involves the various committees of the RASC, including the constitution, nominating, finance, publications, and education committees, to name just a few. Here Board members work with other RASC members to serve the Society, amateur astronomy, and other members. Committee work is also good preparation for joining the Board.

We receive no remuneration for our Board work, other than most but not all of our travel expenses. Every Board member I know makes an effort to keep their travel costs as low as possible. We also post the minutes of our meetings online in the interests of openness.

We on the Board are still developing policies and procedures to make sure that we serve the members and the Centres as well as we can. I would urge members who have concerns or questions about decisions we make to get in touch with a Board member—either directly or through your Centre's National Representative.

I also urge members to consider running for the Board in future elections. The vitality of the Board depends upon your involvement.

Everyone I have worked with on the Board loves astronomy just like you. We are members like you, and so we on the Board all want to make the RASC an effective group that provides good value for time and money.

When there's a break from the business of the RASC, we on the Board all love talking about astronomy. Through our work on the Board, we hope that we make it easier for all RASC members to spend their time enjoying our Universe. ✶

CFHT Chronicles

Wircam

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

Throughout the last year of The CFHT Chronicles, I have written about the exciting science done at CFHT, the astronomers who represent Canada, and our new instruments in development. However, until this column, I have neglected one of our instruments, Wircam. This column will remedy the situation.

Wircam is CFHT's near-infrared mosaic imager, commissioned in November 2006. While smaller than Megacam, Wircam has a field of view of 20sq minutes; making it one of the largest astronomical IR mosaic detectors when it arrived. It acts as an infrared complement to Megacam, and with their powers combined, CFHT has the capability of wide-field imaging from the ultraviolet u filter (0.32 microns) to the Ks band (2.2 microns), a unique feature on Maunakea. The camera is comprised of four HAWAII-2RG detectors with a sampling of 0.3 arcseconds per pixel. The pixel scale allows Wircam to take full advantage of the exquisite seeing found on Maunakea.

Often, infrared cameras have guiders operating in the optical wavelengths, a potential disadvantage. Imagine trying to guide in the heart of the Orion Nebula with an optical camera. As you can see in the picture below, Orion is tremendously opaque in the optical. Finding a guide star can be difficult. Compare that to the infrared, where the optically opaque gases are cool enough to be transparent. Wircam utilizes on-chip guiding so everything is in the infrared. Astronomers using Wircam can set up zones of exclusion, or areas on the chip where they do not want to guide, to avoid their science targets being selected as a guide star.

IR Challenges

Observing in the infrared is different than observing in the optical. Challenge one is keeping the detectors cold enough. The operating temperature of Wircam is 80K or –193 °C. Objects, like humans or cameras, emit most of their thermal energy at infrared wavelengths. A detector sitting at room temperature would ultimately only detect itself. Which leads into the discussion of how detectors work…

Astronomical detectors are comprised of charge-coupled devices or CCDs. Each CCD has a photoactive region layered over a transmission region. Wircam's photoactive layer is made of mercury, cadmium, and telluride or HgCdTe, a blend optimized for infrared observations. The CCD contains a large number of single-sensor elements commonly known as pixels. Each pixel on the CCD acts as a bucket, collecting photons. The photons cause capacitors inside the photoactive region to accumulate an electric charge, which is proportional to the light intensity of that pixel. Once the exposure is completed, the electric charge for each pixel is "read out" and digitized, creating the picture.

If the detector is warm, the movement of electrons creates electric charge. This electron-generated charge is indistinguishable from the charge created by photons from space striking the detector. Cooling the detector to 80K minimizes the electron noise. However, the noise from electrons cannot be eliminated entirely. CFHT engineers create hot-pixels masks of the Wircam detector. These masks show which pixels

Continued on page 118.

Figure 1 — Side-by-side image of the Orion Nebula in the optical with Megacam (Left) and infrared with Wircam. (Right photo credit: CFHT/Coelum and TERAPIX.)

Figure 1 — Dave Chapman took this image he calls "New Moon in the Old Moon's Arms," taken on 2016 January 8 at dawn at Lake Banook, Nova Scotia. He used a Canon EOS SL1, ISO 800, EF 70–300-mm IS USM lens @220 mm, LiveView mode, manual focus with 10x digital zoom, IS on, ƒ/5.0, and a 2-second exposure.

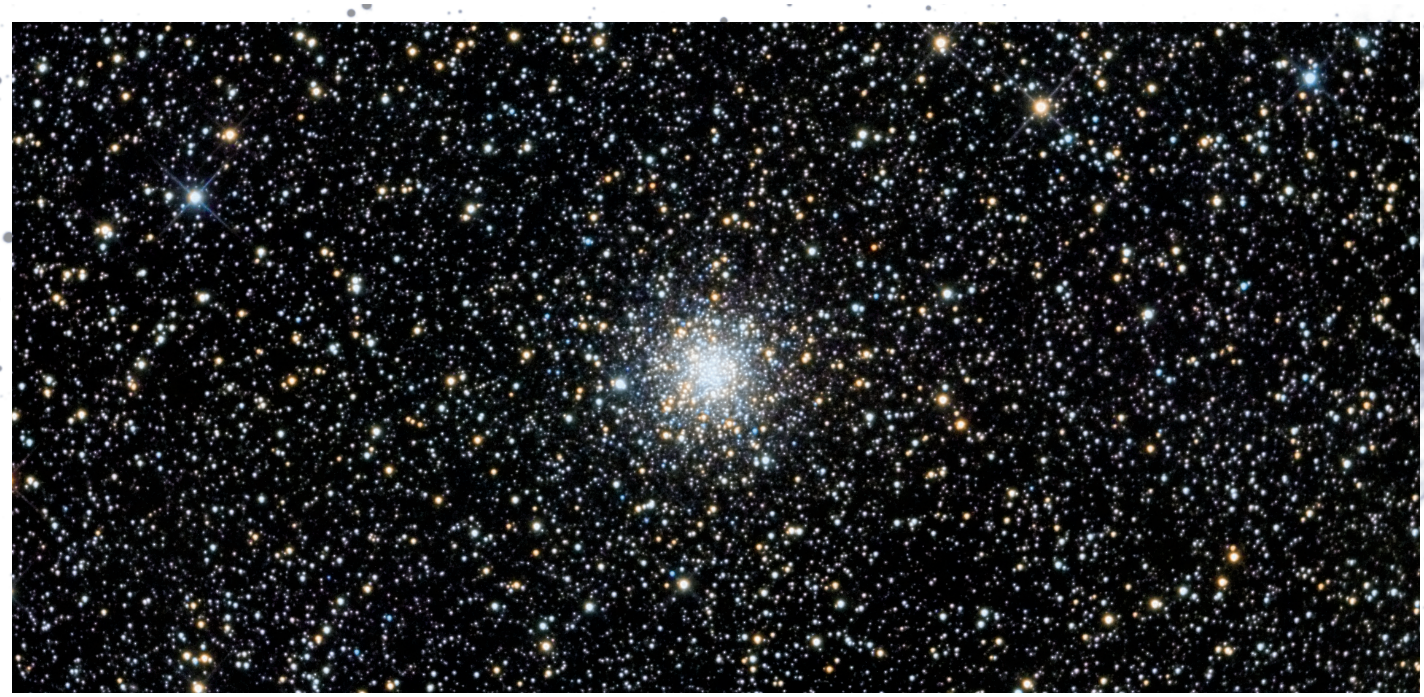


Figure 2 — This beautiful image of globular cluster M56, located in Lyra, was taken by Ron Brecher, using an SBIG STL-11000M camera, Baader LRGB filters, a 10" ƒ/6.8 ASA astrograph, MI-250, and was guided with STL-11000's internal guider. Total time was 3 h and 45 min. "One of the things I like about globular clusters is how different they all are from each other. This one resolves quite well right to the core, and is set in a rich Milky Way star field," Brecher said.

Figure 3 (top) — This image taken by Drew Patterson of NGC 7129, a reflection nebula, using a Celestron C11, SBIG 8300C, and guided with an Orion ED80 using an Orion SSAG and PHD. Image exposure was 19 x 600 seconds and was processed in PixInsight.

Figure 4 — Journal *Editor-in-Chief Nicole Mortillaro took this image of the Tarantula Nebula remotely using iTelescope's T31 Planewave 20″ CDK ƒ/4.4 from Coonabarabran, Australia. Total exposure 1 hour and 15 minutes. Processed using CCD Stack, Luminosity, and Photoshop.*

Continued from page 115.

are noisier, helping the astronomer who reduces the data to account for the increased intensity of jumping electrons rather than photons. Because Wircam has on-chip guiding, the hot-pixels mask also minimizes the odds of the guider choosing a hot pixel as a guide star instead of an actual star.

Wircam's sensitivity to heat requires a very controlled warm-up procedure. If engineers need to access the detector or change the filters, they slowly warm the instrument up before opening it. On the cool down, they bring the camera's temperature down very slowly and under vacuum. A power outage resulting in Wircam's uncontrolled warm-up is a big deal, so precautions are in place to try to prevent that from occurring.

The second challenge of infrared astronomy is our atmosphere. Infrared astronomers look for signatures of heat in space. Our atmosphere glows very brightly in the infrared. To compensate for the bright atmosphere, astronomers take very short exposures called slices that are stacked together to form a deeper image. For example, an astronomer will ask for twelve slices of five seconds each instead of a 60-second exposure.

Water vapour, carbon dioxide, and other compounds in our atmosphere absorb a significant amount of the infrared radiation from space, limiting or blocking those wavelengths from reaching Earth's surface. To compensate, most effective infrared instruments are located at high altitude (like Maunakea) or in space. Even at high altitudes, some programs are only executed when the measured water vapour of the atmosphere is within their constraints.

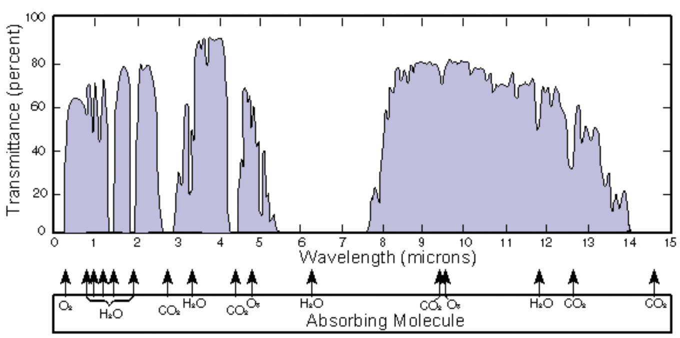


Figure 2 — The infrared windows in Earth's atmosphere. (Photo credit: Wikipedia)

IR Science

Despite the challenges of the infrared, the science benefits are enormous. Refer again to the image of the Orion Nebula. In the optical, the light from the stars and protostars embedded within the nebula illuminates the dense gas and dust. The stars and protostars are hidden from view. Not the case in the infrared—the gas and dust are dense, but cool and thus are invisible, allowing astronomers to study the stars within the nebula. Think of infrared astronomy as night-vision goggles

Figure 3 — Full view of W2 region in YJHKs filters.

Figure 4 — Close view of FSR 584 in YJHKs filters. (Both images courtesy of Loïc Albert, Université de Montréal.)

for space, areas that are optically dense—Orion Nebula, the galactic centre—are transparent in the infrared.

The image above, taken by a team including one of our former Canadian resident astronomers, Loïc Albert, is a composite Wircam image of the star-forming region W2 in the plane of our galaxy. They used the Y, J, H, and Ks filters of Wircam to look at the W2 region to try to settle a debate if the cluster FSR 584 embedded in the region was a stellar nursery or a globular cluster. Spanish astronomers suggested that FSR 584 could be a much older globular cluster that formed simultaneously with the galaxy, 10 billion years ago. It tells a different story. The Wircam image shows that the number of stars within FSR 584 is too low to maintain long-term gravitational cohesion and gives another explanation. The time between the collapse of the dust clouds and gas (dark areas in the picture) and the birth of stars able to produce ionized gas (pink and orange regions) is only a few million years. Afterward, most of stars in the newly formed group scatter over old stars born during a similar, but previously occurring formation epoch, creating the illusion of a globular cluster.

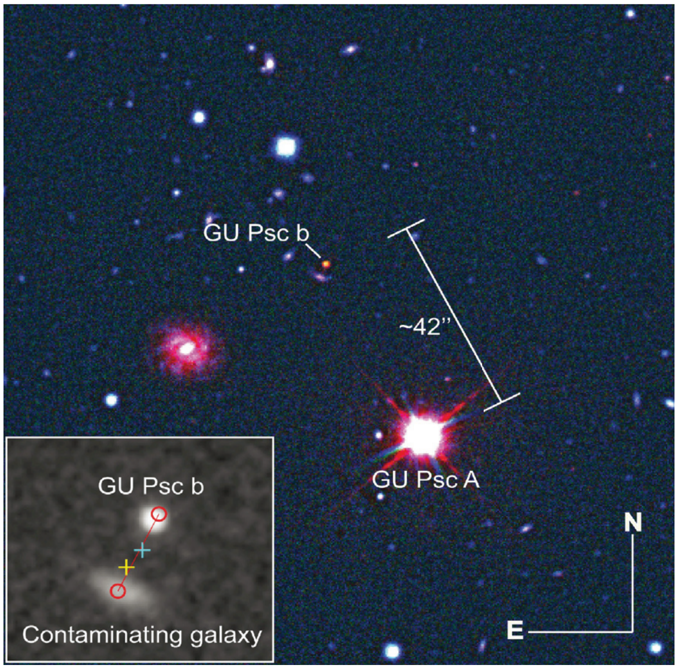


Figure 5 — Gu Psc b (Marie-Eve Naud, Université de Montréal.)

Cool and faints objects, like planets and brown dwarfs, are optimally observable in the infrared. Wircam excels at detecting both. Astronomers planet hunting with Wircam can utilize its unique "staring mode," which is useful for high-accuracy relative photometry, better than one percent. In staring mode, science exposures using the full mosaic are taken over long sequences of time at a fixed telescope position. In staring mode, astronomers stare at one star to get an accurate measure of the change in brightness over several hours. This method is ideal for the study of exoplanet eclipses or transits. As the exoplanet transits or moves across its host star, the brightness of the star will decrease slightly. With staring mode, astronomers can measure how the brightness of the star changes relative to itself over the duration of the observations. The precise measurements of the changing brightness lead to a wealth of information about the planets detected. One set of observations taken by a team led by Bryce Croll allowed astronomers to rule out violent weather changes in the deep, high-pressure atmospheres of the hot Jupiters WASP-3b and Qatar-1b.

Even outside of staring mode, Wircam has proven a powerful planet hunter. In May 2014, an international team led by Marie-Ève Naud from Université de Montréal used Wircam at CFHT, Observatoire Mont-Mégantic, the W.M. Keck Observatory, and the two Gemini Observatories to detect the planet GU Psc b around the star GU Psc. The planet is around 2000 AU from its host star and takes roughly 80,000 Earth years to orbit. The image likely looks familiar to regular readers of this column; it appeared in the SPIRou column last year. The focus in that article was the difficulties in direct imaging of planets. Now, let us look at the role Wircam played in that discovery. The team compared images of the region taken in different wavelengths from Observatoire Mont-Megantic and CFHT. The planet, GU Psc b is cold, approximately 800 °C, so it is most prominently observed in the infrared images from Wircam. Gu Psc b is roughly 2000 AU from its host star with a period of 80,000 Earth years. The incredible distance between the planet and its host star provided an advantage to the team.

As mentioned in the SPIRou article, observing a planet does not allow astronomers to directly determine the mass of the object. Because of the distance between Gu Psc b and its star, Wircam's staring mode was not an option. The teams used theoretical models of planetary evolution and spectroscopy to determine the planet's characteristics. Spectra obtained by the Gemini Observatory yielded the temperature measurements, while knowing the age of the star by its location in AB Doradus allowed the team to determine its mass as 9-13 $M_{Jupiter.}$

Building off the discovery of Gu Psc b, the team started a project to observe several hundred stars to try to detect planets lighter than GU Psc b with similar orbits. One grad student, Frederique Baron from Université de Montréal, is using Megacam and Wircam at CFHT to hunt for similar planets. She looks for objects visible in the infrared Wircam images, but not visible in the optical Megacam images. Frederique is a member of the Institute for research on exoplanets (iREx), which is devoted to exploring new worlds and seeking life on other planets. iREx's headquarters are located at Université de Montréal with René Doyon serving as the institute's director.

Continuing on the theme of Wircam and unusual planetary objects, in 2013 an international team led by Michael Liu from the University of Hawaii discovered a young planet that is not orbiting a star—a rogue planet called PSO J318.5-22. Initially, the team identified a faint object with a unique heat signature using the Pan-STARRS wide-field telescope. They followed up with Wircam, observing the target nine times in two years. The resulting astrometric precision per epoch was 4.0 milliarcseconds, a very precise measurement for such a precise object. Using this result, the team concluded that the rogue planet belongs to a collection of young stars called the Beta Pictoris moving group that formed around 12 million years ago. The team determined the mass of the planet to be 6 $M_{Jupiter}$ at a distance of 80 light-years from Earth.

Let us end our discussion of Wircam with an aside into a topic that often causes confusion, brown dwarf vs large planet. Planets are defined as objects $<13M_{Jupiter}$, while brown dwarfs have a mass of $>14M_{Jupiter}$. However, these metrics are arbitrary to a point, what do we call an object with 13.5 $M_{Jupiter}$? Astronomers studying brown dwarfs believe they form like stars but are not large enough to sustain fusion in their cores. Planets are hypothesized to form in accretion disks comprised of the "leftover" materials from the formation of stars. Some astronomers refer to brown dwarfs as failed stars, but Frederique calls

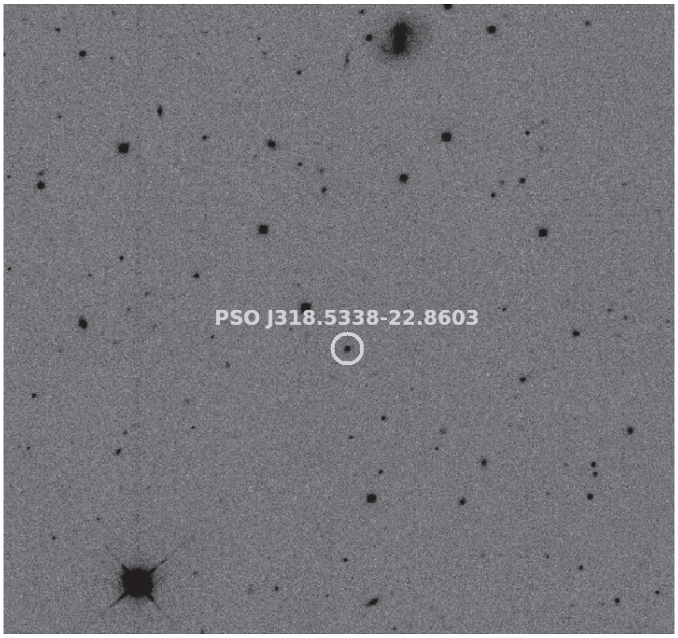


Figure 6 — Wircam stacked image of the planet PSO J318.5-22. (Photo credit: CFHT, Dr. Trent Dupuy, Harvard-Smithsonian Center for Astrophysics.)

them "overachiever planets," a phrase much friendlier to their plight. This begs the question, can we have an object that formed like a planet, but is heavier than 13 $M_{Jupiter}$? Conversely, can we have an object that formed like a star, but is lighter than 14 $M_{Jupiter}$? When in doubt, we have a third term—planetary mass object.

Wircam users continue to explore the Universe in the infrared wavelengths, trying to answer questions like the one posed above about planets vs brown dwarfs. This column only covered the tip of the infrared iceberg; for example, we did not even begin to discuss the benefits of infrared astronomy in exploring the early Universe. Another column perhaps…

A special thank you goes to Frederique Baron for her permission to describe her work and her insights into planet vs. brown dwarf vs. planetary mass object.

SITELLE update

As readers know, over the past year CFHT commissioned SITELLE, a Fourier Transform imaging spectrograph. We are very pleased to announce that, as of March, SITELLE is now a fully commissioned member of the CFHT instrumentation suite. Congratulations to the SITELLE team! ✶

Mary Beth Laychak has loved astronomy and space since following the missions of the Star Trek Enterprise. She is the Canada-France-Hawaii Telescope Outreach Coordinator; the CFHT is located on the summit of Maunakea on the Big Island of Hawaii.

Binary Universe

ISS on iOS

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

Something peculiar happened before I tested GoISSWatch. I couldn't find a good app!

In the last *Journal* issue, on reviewing the Android-specific application to help in planning for and monitoring flyovers of the *International Space Station* (ISS), I promised to review a software app for the Apple iOS platform. And I just assumed that I'd have an easy go of it. I also assumed there would be a cornucopia of apps and they'd be feature-rich and they'd make the ISS Detector Android tool look possibly pale by comparison.

The choices for the iOS platform surprised me. Not for lack of titles; rather, the features of each application. And I checked a few. I looked briefly at *ISS Finder* version 3.5 by Harry Works, *ISS Spotter 1.5.1* by Mediapilot, *Satellite Safari* by Simulation Curriculum, the old *Sputnik!* app, and *ISS Locator 4.0.2* by Will Lyons. None seemed well equipped, encompassing, or included the various useful features I have come to enjoy in *ISS Detector*. It seems the bar had been set fairly high!

I was getting to the end of the rope and beginning to settle on the attractive *Satellite Safari* when I came across, at last, *GoISSWatch*, version 3.2.0, by GoSoftWorks. And even then, I had concerns as I noted reviews and update information appeared to be about 2 years old.

On launching the iOS product, you will see an image of the Earth bisected by a couple of lines (see Figure 1). The yellow line indicates the path along the surface of the Earth, the ground or water, of course, which in turn alludes to how close your viewing location will be to the path. The red line on the other hand is the actual orbital trajectory above the surface. The ISS icon moves in real-time along said red arc. The eye icon naturally shows your home location.

The app obviously can use your current sensed location data, but you can add custom locations, as needed, via the Settings feature.

The main 3-D globe view also gives a good sense of the orbit inclination, approximately 52°, the angle of the outpost's orbit plane in relation to the Earth's equator.

Figure 1 — World display showing the ISS skimming over the Earth.

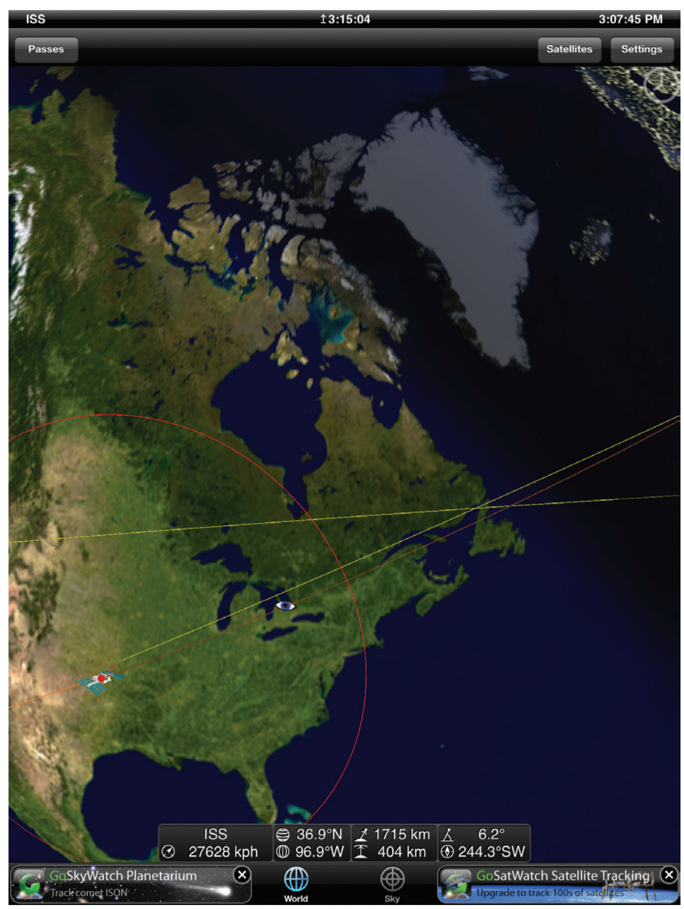


Figure 2 — Zoomed display with visibility footprint circle showing the ISS now in range.

The main view also makes apparent the *International Space Station* is in a rather low orbit. At any given moment, the ISS is about 400 kilometres up. We've all heard the description of recent human spaceflight operations being in low-Earth orbit (LEO). That becomes abundantly clear as you take in the whole planet view. Swiping across your smart phone or tablet display only further emphasizes, in three dimensions, how the ISS is just skimming over the surface of our home world. It looks very neat on the large iPad screen.

Not only can you pan the World View or Map display, you can zoom in or out with the pinch gesture (see Figure 2).

You should also see a footprint circle around the station. This indicates the range of visibility.

The status bar at the bottom of the screen shows the fantastic speed of the ISS (preventing its fall to Earth), the current latitude and longitude, the distance from the observer, the true height above the planet surface, the altitude or elevation from the viewer's location, as well as the azimuth.

At the top right of the screen, there is a clock icon. When you tap it, the time-control slider appears. Swipe or drag the slider up or down to move backward or forward in time. This is handy when you want to preview future flyovers or double-check particulars of a past event.

To see the predicted flyover events in the immediate future for the current location, tap the Passes button at the top left of the display. A list appears (see Figure 3) that shows upcoming passes for the selected evening along with the sunset and sunrise times. The chevrons near the top of the list allow easy access to other days in the current week.

Each pass row in the What's-Up-Next list shows various details including the start and end times, the peak or culmination time, with elevation and magnitude at the peak, and the range from the observer.

Tapping an event from the list makes an overhead map appear (see Figure 4). It shows the path of the ISS, direction (although, for the ISS, it is always west to east), as well as

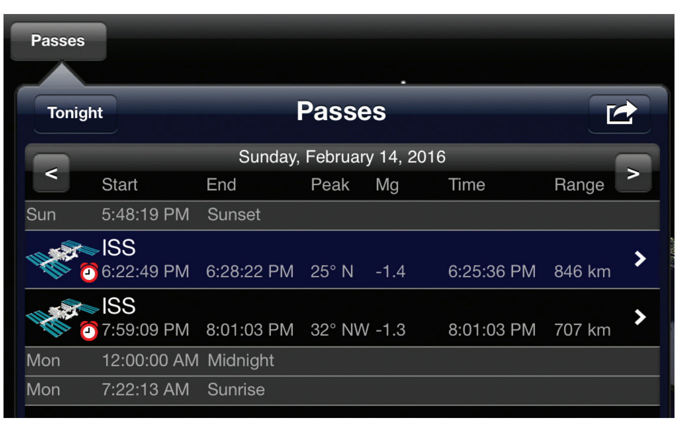


Figure 3 — Upcoming ISS Passes listed with helpful details.

Figure 4 — Overhead sky chart showing satellite path along with time and elevation details.

details of the start, peak, and end. If you look closely, you'll see the darned Moon is noted as well. Careful examination of the yellow line will show it dimming off in the east, presumably when the station experiences its local sunset, and fades from our view.

One can share flyover details easily from either the Passes list or Specific Event panel by tapping the Share button. You can transfer information via email, Twitter, Facebook, etc.

Technical information for flyovers can be viewed by tapping the Satellites button. It shows the TLE data or the Two Line Element data acquired online used to plot the target path.

Tapping the Settings button shows a menu with Location, Night Mode, Preferences, and About. The Location option is for programming a custom favourite viewing spot, bypassing whatever is automatically detected. The Night Mode activates astronomer-friendly deep-red lighting to help preserve one's dark-adapted vision.

Digging deeper in the Preferences reveals a plethora of handy options (see Figure 5).

For example, you can turn off the 3-D display, if you'd rather examine a flat map of the Earth. The Earth Night option

Figure 5 — After activating Night Mode, we access the Preferences.

toggles the terminator emphasizing the sunlight side of the planet. For the side of the Earth opposite the Sun, the app appears to map in a familiar image of our light-polluted planet (which always makes me a little sad).

You have control over the orbit display. In particular, you can designate if past orbits should be shown; you can adjust the number of future orbits plotted. By default, the app shows visible passes only, in other words, night-time passes (if you know where to look, you could see the ISS in the daytime). Setting minimum elevation and magnitude constraints may be relevant if you have obstructed horizons or if battling significant light pollution.

As expected, there are good options for triggering alerts from the app. You can control the lead time before a flyover and enable specific sounds.

The Canadian developer responded promptly to my questions. I learned that the TLE data is obtained from NORAD, and from NASA for the ISS. The app tries to download updates when started. Once the app has downloaded orbital updates it can continue to track satellites without an active internet connection.

The app does what it needs to. It looks great on a large display. It works well in portrait or landscape mode. The app crashed unexpectedly on me a couple of times. Personally, that drives me nuts, but that's the nature of the beast these days, it seems.

I found the *GoISSWatch* app in and downloaded it for free from the Apple iTunes store. But when I tried to find out more information about it, I hit a few dead ends. As I noted at the onset, it gave me pause—I started to wonder if the app was obsolete and discontinued.

Later, when I visited the Vancouver developer's website (http://gosoftworks.com/GoSoftWorks/Home.html), I did not immediately see the software program noted. Instead, I found *GoSatWatch*. Ah, that explained everything. *GoISSWatch* is, technically, ended. The app available on the website appears to be a more modern and up-to-date tool and I wasn't entirely surprised when I spotted the USD $10 price tag.

So, if you want a basic app for your iPad, iPhone, or iPod to show ISS flyovers only, with attractive graphics and an easy to use interface, through the App Store search specifically for *GoISSWatch*. If you want other satellites, including *Iridium* flares, or you want to accurately determine geostationary satellite locations, then you'll need to scrounge up 10 US bananas.

Update Bits

Back in February I wrote about the computer application *Where Is M13* (WIM)? Bill Tschumy no longer supports WIM directly. However, you'll find these app features in the latest version of *SkySafari*! In fact, he is one of the two developers of *SkySafari*. ✶

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

Dish on the Cosmos

How Hot DOGs Are Made

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

The innocuously named galaxy W2246-0526 holds the title for the most luminous galaxy that we know of. The galaxy is radiating energy at 350 trillion times the rate of the Sun's radiation. These numbers are huge and hard to contextualize, but this is roughly the same ratio as the energy received on Earth by the Sun compared to the energy from a ninth-magnitude star, which is fainter than the faintest star we can see in the night sky with our naked eye.

Astronomers love extremes: not just because they lead to punchy headlines and article titles, but also because the extreme objects are typically found right at the boundaries of what is physically possible. Since the Universe is so wide and varied, objects will form with a wide range of possible configurations. When we see a boundary or an extreme, we have to ask what processes set that boundary. One of the major results of stellar physics is that the least massive possible star is only eight percent of the Sun's mass. Below that boundary, the fusion processes that define stars simply do not ignite during the star-formation processes. This boundary describes the physical balance between collapse and pressure in these objects. Similarly, the galaxy W2246-0526 sits at the upper limits of galaxy luminosity. The object's extreme nature tells us a great deal about galaxy formation.

First, the galaxy is far away: over 12.5 billion light-years. The distance, like so many numbers in astronomy is too big to readily comprehend. However, we define a light-year based on the distance that light travels in a year, leading to the truism of astronomy: looking into space is looking far back into time. Combined with the age of the Universe being 14 billion years, we conclude that the most luminous galaxy is a product not of where it is but rather when it was found: in the earliest chapters of galaxy formation, a small fraction of the current lifetime of the Universe after the Big Bang. These early days of galaxy evolution are when galaxies show off their rapid buildup.

The picture is emerging that galaxies appear promptly after the Big Bang, and that they build up rapidly. Now the open questions turn to answering what physics sets how the galaxies manage to get such a quick start. One particular clue to this process has emerge over the past decade, namely the vital role that a galaxy's central supermassive black hole (SMBH) plays in regulating galaxy evolution. This link first became clear when the mass of the SMBH was compared to the motions of the stars in a galaxy's central bulge. This relation between these measurements was so tight the relationship was expected to arise because one property controls the other (i.e. causation and not simply correlation). The connection was surprising because the random motions of the stars in the galaxy bulge should have nothing to do with the relatively tiny SMBH at the centre of the bulge. In the Milky Way, the SMBH at the centre of the galaxy is a mere 0.02% of the central-bulge mass. Using the random motions of the stars to measure the mass of the bulges, it became clear that this tiny fraction was typical.

The tight correlation implies a real, physical connection, but how does that connection act: do big galaxies make big SMBHs or does the process work in reverse where the SMBH controls how the galaxy builds up mass? At the heart of this debate are two processes: star formation and feedback. Star formation builds up the mass of the galaxy by turning the gas that pervades the early Universe into stars in galaxies. This is the default path for galaxies: the gravity of a galaxy (mostly its dark matter) pulls gas into the centre of the galaxy. The gas gets compressed down and forms stars. Those stars are net additions to the mass of the galaxy. Feedback will disrupt this process by pushing the gas out of the galaxy: either the high-mass stars in the new stellar generation blow out the fuel for star formation or matter falling onto the SMBH causes large jets to push out the gas (Figure 1). These two effects are called stellar feedback and black-hole feedback respectively. Strong feedback will limit the star-formation process and this will set the basic cycle of galaxy formation: gas falls into galaxies, and then forms stars until feedback disrupts the process.

For the most luminous galaxy in the known Universe, W2246-0526, the huge energy output must be linked to feedback processes, but which one? How long could this galaxy hold its title? This is where new observations with the Atacama Large Millimetre/submillimetre array (ALMA) become critical. A great deal of the progress in this field has been set using optical telescopes, but W2246-0526 is difficult to observe because the light is blocked by dust. Dust is essentially the sooty pollution that stars give off at the end of their lives (leading also to dark/extinction nebulae). This far-off system is filled with dust, which blocks out the light of both the SMBH jets and from the forming stars in the system. Channelling the poetic nature of the field, astronomers call these objects dusty obscured galaxies or DOGs. Since W2246-0526 is particularly luminous, the dust becomes quite warm, leading to the system being labelled a "hot DOG," which almost captures the majesty of such an extreme source. To see hot DOGs being made, astronomers need to turn to long-wavelength observations, highlighting why ALMA is so useful.

Astronomers from Chile recently used ALMA to tune into a spectral line of carbon coming from this system. ALMA made this observation possible in two ways: first the interferometric

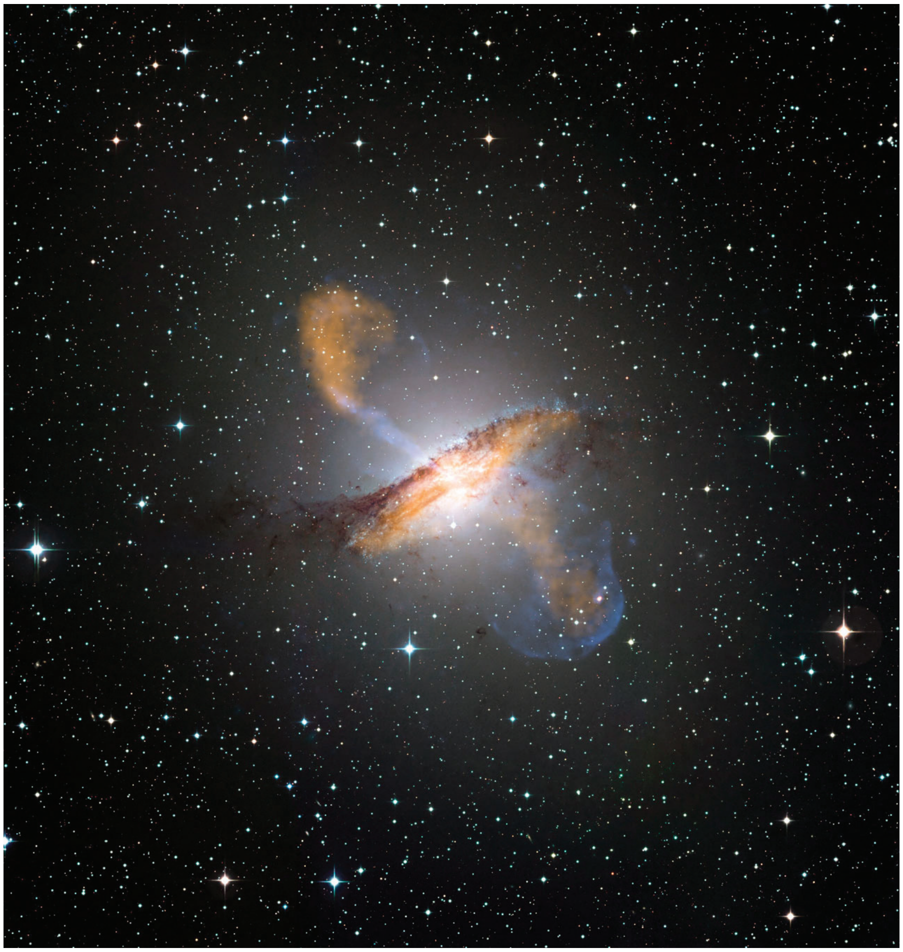


Figure 1 — The jets driven by the SMBH in Centaurus A. This image shows a combination of X-ray data (blue) that traces the shock waves at the front of the jets, the jets themselves in orange superimposed on an optical image of the galaxy. This image highlights the vast power of the jets that black holes can drive, sufficient to disrupt star formation in the galaxy. Credit: ESO/WFI (visible); MPIfR/ESO/APEX/A.Weiss et al. (microwave); NASA/CXC/CfA/R.Kraft et al. (X-ray)

nature provided the resolution needed to map out the extent of the carbon emission from the system. Second, ALMA is built on radio-telescope technology, allowing the frequencies of the emission to be precisely measured. These precise measurements of the spectrum can be combined with the physics of the Doppler effect to measure how fast the gas in W2246-0526 is moving around. Figure 2 shows the (relatively unimpressive) results of the mapping. The galaxy appears as a bright ball of emission in the submillimetre band. ALMA measures the spectrum of the emission at every position in the image.

The results of this spectral analysis were surprising because the motions of the galaxy were huge (>500 km/s) and widespread across the entire emitting region. The large speeds tell us that the feedback is in the process of destabilizing the star-forming gas galaxy. The speeds are much larger than the gravitational escape speed so the gas will be blown out of the galaxy readily, indicating that the driving energetics will disrupt the star formation. The observation that the large speeds are spread over the entire galaxy points to feedback from both the black hole and star formation acting together. If the feedback were just from the black hole, the gas would only show large speeds at the centre of the system. Instead the very gas that produces the star formation is being driven outward in an explosion out in
all directions.

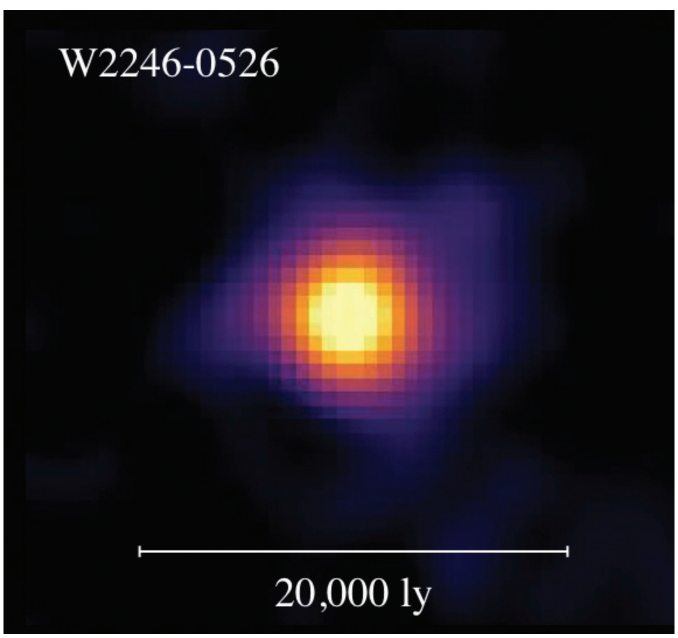


Figure 2 — Carbon emission from W2246-0526 imaged using the ALMA interferometer. The image is in false colour, where white represents the brightest emission. While visually unimpressive, ALMA can measure the velocity of the carbon gas at every position in the image and finds it to be moving around at speeds >500 km/s. Image credit: E. Rosolowsky based on data from ALMA project 2013.1.00576.S.

In this case, the extreme systems have shown us that the high energy of galaxy formation cannot last long. Along with other studies, this suggests that the largest galaxies are built up in bursts of star formation. To learn more, you can read about the article by Diaz-Santos et al. at http://arxiv.org/abs/1511.04079. ✶

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

John Percy's Universe

Astronomy and the Arts

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

Astronomy is an engaging frontier science that reveals the beauty and grandeur of the Universe, our cosmic roots, and our place in space and time. This is enough to satisfy most amateur and professional astronomers. But there's more to astronomy: its deep and ancient connections to philosophy, theology, history, literature, culture, and the arts. These connections have tremendous potential for reaching new audiences and other cultures, as we found during International Year of Astronomy 2009 (IYA: Hesser et al. 2010), as well as for enriching our own relationship with astronomy. We must remember that, in times past, astronomy played a more prominent role in culture, broadly defined. It provided a clock, calendar, and compass. Star and constellation names reflected a civilization's most important stories. The Sun, Moon, and planets were associated with powerful deities—the "theology" of the day.

Much has been written about the astronomy–arts connection, including useful resource lists such as those compiled by Andrew Fraknoi for the Astronomical Society of the Pacific, and that provided by PBS for Timothy Ferris's film *Seeing in the Dark*[1]. In this column, I shall list some Canadian examples, and personal experiences, especially from my role in IYA activities such as Tafelmusik Baroque Orchestra's *The Galileo Project* in 2009 (Percy 2014), which has been performed 72 times around the world to great acclaim and, in 2015 with the contemporary composers group *SpectrumMusic*[2], and with the ASLAN Boys Choir. This column is necessarily brief, incomplete, personal, Euro-centric, anglo-centric, and highbrow-centric.

Astronomy and Music

The concept of "the music of the spheres" was developed by philosophers in ancient Greece — the idea that the motions of celestial objects, through their mathematical underpinning, "resonated" with the human brain, as music does. Renaissance astronomer and numerologist Johannes Kepler expanded on this idea when he developed his laws of planetary motion. There's anecdotal evidence that astronomers tend to have a talent or interest in music: Galileo Galilei came from a musical family; William Herschel was a musician before he was an astronomer (as was his sister Caroline); Albert Einstein played the violin (and renowned amateur astronomer and keyboardist Patrick Moore once played a piano-violin duet with him); Brian May studied astronomy (and now has a Ph.D. in it) before he became lead guitar for Queen. And we Canadians proudly remember astronaut Chris Hadfield's lofty performance of David Bowie's "Space Oddity." It's now on the concert circuit!

Astronomy-themed concerts are too often restricted to Gustav Holst's *The Planets*, which is actually astrological. John Williams's music from *Star Wars* is very popular, and certainly conveys the spirit of exploration and wonder, and too often, conquest. At a deeper level, Claude Debussy's "Clair de Lune," and the first movement of Beethoven's "Moonlight Sonata" communicate the emotion of a moonlit sky in the same way that an Ansel Adams's moonlit landscape photograph does.

At least three Canadian orchestras (Victoria and Toronto Symphonies, and Tafelmusik) presented astronomy-themed concerts during IYA, for the public and/or for schools. Some of these concerts included star parties, organized by local astronomy groups. At least two award-winning Canadian composers premiered astronomy-themed compositions during IYA: Andrew Staniland (*Big Bang!,* a percussion concerto) and Michael Oesterle (*Cepheid Variables,* for glockenspiel, marimbas, and vibraphones). Physicist and jazz singer Diane Nalini[3] issued a CD of songs with astronomical imagery. For comprehensive lists of classical and popular music inspired by astronomy, see the article on space-themed music in *wikipedia*[4], and the very broad and comprehensive resource compiled by Andrew Fraknoi (2008) especially for IYA.

Astronomy-themed songs—serious or otherwise—have long been part of RASC General Assemblies (thanks especially to Peter Jedicke and David Levy). I'm pleased to see that the 2016 GA also includes a display of both images and original artwork.

Astronomy and Dance

Movement is obviously important in both astronomy and dance. For *The Galileo Project*, the musicians memorized the score, so that they were able to move, interact, and illustrate concepts such as the Earth's revolution (in Vivaldi's *The Four Seasons,* for instance). This was an important aspect of the educational version of *The Galileo Project.* I have often demonstrated the concepts of rotation, revolution, and day and night, by modeling them with simple apparatus and with my own motions. One of Howard Gardner's (somewhat controversial) "multiple intelligences" is bodily-kinesthetic intelligence.

There is even a new science outreach and communication activity called "Dance Your PhD"[5], sponsored by *Science* magazine and the American Association for the Advancement of Science. My astronomer friend Katrien Kolenberg (katrien.pomoto.com) was a contestant in the first Dance Your PhD contest, and she subsequently won the first EURAXESS North America Science Slam by playing her PhD dance, and weaving in material on how she uses art to explain and explore scientific concepts[6].

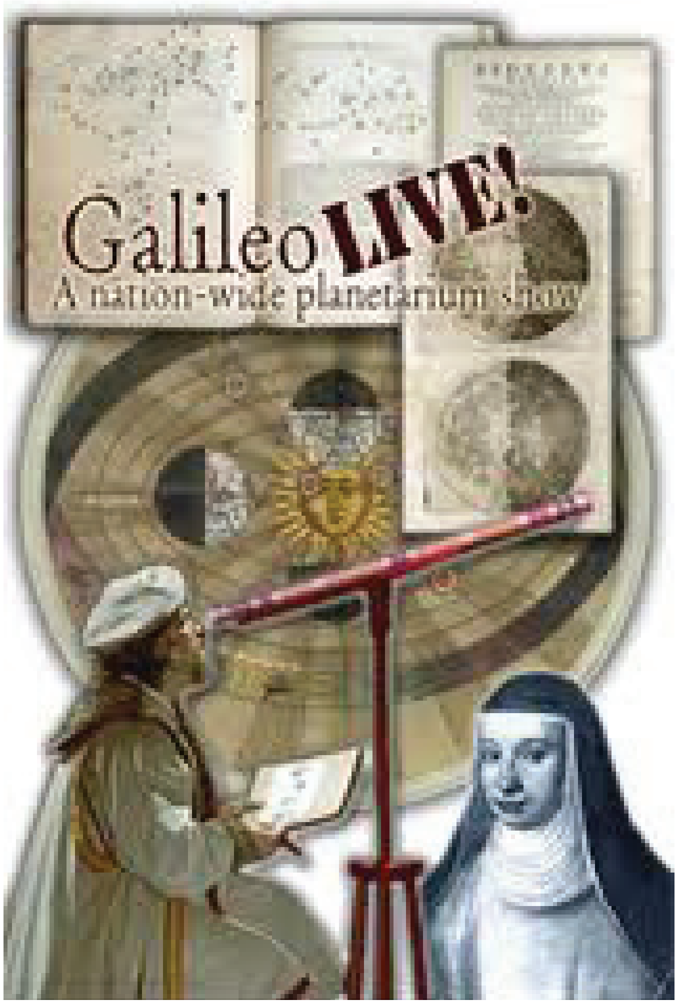


Fig 1 — Four of Canada's planetari collaborated to produce an award-winning IYA program Galileo Live! *It creatively combined live acting and theatre with big-screen planetarium imagery.*

Astronomy and Art

Many amateur and professional astrophotographs are works of art, as readers of this *Journal* well know. University of Manitoba astronomy professor and artist Jayanne English was part of the Hubble Heritage Project, "specially chosen images from the Hubble telescope, enhanced and explained by experts in order to educate and inspire." Canadian astronomical images graced many venues during IYA, and reached millions through Canada Post's attractive and popular circulating stamps.

Space art is a sub-genre that produces images of astronomical environments that we could not otherwise see (Hardy 1990). Lucien Rudaux (1874–1947), in France, was one of the first space artists. Chesley Bonestell (1888–1986), in the US, was one of the best-known. Lynette Cook, Don Davis, and professional astronomer William Hartmann are well-known astro-artists today. Paul Fjeld (www.pfinspace.com) is an award-winning Canadian space artist, and Jon Lomberg (www.jonlomberg.com), who lived for many years in Toronto, was a long-time collaborator with Carl Sagan.

Much astronomy-inspired art goes far beyond realistic depiction of space environments. Eminent Canadian artist Paterson Ewen (1925–2002) was often inspired by astronomical and geological phenomena such as the aurora in an abstract way, and much of Jon Lomberg's work is creatively abstract. For things related to art and astronomy, Robin Kingsburgh (robinkingsburgh.com) is my go-to person in the Toronto area. She teaches both astronomy (at York University) and art (at OCAD University). For IYA, her students mounted a varied and interesting exhibit at the Ontario Science Centre.

A totally different intersection of astronomy and art is the use of astronomical references to deduce information about works of art, literature, etc. Donald Olson (2014), author of *Celestial Sleuth,* is well-known for this. Among other things, he dated Vincent van Gogh's painting "Moonrise" to 9:08 p.m., 1889 July 13. Closer to home, Canadian astronomer and journalist Ivan Semeniuk used astronomy to deduce the site (Canoe Lake) and date (April 1917) of Tom Thomson's "Northern Lights."[7]

Astronomy, Theatre, and Opera

Mythological aspects of astronomy have appeared in stories for millennia, and were incorporated into early operas such as Jean-Baptiste Lully's *Phaeton* (1683). One goal of IYA in Canada was to record and celebrate the sky stories of our Aboriginal peoples, e.g. Marshall et al. (2010). Connections between *modern* astronomy and theatre (and the other arts) began with the Copernican revolution. In 1620, only a few years after Galileo first turned a telescope on the Moon, the English dramatist Ben Jonson wrote a masque called *News from the New World Discovered in the Moon.* (A masque is an early form of entertainment, combining dance, theatre, and song, originally performed by masked players). Much later, in 1777, Franz Josef Haydn wrote an opera *Il Mondo della Luna,* which was performed in Toronto during IYA. These represent the beginning of modern science fiction (sci-fi). In the 18th century, science and the arts came together more closely, as public lectures, museums, and organizations drew scientists, writers, and artists together (Holmes 2008).

Astronomy, like the other sciences, is a human endeavour. The stories of astronomers can be as riveting as the characters in any other novel or play. Berthold Brecht's *Life of Galileo* immediately comes to mind. Another example is the tragic figure Guillaume Le Gentil (1725–1792) in *Transit of Venus*, written by Canadian playwright Maureen Hunter and transformed into an opera by Canadian composer Victor Davies. These were recalled in 2012 in Toronto, when a recent transit of Venus was observed and celebrated. Incidentally: stories of Le Gentil and other intrepid astronomical travelers are well-told in *Setting Sail for the Universe*, by Don Fernie (2002), an RASC past president.

During IYA, four Canadian planetaria collaborated on the award-winning *Galileo Live!*, which combined acting and theatre with traditional planetarium programming (Figure 1). University of Victoria Professor Jennifer Wise's 2009 play about Galileo "Moons of Jupiter" was workshopped in 2009[8], and later performed at Queen's University under the title "Orbit."

On a lighter side: the popular 1927 musical *Good News* revolves around a test in an astronomy course, and contains the song, and well-known expression "The Best Things in Life Are Free." The words to that song include "the stars belong to everyone", which became the title of a book by Helen Sawyer Hogg, Canada's best-known and most beloved astronomer, and another RASC past president.

Astronomy and Literature

Astronomy, because of its deep cultural connections, pervades literature. One illustration is Canadian writer Dan Falk's (2014) latest book, *The Science in Shakespeare*. As with theatre, the lives of astronomers make great literature; Dava Sobel's *Galileo's Daughter,* and *A More Perfect Heaven* (about Copernicus) are superb. On the poetry front: prolific author David Levy, born and raised in Canada, is an authority on astronomy in poetry; he wrote a doctoral thesis on it. His *Starry Night: Astronomers and Poets Read the Sky* (Levy 2001) is a real gem. Eminent astronomer Dame Jocelyn Bell Burnell is co-editor of a wonderful collection of poems about space (Riordan and Bell Burnell 2008). I must admit that I occasionally include Walt Whitman's famous *When I Heard the Learn'd Astronomer* at the end of my public lectures, to encourage the audience to go out and look at the real sky.

The most obvious intersection between astronomy and literature is sci-fi which, as noted above, began in earnest after the Copernican revolution, and evolved into both serious literature (think Margaret Atwood) and rather trashy forms of science fantasy. Much has been written about sci-fi, so I shall not say more, other than to point out that Canadians have made important contributions; just look at a list of winners of the *Aurora Award*[9]. Writer and anthologist Judith Merril was a strong influence on my understanding of sci-fi. Her library now forms the core of the Toronto Public Library's extensive Merril Collection.

Good astronomy writing obviously qualifies as "literature," and Canada has been blessed with some outstanding astronomy authors – notably Clarence Augustus Chant, Helen Sawyer Hogg, Terence Dickinson, Ken Tapping, Dan Falk, and Ray Jayawardhana.

Astronomy, Film and TV

Astronomy is a mainstay of sci-fi: just think *Interstellar* and *The Martian*, *Star Trek*, and *Star Wars*. As for slightly "deeper" film: there is Stanley Kubrick's *2001: A Space Odyssey* (which, in my opinion and others', has the most effective score of any film). And Carl Sagan's *Cosmos* is still enlightening and moving, many decades later.

Not all astronomical documentaries have both educational and artistic merit, but Canada's Alison Rose has created two: *Galileo's Sons* (2003), about the astronomers at the Vatican Observatory, and *Star Men* (2015), about four eminent British astronomers who, 50 years after going to California as post-docs, retrace their travels around the American southwest as they philosophize about science, life, and death.

The most famous Canadian astronomy documentary—one of the world's best, and still available on-line—is the award-winning National Film Board's *Universe,* filmed largely at the David Dunlap Observatory[10]. It was an inspiration for Stanley Kubrick as he undertook *2001: A Space Odyssey*, and is still inspiring today.

Universe is a good place to end. It's a superb combination of content, narration, imagery, and music. And it's Canadian!

Acknowledgement

I thank Jim Hesser for many helpful comments on a draft of this article. ✶

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

Endnotes

1 www.pbs.org/seeinginthedark/resources-links/astronomy-and-the-arts.html

2 spectrummusic.ca/event/details/starry-night/

3 www.youtube.com/watch?v=a3o2kGFU8iI

4 en.wikipedia.org/wiki/Space-themed_music

5 gonzolabs.org/dance/

6 www.youtube.com/watch?v=0zJDCTBS7Yk

7 www.theglobeandmail.com/technology/science/thomson-paintings-location-is-written-in-the-stars/article1047294/

8 ring.uvic.ca/09dec03/galileo.html

9 www.prixaurorawards.ca

10 www.nfb.ca/film/universe

References

Falk, Dan. (2014). *The Science of Shakespeare.* Goose Lane, Toronto.

Fernie, J. Donald. (2002). *Setting Sail for the Universe*. Rutgers University Press, Piscataway NJ.

Fraknoi, A. (2008). "Music Inspired by Astronomy." In *Preparing for the International Year of Astronomy 2009*, ed. Michael G. Gibbs, Jonathan Barnes, James Manning & Bruce Partridge. Astronomical Society of the Pacific, San Francisco CA, 514.

Hardy, David A. (1990). *Visions of Space.* McClelland & Stewart Inc., Toronto.

Hesser, J.E., Bartlett, C., Bolduc-Duval, J., Breland, K., Hay, K.D., Jobin, M., Lacasse, R., Lane, D.J., Lemay, D., Percy, J.R., Welch, D.L. and Woodsworth, A. (2010). *JRASC, 104*, 51.

Holmes, Richard. (2008). *The Age of Wonder.* HarperCollins, New York NY.

Levy, David. (2001). *Starry Night: Astronomers and Poets Read the Sky.* Prometheus Books, Amherst NY.

Marshall, L., Marshall, M., Harris, P. and Bartlett, C. (2010). *Muin and the Seven Bird Hunters.* Cape Breton University Press, Sydney NS.

Percy, J.R. (2014). "Galileo and the Galileo Project," *JRASC 108,* 44.

Riordan, M. and Bell Burnell, J. (2008). *Dark Matter: Poems of Space.* Calouiste Gulbenkian Foundation (UK Branch), London UK

Second Light

The Nearest, most Recent Supernovae to Earth

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

Averaged over time, supernovae should explode within about 100 pc of Earth every 2–4 million years. I hasten to point out that 100 parsecs is far enough away not to have any damaging effect on Earth. It might be surprising to some readers, but radioactive isotopes created in a supernova could be carried to Earth on interstellar dust grains (such grains rain down on us every day). In fact, the isotope ^{60}Fe (iron) was discovered in one sample of ocean crust back in 1999 and attributed to a supernova. Now two studies, one by Anton Wallner of the Australian National University and his colleagues, and one by Dieter Breitschwerdt of the Berlin Institute of Technology and his collaborators, have considerably expanded what we know about that supernova (see the 2016 April 7 issue of *Nature*).

Because radioactive decay times are generally well known, it was relatively easy to determine when the supernova exploded—it was about 2.2 million years ago. An analysis last year led to the conclusion that it occurred between 60 and 130 parsecs away.

Wallner has now studied ocean crust samples from around the world and found that the ^{60}Fe signal is global and from multiple supernovae. He has also found the signature of a second spike between 6.5 and 8.7 million years ago.

It is known that the Solar System sits inside an area called the Local Bubble—a region filled with hot plasma that has carved out a bubble in the interstellar medium. The size of the bubble implies that it was created by multiple supernovae. Modelling, based upon the usual "initial mass function" that describes the number of new stars formed of various masses, led Breitschwerdt to conclude that between 14 and 20 supernovae contributed to the bubble. Previous work identified the group as part of the present day Scorpius–Centaurus association—that is what is left of a region of star formation. There are hundreds of stars in the association, including most of the brightest ones in the constellations of Scorpius, Lupus, Centaurus, and Crux. Antares, at 15 solar masses, is the most massive star remaining in the association. There are three sub-groups, ranging in ages from about 5 million years to about 15 million years. The most massive stars have the shortest lives, with very massive ones living just a few million years. Antares is a member of the youngest subgroup. So, for the last 15 million years, supernovae have been exploding, inflating the Local Bubble.

Breitschwerdt has used the timing information, measured proper motion and radial velocity of the group, and modelled the transport of material from the association to Earth. He then uses another model to estimate where the supernovae were located when they went off. There are a number of assumptions and uncertainties associated with these models, but the result is nevertheless very interesting.

The most recent supernova happened 1.5 million years ago, at a distance of 96 parsecs, and in the (present) location of RA 15 h 32 m, Dec -24 d 44 m. The closest to us happened 2.3 million years ago, at a distance of 91 parsecs. The RA is about the same, but it was at a declination of –45 degrees. The table lists his estimates of the past supernovae in the Sco-Cen association, and there is indeed a cluster of them from 6 to 9 million years ago, which might correspond to Wallner's second peak, though the dust would have had to travel a rather long way.

This brings us back to the topic of safety. The gamma rays generated by a supernova at a distance of about 8 parsecs would probably destroy about half the ozone in our upper atmosphere, based upon an extrapolation from SN 1987A. This could have catastrophic effects by allowing ultraviolet light from the Sun to reach the surface. Phytoplankton and ocean reefs would be particularly hard hit, and there has in the past been speculation that a close supernova (or a related gamma-ray burst) was responsible for at least one mass extinction event. But that has never been widely accepted, because the evidence is too weak. Fifteen parsecs would likely be a safe distance.

There are at the present time no stars within 15 parsecs that are massive enough to explode, so heave a sigh of relief. But readers will likely recall that some supernovae are not what astronomers call "core collapse," where a massive star explodes. Type Ia supernovae are thought to happen when a white-dwarf star exceeds the Chandrasekhar mass (about 1.4 solar masses). Until the past few years we thought that type Ia supernovae mainly came from a tight binary system with a main-sequence or giant star together with a white dwarf. The white dwarf, the thinking went, would accrete gas from its nearby companion. There is one such system—IK Pegasi—that is about 50 parsecs way. Again, we can have a sigh of relief.

But current evidence seems to suggest that many type Ia supernovae arise in binary systems where two white dwarfs spiral in and finally merge. There is a white dwarf-white dwarf binary system with an orbital period of just 5 minutes (HM Cancri). Fortunately, that system is almost 5000 parsecs away from us. It is a source of X-rays, as presumably any other compact binary white-dwarf system would be. There have been enough X-ray surveys of the sky that if there were such a system within 15 pc it would likely have been found by now. So a final sigh of relief.

Of course, it is well known that the early Solar System had nearby supernovae—we see the remnants of the ^{26}Al created in them in meteorites today. As star formation takes place inside molecular clouds, and when they collapse, there are many stars formed, inevitably there were some massive ones, just as there were in the Sco-Cen association. They would have had no impact on life on Earth, because there was not any at that time. But all the same, the Universe is a dangerous place.

Table courtesy of Dieter Breitschwerdt and *Nature*. ✶

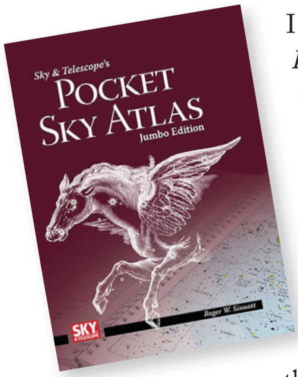
t_{SN}	m ($M_\odot$)	M_{ej} (10^{-5} $M_\odot$)	x (pc)	y (pc)	z (pc)	D (pc)	l (°)	b (°)	α	δ	sc
-12.6^2	19.86	6.3	277	75	89	300	15.15	17.23	17^h17^m	$-7°09^m$	Oph
-12.0^3	18.61	5.5	223	99	71	254	23.94	16.22	17^h37^m	$-0°21^m$	Oph
-11.3^2	17.34	5.0	251	67	87	274	14.95	18.52	17^h12^m	$-6°39^m$	Oph
-10.0^2	15.41	4.2	227	57	83	248	14.10	19.53	17^h07^m	$-6°48^m$	Oph
-10.0^3	15.36	4.1	185	77	67	211	22.60	18.49	17^h27^m	$-0°23^m$	Oph
-8.7^2	13.89	3.6	203	45	79	222	12.50	20.80	17^h00^m	$-7°23^m$	Oph
-8.0^3	13.12	3.4	151	49	57	169	17.98	19.75	17^h14^m	$-3°34^m$	Oph
-7.5^2	12.65	3.3	181	31	75	198	9.72	22.22	16^h49^m	$-8°46^m$	Oph
-6.3^2	11.62	3.0	163	11	73	179	3.86	24.10	16^h30^m	$-12°03^m$	Oph
-6.1^3	11.48	2.9	121	19	47	131	8.92	20.99	16^h52^m	$-10°04^m$	Oph
-5.0^2	10.76	2.7	145	-5	69	161	-1.97	25.43	16^h12^m	$-15°19^m$	Sco
-4.2^3	10.21	2.6	97	-15	33	104	-8.79	18.58	16^h16^m	$-24°35^m$	Sco
-3.8^2	10.02	2.6	125	1	51	135	0.46	22.19	16^h28^m	$-15°40^m$	Oph
-2.6^2	9.37	2.4	95	-9	47	106	-5.41	26.22	16^h01^m	$-17°05^m$	Lib
-2.3^3	9.21	2.4	75	-49	17	91	-33.16	10.74	15^h10^m	$-45°35^m$	Lup
-1.5^2	8.81	2.3	83	-25	41	96	-16.76	25.31	15^h32^m	$-24°44^m$	Lib

Table 1 — Supernova explosions that created the Local Bubble—The first column is the time of the supernova, in millions of years before the present. The second is the original mass (at birth) of the progenitor. Third is the mass of the ejecta. The x, y, and z columns are the positions relative to the Local Standard of Rest for the Galaxy, and D is the distance at the time of the supernova. The Galactic coordinates l and b, and the right ascension and declination mark the position in the sky where the supernova would be seen today, and the final column is the constellation in which those coordinates lie.

Leslie J. Sage is Senior Editor, Physical Sciences, for Nature Magazine *and a senior visiting scientist 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.*

Reviews / Critiques

***Sky & Telescope*'s Pocket Star Atlas, Jumbo Edition**, by Roger W. Sinnott, pages 130; 30 cm × 20 cm, , F+W Media, Inc., 2015. Price ~ $40 USD hardcover (ISBN-13: 978-1-970038-25-4).



I suppose the oxymoron of a *Jumbo Pocket Star Atlas* is not lost on anyone, but to be honest, I truly appreciate the idea of a larger version of the very useful *Pocket Star Atlas*. Since the *Jumbo Atlas* is mostly a reformatted version of the original pocket-sized atlas, it seems appropriate to refer readers to the various reviews of the *Pocket Sky Atlas* available on-line, since there is no point in simply repeating what has been stated previously by others. Links to several such reviews are available from the reviewer.

For the past decade I have carried my small-size (not quite pocket size, but certainly parka-pocket size) *Pocket Sky Atlas* while travelling on business around the world, in order to be sure I had an astronomy reference wherever I went. Throw it in a suitcase—it takes up no room and the Universe is at my fingertips. But I never did like it much for observing with a telescope because its small format made it difficult to read and to follow star-hops. The larger scale of the *Sky Atlas 2000* always won out at my scope.

Now, nine years in the future, the enlarged and slightly expanded *Jumbo Pocket Star Atlas* is, in my opinion, simply an excellent idea! The Universe is ripe for a new printed atlas useful at the scope, since the out-of-print *Sky Atlas 2000* is very difficult to find. The point of being useful at the scope is very important. The charts are about 40% larger, and the whole atlas is a convenient size that does not take up too much room on the observing table, and it is now large enough to read comfortably in the dark without squinting. The *Jumbo Atlas* is also spiral bound, which allows the charts to open flat and permits the cover to fold back onto itself, so that one chart is conveniently presented if you need to hold the atlas near the eyepiece. The hardcover design (as opposed to the soft vinyl cover of the smaller version) makes the charts stiff, so that they do not fall away when you are holding them with one hand.

If you are already using the smaller *Pocket Atlas*, then there is essentially no learning curve for the *Jumbo Atlas*; the *Jumbo* charts are identical in content and order. Just as in the original atlas, the *Jumbo Atlas* portrays stars to magnitude 7.6, indicates double and variable stars, galaxies to magnitude 11.5, globular clusters to 10.5, and planetary nebulae to 12. Open clusters, bright diffuse nebulae, and dark nebulae are mapped with their outlines indicating true sizes or shapes (mostly). The Messier and Caldwell objects are identified, and the entire Herschel 400 list is included, even if the objects are dimmer than the normal catalogue limit. The *Jumbo Atlas* also expands the number of Close-up Charts for crowded and interesting areas from 4 to 10, originally with M45, Orion's sword, the Virgo Cluster, and the Large Magellanic Cloud (LMC), but now including the Cone/Rosette area, the Big Dipper bowl, Leo's tail, the North America Nebula, the Sagittarius Milky Way, and the tail of Scorpius.

There are a few errors and inconsistencies within the atlas that I discovered while thumbing through it. For example, NGC 6540 is correctly shown as a globular cluster on Chart 67, but incorrectly as an open cluster on Close-up Chart I. Also on Chart 67, NGC 6595 is an unlabelled diffuse nebula, but becomes an open cluster on Chart I—it should be labelled a diffuse nebula around a double star. For purists, the cluster of three nebulae in this area, NGC 6589, NGC 6595, and IC 1283-4, are overlaid by the coarse open cluster Collinder 371, which is not identified in the atlas. Looking a bit further into correct identifications, I found that NGC 6589 is also wrongly positioned—it should be more north of NGC 6595. Then again, someone's database is wrong, since the same position error is repeated in the *Millennium Star Atlas* (chart 1368) and *SkyAtlas 2000* (charts 16 & 22). For correct identification of the objects, see the photograph in *Star Clusters* (2003, page 125), or *Uranometria* (chart 145). All atlases end up with some sort of minor identification issues, here and there, that are hopefully corrected in future editions.

To confirm that the *Jumbo Atlas* is truly useful, I took it under the stars and put it through its paces with my red flashlight. I found the enlarged charts easy to read in dim red light, and the black outlines around the red-printed galaxies insured that they did not disappear off the charts at night. The arrangement of the charts, however, is not to my preference, although that may not bother other observers. The *Jumbo Atlas* is arranged in eight North Pole to South Pole gores (orange slices), and each gore becomes a chapter of ten paired charts reading sequentially from north to south. The issue I have is that throughout the night the sky moves from east to west, and most often observing is carried out in the opposite direction. So, as the sky runs off one page, the natural instinct is to flip to the next page, only to find the printed sky moves southward. To go from Lyra to Hercules, just to the west, you have to flip nine charts backward in the atlas. I found it confusing in spite of the margin flags. I constantly had to refer to the all-sky index on the inside of the rear cover to jump around the sky effectively. In other words, the atlas is not laid out for experienced observers.

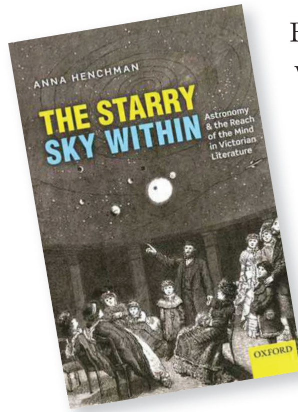
All in all, I do not believe that such issues should deter from the fact that it is an excellent atlas for beginning-to-intermediate level observers. Even if you have a large scope and chase down galaxies at the edge of the Universe, the *Jumbo Atlas* will still serve as an excellent reference in your observing box. Why a printed star atlas? Planetarium software on your laptop, tablet, or smart phone is great, but notorious for having poor and inaccurate databases, and the screens are never truly red enough or dim enough to preserve good dark-adaption. They also have small screens, making them difficult to jump around in. I still prefer printed-paper charts, since they are also immune to loss of Internet service, forgotten chargers, or dead batteries, and it is difficult to make mark-up pencil corrections on your device screen.

If you do not already have a favourite printed atlas, the *Jumbo Pocket Sky Atlas* will not disappoint you. I am impressed. Thanks, Roger and crew, for another excellent product.

Richard Huziak

Richard Huziak is a seasoned visual observer and CCD photometrist with almost 50 years of observing experience using small- and medium-sized telescopes. He has physically worn out at least four atlases while star-hopping to and sketching several thousand objects. He is an active member of the Saskatoon Centre of the RASC.

The Starry Sky Within: Astronomy & the Reach of the Mind in Victorian Literature, by Anna Henchman, pages 294 + xviii, 32 illustrations; 23 cm × 15.5 cm, Oxford University Press, New York & Oxford, 2014. Price $19.95 hardcover (ISBN: 978-0-199-68696-4).



By the end of the 17th century, the walled-in world view postulated by Aristotle, the medieval cosmology of concentric ethereal spheres, continuously and uniformly driven by unchanging divinities, had been re-conceptualized through the work of Copernicus, Kepler, Tycho Brahe, Galileo, and Newton into "a piece of machinery vast in magnitude, complicated in structure, beautifully exact in its proportions, and eminently and universally beneficial in its uses." Perceived as a rigid, immutable structure of forces, tensions, pressures, and oscillations, it was the most sublime construct ever conceived, its aim no less than to quantify the dynamics of the Universe into a coherent, all-predicting system. So effectively were observation and theory reconciled, that whenever they were found to disagree, an explanation was always available. There was nothing it seemed that could not be illustrated by a tangible model or predicted by the amazingly precise laws of mechanics.

Though some problems proved intractable, most yielded eventually, acclaiming the supremacy of the formal mathematical scheme of Isaac Newton. Yet early in the 19th century, doubts about its validity surfaced when observation demonstrated that Uranus, then the most distant outpost of the solar empire, was found to be out of step with Delambre's theory of the planet published in 1790. The anomaly was slight, insignificant by ordinary standards, but it posed the gravest threat to Newtonian law, leading some to suggest it did not apply beyond Saturn. In effect, William Herschel's serendipitous discovery of 1781 had done more than add another planet to the solar family, it had doubled the size of the solar domain and reorganized the way we perceive time and space, bringing into sharp focus how much of the cosmos escapes common perception. With each discovery, such as Bessel's determination that the insignificant star 61 Cygni was over 10 light-years distant from Earth, it became glaringly obvious the Solar System was neither central to the Milky Way or the Universe. Importantly, by the time Einstein came on the scene, the old notion of fixed stars of a uniformly stable Universe had been long discarded, replaced by a perception of physical reality chaotic in comparison with the majestic clockwork decreed by Isaac Newton.

That magnificent scenario, of celestial systems in flux, of complex and changing relationships, resonates with the dynamic of humankind, demonstrating that as individuals people can never observe from a stable position, that everything is in constant motion. What is seen as reality is little more than an amalgam of fractured perspectives. As Anna Henchman astutely observes in her elegant and innovative academic study *The Starry Sky Within*, "Astronomers such as Richard Proctor (1837-88) and Felix Eberty (1812-84) conceived of the Earth itself as a perpetual projector, sending versions of itself out into space, with each moment in history still perceivable from a distant star."

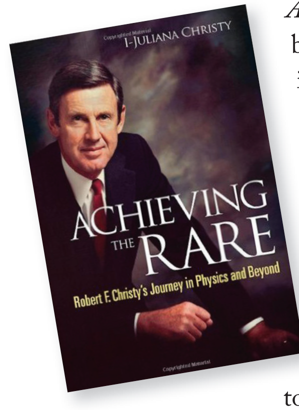
Henchman, who follows in the genre pioneered by Marjorie Hope Nicolson (1894-1981), links astronomy and optics to the multi-plot novel with its complexity of relationships, and centres of consciousness and network of varying points of view. Applying parallax, gravity, and optical aberrations, as critical metaphors to a collection of Victorian writers such as Thomas Hardy, George Eliot, and Alfred, Lord Tennyson, she makes compelling connections between narrative and cosmic distances, to reveal new truths and fresh insights. By so doing she offers a new understanding from a literary point of view of the impact astronomy made on the Victorian imagination. *The Starry Sky Within* is beautifully written and highly recommended for its erudition and stimulating exploration of little travelled highways, which in turn open more doors into a many-roomed mansion. It is a remarkable work that will renovate jaded minds with new vistas, and transform familiar scenes into temples of wonder and treasured memories.

Well illustrated with period images and diagrams, many from well-known classical astronomical texts, the book is highly recommended as an unusual and important addition to the literature of cultural astronomy.

Richard Baum

Richard Baum is the recipient of the 2005 Walter H. Haas Award from the Association of Lunar and Planetary Observers, the BAA's Walter Goodacre Medal and the Lydia A. Brown Medal, and is the director emeritus of their Terrestrial Planets Section, and Mercury and Venus Section. He is the author of The Haunted Observatory: Curiosities from the Astronomers' Cabinet *(2007), and with Bill Sheehan,* In Search of Planet Vulcan: The Ghost in Newton's Clockwork Universe *(1997). The IAU named minor planet 7966 Richardbaum (1996 DA) in his honour.*

Achieving the Rare: Robert F. Christy's Journey in Physics and Beyond, by I.-Juliana Christy, pages 349 + xv; 25 cm × 16.5 cm, World Scientific Publishing, Singapore, 2013. Price $29 USD paperback (ISBN: 978-981-4460-24-8).



Achieving the Rare is primarily a biography of Bob Christy's career in science and university administration written by his second wife Juliana Christy, including autobiographical details assembled from descriptions provided by Christy himself. The book was previously reviewed in this *Journal* by John Percy a year ago (JRASC, 108, 85-86, 2015), so I was surprised to find a copy still sitting at RASC head office in a stack of books awaiting reviews. From curiosity I began reading it myself, and soon found myself unable to put it down. It is so intriguing a story that it must surely be of interest to anyone interested in developments in 20th-century physics and astrophysics. Percy's review provides most of the details about the contents, so they need not be repeated here. And, like John, I have personal links to a few of the events described, so have a natural interest in the story.

In brief, Robert Christy (1916-2012) is a Canadian graduate in physics from the University of British Columbia who spent much of his lengthy career at the California Institute of Technology (Caltech) in either faculty or senior administration positions, including time as its president. During World War II, he was involved at Los Alamos in the Manhattan Project, during which period he designed the trigger mechanism, or "Christy Gadget," for the implosion device used to detonate the two atomic bombs tested at Alamogordo and dropped on Nagasaki, Japan. He later became interested in the astrophysics of pulsation for Cepheid variables, developing some of the first successful non-linear pulsation models for such stars in an era when computer modelling still involved IBM punch cards fed into large, room-sized, programmable supercalculators.

Although *Achieving the Rare* relates all of that, and considerable additional material, in a detailed biography of the life of Robert Christy, it is also much, much more than that, having been assembled in true loving fashion by his devoted wife Juliana, who shared the second half of his life with him. Juliana includes intimate details of her own life in the biographical account, as well as Robert's opinions on a variety of topics: one being his preference for quality rather than quantity in published work, which should, in essence, help to advance science. His work influenced a wide variety of scientists over the years, so it is fitting that *Achieving the Rare* allows us a glimpse into the high standards and moral ideals of a highly respected individual.

My own association with Robert Christy goes back to the events associated with Juliana's first encounter with him at the University of Toronto's June Institute in 1968. I had just begun graduate studies in Astronomy at the University of Western Ontario, and was familiar with Christy's work from his article on Pulsation Theory in the 1966 edition of *Annual Reviews of Astronomy and Astrophysics*. I had become "hooked" on astronomy during my senior years at the University of Waterloo, so was quite interested to hear Christy describe his computational work related to pulsation in Cepheids. Although I was not then involved directly in observational studies of Cepheids—that would come many years later—it is fair to say that Christy's easy-going, easy to follow, and dignified manner as a lecturer had a positive influence on my views of the field. The last time I heard him speak was during the 2009 Santa Fe Pulsation Conference, as described in the later pages of *Achieving the Rare*, so quite by accident I seem to have been associated with two of the end points in the story described in the book.

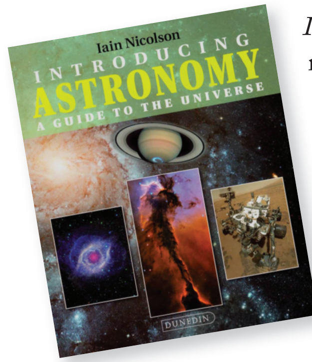
Some thoughts: I found it interesting that both of Christy's wives, Dagmar and Juliana, had hereditary links to the East Prussian upper class. Details about Los Alamos during the war, and Robert's later interest in combatting the effects of radiation exposure are also well worth reading. The writing style is captivating, yet the book could have profited from a solid copyediting. Several typographical errors slipped through, and much of the text is repetitive, since Juliana includes both transcripts of Robert's taping sessions as well as her own summaries of the events. The sequence of events spanning Robert's life is also told at times out of strict temporal order, which leads to occasional confusion. *Achieving the Rare* could be an even better product than it reads.

As I read through the pages, it struck me that many individuals on the observational side of astronomy have life stories that may be just as interesting as that of Robert Christy. Readers are referred to "Extracts from the Diaries of the University of Toronto Southern Observatory" in this *Journal* (JRASC, 90, 1996, February, April, and June issues) for just a few links to "the old days" of Canadian astronomy, prior to the modern comforts of automated domes, warm rooms, and remote observing runs. Many of us have had our share of life-threatening observing runs to make life just as interesting as Bob Christy's in physics, and I look forward to the time when our older astronomers publish their life histories. Perhaps some encouragement is needed? Try reading *Achieving the Rare*. It should provide some inspiration!

David Turner

David Turner is review editor for the Journal *and professor emeritus of astronomy and physics at Saint Mary's University.*

Introducing Astronomy: A Guide to the Universe, by Iain Nicolson, pages 166 + x; 19.5 cm × 16.5 cm, Dunedin Academic Press Ltd., Edinburgh, 2014. Price $20 paperback (ISBN: 978-1-78046-025-3).



Introducing Astronomy is one of two recent contributions to introductory astronomy by Dunedin Press, and is probably the better of the two. Iain Nicolson is a good writer, and speaks with a great deal of expertise on the subject matter of the book. He is a lecturer on astronomy and space science in Britain (the University of Hertfordshire 1983-98), author of several books and magazine articles, and contributor to an extensive selection of books and encyclopedias. He is a consultant to *Astronomy Now*, has been chair of AstroFest since 1996, and is a frequent contributor to BBC's *The Sky at Night*, where he has helped foster the public understanding of astronomy.

Introducing Astronomy is a concise introduction to all areas of astronomy that is written extremely well, avoiding the many grammatical errors and misspellings that plague most research papers in every journal in astronomy published currently. Equations are avoided, and Nicolson's wording is crafted to retain interest while ensuring a continuous flow from beginning to end, despite the variety of topics covered. The book can therefore be read completely in a matter of hours, with content assuring a constant state of interest. Consider, for example, the following introduction to chapter 6 on Stars: "Stars are incandescent globes of gas, which are broadly similar in nature to our Sun. Some are larger, some smaller, some hotter, some cooler, some are far more luminous, while others are, compared to the Sun, mere celestial glow-worms."

The chapters are laid out mainly in standard fashion: an overview, viewing the night sky, planets, the Sun, Solar System, stars, interstellar clouds, galaxies, the evolutionary Universe, exoplanets, and tools of the trade. The section on our Solar System is very well done despite its brevity, likewise for the introduction to the phases of the Moon and planets. It was refreshing to find celestial coordinates covered in such a short text, and generally quite well. However, I was left scratching my head over Nicolson's definition of the coordinate azimuth as "the point on the horizon that is vertically below the star," replicated in a Glossary of Terms. If one defines "vertically" as measured relative to the observer's zenith, and considers the angle from north measured to the point, the definition begins to make sense. Yet this is simply one of several definitions in the text that needs some work to avoid confusing the reader. Terms such as vernal equinox, leap years, mean solar day, and others, are also not quite as described, although that could readily be solved by the instructor, if *Introducing Astronomy* was used as a course textbook. In that case, it would also need much additional material provided by the instructor.

Some statements in the text are just plain wrong, although it may be years before the truth of that statement is known. For example, current research is still working out the layout of our own Galaxy; the observational evidence is not as clear-cut as depicted in the text. Figure 7.6 is a poorly displayed schematic diagram used to illustrate stellar evolution in an H-R diagram that is, well, horrible. Although similar horrors are also inflicted on introductory students in astronomy by lots of other textbook writers, perhaps it is time to get it right. Stellar evolution need not be a black art.

The section on observational cosmology does well at spouting the "party line," but provides little insight to readers about the fallacies of some arguments. Some terms are included that seem only to take up space that might have been more usefully spent providing explanations for additional insightful comments. Many areas of introductory astronomy are solidly understood, while others are still in the early stages of development. Should it be the duty of the course instructor or the textbook writer to spell out where that is important? *Introducing Astronomy* provides no line of demarcation on that, and is best considered in that light. It would likely do well as a course textbook because it is inexpensive, up to date, and easily supplemented by material provided by the course instructor. As reading material for the novice, however, it may mislead readers regarding how much is known about the Universe around us.

In summary, *Introducing Astronomy* is an easy and interesting read that can be recommended to novices. It serves its intended audience well. Those wishing more-detailed insights, and solid physical arguments, into specific areas should be prepared to move on to specialized books in those fields.

David Turner

David Turner continues to be involved in astronomy education as professor emeritus of astronomy and physics at Saint Mary's University. His research interests revolve around pulsating stars, interstellar extinction, Galactic astronomy, and the continuing mystery of the Star of Bethlehem.

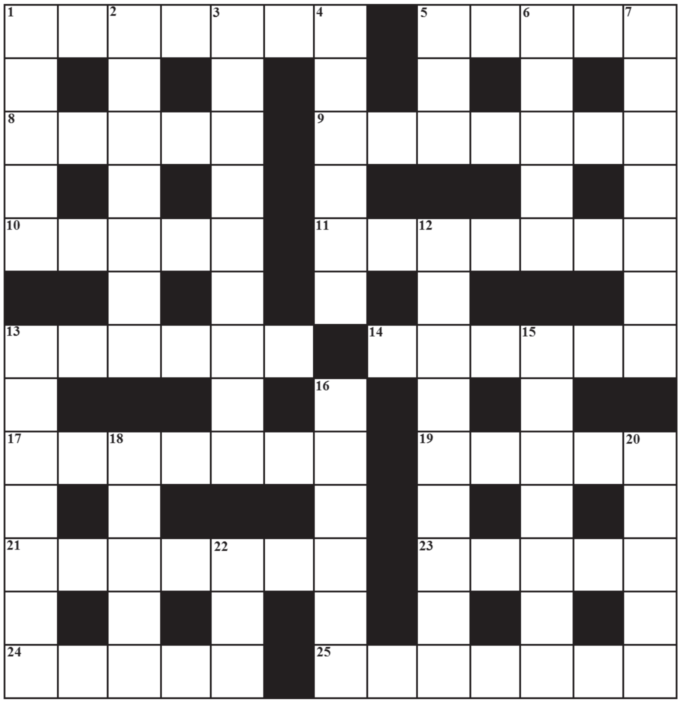
Great Images

by James Edgar

RASC President James Edgar sent this image that he took several years ago from his back yard in Melville, Saskatchewan, when he was just learning how to use his first DSLR, a Canon 20D. It was taken on the early morning of 2007 July 4, using an unguided Canon 18-mm lens at f/3.5 for 15 seconds and ISO 400. The Pleiades had just cleared the north-eastern horizon at the time of the photo, so this aurora covers the entire eastern sky from horizon to zenith.

Astrocryptic

by Curt Nason



ACROSS

1. Telescope inserted in pier after first half of June to observe a planet (7)
5. His big comeback led to a degree and a heliochronometer (5)
8. American astronomer gave everything to European research (5)
9. Clues to a stationary focus position found in Carina's mythology (7)
10. Sky survey conducted across Oslo and Helsinki (5)
11. Overexpose red with sensitized film (7)
13. Titan was seen as Saturn by Caesar (6)
14. Poetic evening star observed as a misshapen sphere (6)
17. Barnard makes Earth's leader a radio astronomer to friends (7)
19. Torrid sounding sisters seen around Venus (5)
21. Creeping sky critter is not a real cat, apparently (7)
23. Proxima discovered by astronomer dipping into a Guinness (5)
24. Oceans recede and move forward with haste (5)
25. Maritime Mount where they saw the disappointing comet after all (7)

DOWN

1. Its length is an inseam or minimum size of a collapsing cloud (5)
2. At Russian observatory, back-up to gutted Lick, Vesta first spotted in spectacles (7)
3. A large nebula is natural at mixing (9)
4. Mirror test for seeing the rotation of Chiron (6)
5. Interstellar cloud flows up in Sagitta (3)
6. Greek letters charted first for brightness year round (5)
7. Playing charades, lost a queen's gem (7)
12. Looks could do this with a meteorite (9)
13. Looking for outer asteroid group, celebs scatter around the gym (7)
15. First pulse of a returning nova is assigned to the peacock (7)
16. Dog stars in flyer with head start to the altar (6)
18. Chore broken up within the limit (5)
20. Hey, it's either me or some occultation guy (5)
22. The German comes up from his shift in the recession (3)

Answers to April's Astrocryptic

ACROSS

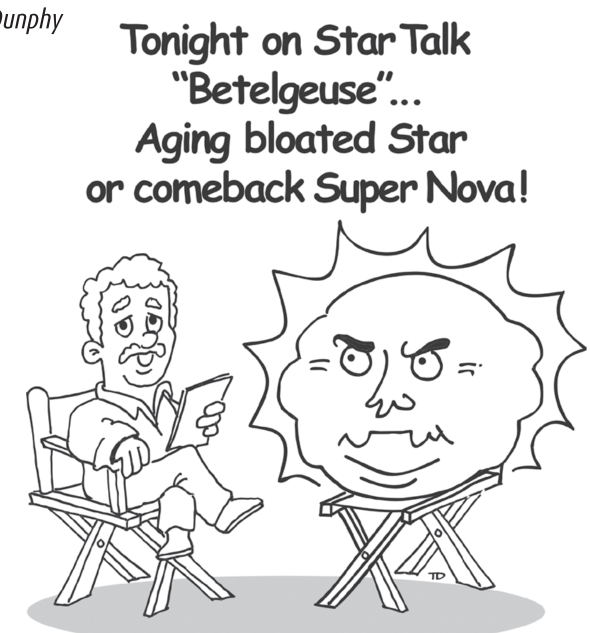
2 MILKOMEDA (anag); **8** RUNAWAY (an(a)ag); **9** GATTO (an(T)ag); **10** ATRIA (2 def); **11** ELTANIN ((anag-p) + in); **12** EGRESS (anag); **14** STRATA (anag); **18** ALBIREO (anag); **20** LUPUS (l+up+us); **22** ARRAY (hidden); **23** ALSHAIN (anag); **24** ASTRONOMY (anag)

DOWN

1 SURFACE (surf+ace); **2** MINOR (mi+nor); **3** LOW MASS (an(sam (rev))ag); **4** OXYGEN (ox+y+gen); **5** EIGHT (hom); **6** ANTENNA (recurrent anag); **7** BROWN (2 def); **13** ROBERTA (anag); **15** TELESTO (anag+O); **16** ARSENIC (anag-am); **17** DORADO (do+RA+do); **18** ADAMS (anag); **19** RAYET (ray+ET); **21** PEARY (P(anag)y)

It's Not All Sirius

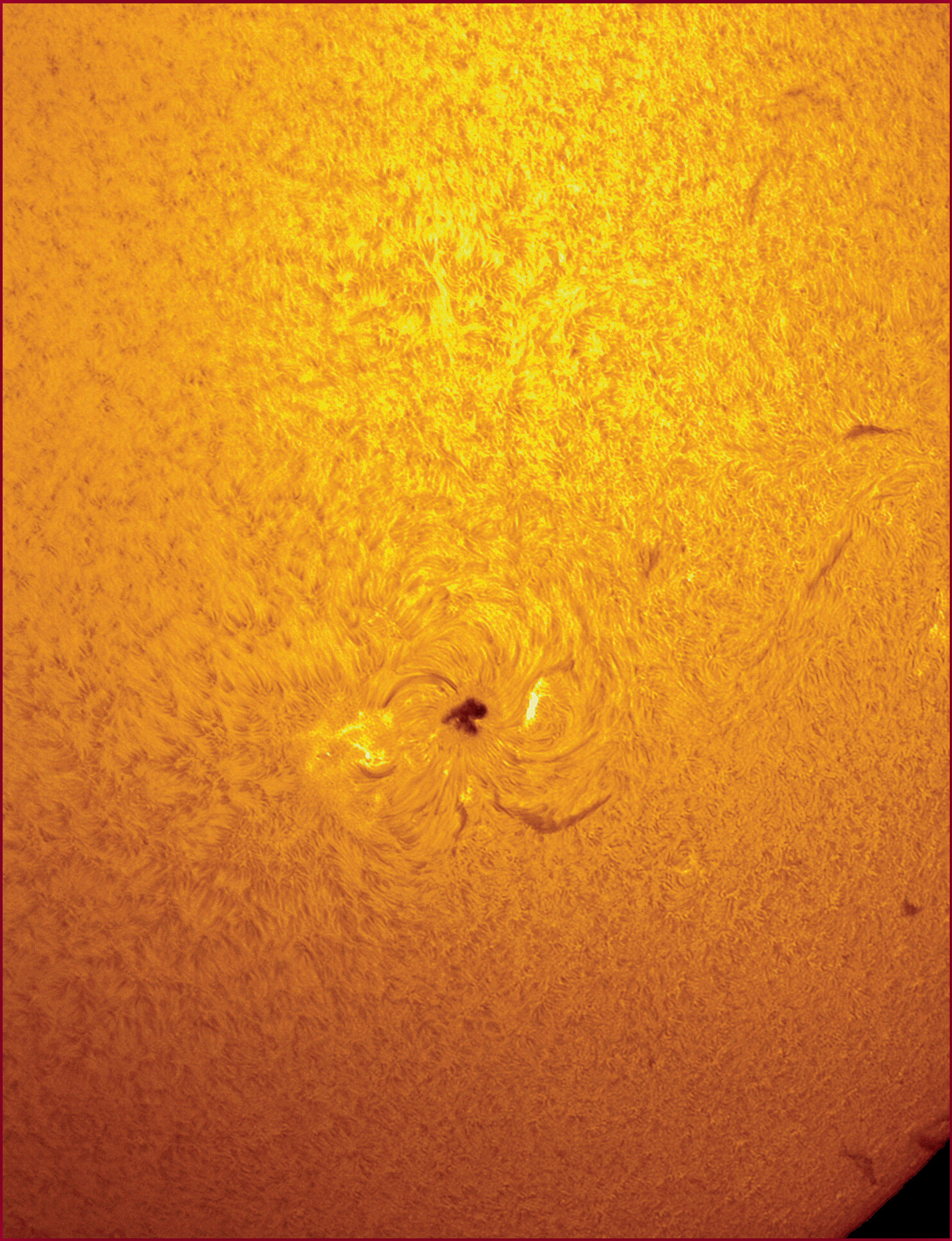
by Ted Dunphy



Great Images

by Serge Théberge

Serge Theberge: Jones-Emberson 1 is an expanding planetary nebula in Lynx with a decent emission in $H\alpha$ although with low surface brightness. This is the result of 14 × 15-min images taken in $H\alpha$ (Tak FS152 @ $f/8$ with ST10XME and Astrodon $H\alpha$ Gen 1 filter). Image is at full resolution of 1.15 arcsec/pixel.



Journal

Great Images

Bill Longo of Toronto Centre took this image of the Sun using his Coronado 60 double stack, PGR Chameleon on a Star Adventurer mount. He processed the image using Photoshop CC.