The Journal of The Royal Astronomical Society of Canada

Journal

Le Journal de la Société royale d'astronomie du Canada

PROMOTING ASTRONOMY IN CANADA

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The Last Years of the David Dunlap Observatory

Tulip in the sky

Great Images

By Andrea Girones

Andrea Girones imaged the Cone Nebula, the Fox Fur Nebula, and Christmas Tree Cluster found in Monoceros. She says she imaged them from her Ottawa backyard on 2023 March 11 "as a last gasp to shoot some disappearing winter constellations." She used a Celestron C11 SCT telescope, the L-Enhance dual-band filter, and the Hyperstar reducer at ƒ/1.9 and 540-mm FL for a total of 3 hours of 180-s exposures stacked and processed in PixInsight. She also used some new AI tools such as Blur Exterminator and Star Exterminator in processing.

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Société Royale d'Astronomie du Canada

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Great Images

Now that we're leaving spring behind, why not include a cosmic tulip to remind us of the favourable weather we're heading into? Steve Leonard captured the Tulip Nebula, a bright and colourful emission nebula found in Cygnus. "This beautiful nebula features colourful glowing gas that extends like petals of a tulip and dark trails of dust resembling stamens," Steve says. "The gas in the nebula is excited by the star HDE 227018, which lies near the centre of the nebula." Steve used an Astro–Tech AT115EDT 4.5-inch triplet refractor at ƒ/5.6 on an HEQ5 mount, with N.I.N.A., an ASI 1600MM Pro camera, and Chomra 3-nm filters in Hα, OIII, and SII. Processing was done in PixInsight for a total of 14 hours of integration. Taken under a Bortle 8/9 sky.

Journal

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

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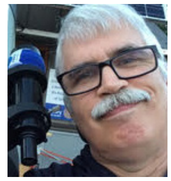
President's Corner

The Role and Value of Citizen Scientists



by Charles Ennis,
Sunshine Coast Centre
(cuhulain@telus.net)

People frequently remind me that our Society depends on its Centre volunteers. I've often wondered if the average member has given any thought to what that means. Our Society has only survived for over 150 years due to its volunteers. People who are the first through the door on meeting days to set up, and when the second-to-last person leaves, are still pushing a vacuum around the meeting room. A person who drew up the designs and applied for the permits and grants for your observatory project. Men and women who showed up with shovels and mattocks, hammers, and saws to frame that observatory. Someone who climbed ladders and into crawl spaces to install the solar panels and batteries. The person who regularly mows the field around the observatory and who rebuilt the outhouse with their own materials and funds without being asked. A lonely volunteer with a paint can in one hand and a brush in the other stained that observatory. Volunteers are the first to arrive to roll back the observatory roof, set up the telescope, and spend long hours near the eyepieces of telescopes, showing the public the wonders of the sky.

As the last visitor's tail lights disappear into the distance, it is volunteers rolling the roof to close the observatory and putting everything away. It is their tail lights that are the last ones going down the hill. Who manages all these volunteers? More volunteers. People volunteer to engage in the time-consuming process of taking care of Society business with no expectation of remuneration.

Volunteers put innumerable hours into editing handbooks and other publications, and when they get an honorarium from us, turn around and donate it back to the Society. Volunteers write handbooks and courses for the Society and donate all the proceeds to the Society (then write newer editions for free). Volunteers spend hours writing scripts, taping, and editing content for YouTube. Volunteers spend hours balancing budgets and dealing with expenses on their own clock. We rely on people who regularly donate to support the programs of our Society. We survive on the sweat equity of our members. ✶

From the Editor

The Society welcomes our newest Executive Director, Jenna Hinds. She starts May 1 into her new role. Many of us know her from a previous employment as Youth Outreach Coordinator, in which she fashioned programs that connect with young people. In addition, Jenna created numerous YouTube videos for use during our pandemic lockdown. She is a welcome addition to our team at National Office.

Also, with this issue, we kick off a new centrefold feature, "What's Up in the Sky?" borrowing on some of the material prepared for the defunct *SkyNews* magazine, with sky charts, tables, and a new portion contributed by Past President Scott Young of the Winnipeg Centre. ✶

News Notes / En manchette

Compiled by Jay Anderson

Rings heat Saturn's upper atmosphere

The secret has been hiding in plain view for 40 years, but it took the insight of a veteran astronomer to pull it all together, using observations of Saturn from NASA's *Hubble Space Telescope* and retired *Cassini* probe, in addition to the *Voyager 1* and *2* spacecraft and the retired *International Ultraviolet Explorer* mission.

The discovery: Saturn's vast ring system is heating the giant planet's upper atmosphere. The phenomenon has never before been seen in the Solar System. It's an unexpected interaction between Saturn and its rings that could provide a tool for predicting if planets around other stars have glorious Saturn-like ring systems, too.

The telltale evidence is an excess of Lyman-alpha (Ly-α) ultraviolet radiation, visible as a spectral line of hot hydrogen in Saturn's atmosphere extending over a latitude range of ~5°–30°N. Because Ly-α radiation is sensitive to temperature, the bump in radiation means that something is contaminating and heating the upper atmosphere from the outside.

The most feasible explanation is that icy ring particles raining down onto Saturn's atmosphere cause this heating. This rain could be initiated by the impact of micrometeorites, solar-wind particle bombardment, solar ultraviolet radiation, or electromagnetic forces picking up electrically charged dust, which then falls into the planet's upper atmosphere. When NASA's *Cassini* probe plunged into Saturn's atmosphere at the end of its mission in 2017, it measured the atmospheric

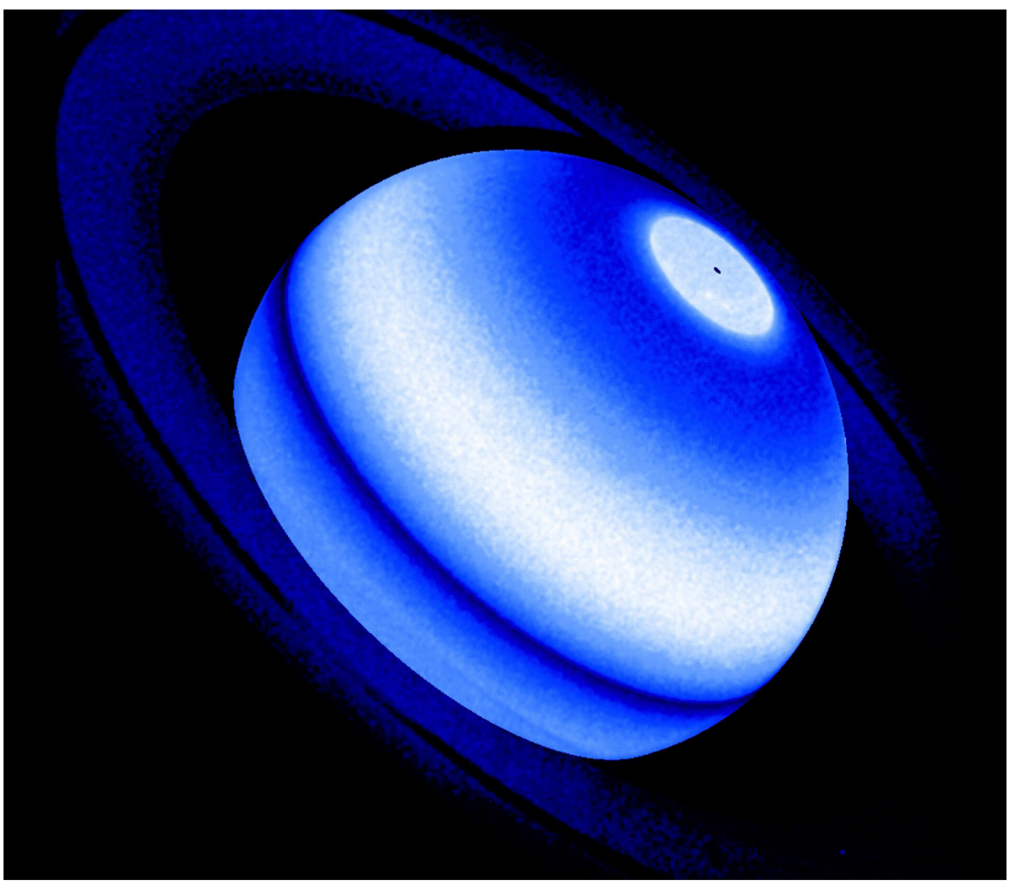


Figure 1 — This composite image shows the bright Saturn Lyman-alpha bulge, superimposed on a Hubble near-ultraviolet image that is used as a reference to sketch the Lyman-alpha emission. The rings appear much darker than the planet's body because they reflect much less ultraviolet sunlight. Above the rings and the dark equatorial region, the Lyman-alpha bulge appears as an extended (30 degree) latitudinal band that is 30 percent brighter than the surrounding regions. Credit: NASA, ESA, Lotfi Ben-Jaffel (IAP & LPL)

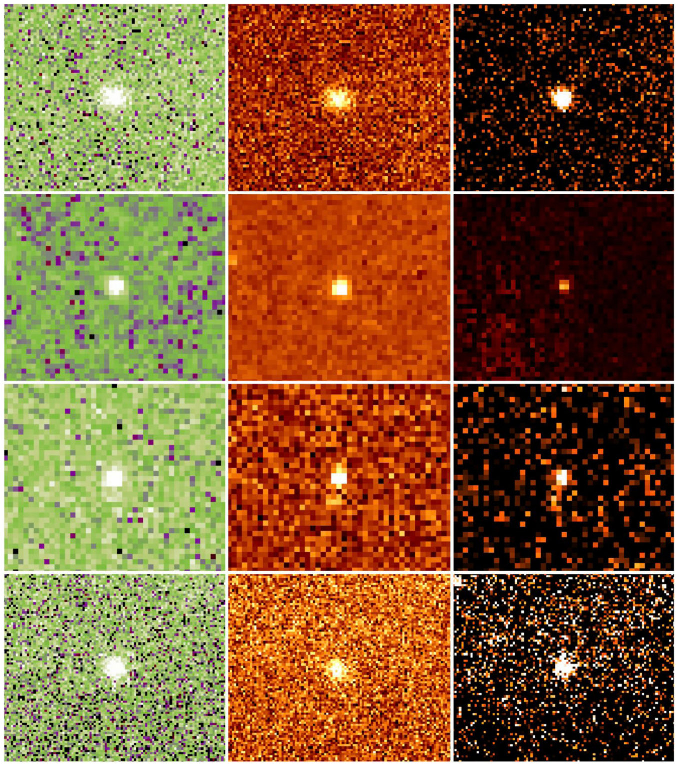


Figure 2 – Multi-band images of Neptunian Trojans 2015 VW165, 2014 QO441, 2014 YB92, and 2014 SC374 taken with the Palomar 200-inch, Gemini, and Keck telescopes. Credit: Dr Bryce Bolin.

constituents and confirmed that many particles are falling in from the rings.

"Though the slow disintegration of the rings is well known, its influence on the atomic hydrogen of the planet is a surprise. From the *Cassini* probe, we already knew about the rings' influence. However, we knew nothing about the atomic hydrogen content," said Lotfi Ben-Jaffel of the Institute of Astrophysics in Paris and the Lunar & Planetary Laboratory, University of Arizona.

"Everything is driven by ring particles cascading into the atmosphere at specific latitudes. They modify the upper atmosphere, changing the composition," said Ben-Jaffel. "And then you also have collisional processes with atmospheric gasses that are probably heating the atmosphere at a specific altitude."

Ben-Jaffel's conclusion required pulling together archival ultraviolet-light (UV) observations from four space missions that studied Saturn. The observations included those from the two NASA *Voyager* probes that flew by Saturn in the 1980s and measured the UV excess. At the time, astronomers dismissed the measurements as noise in the detectors. The *Cassini Mission*, which arrived at Saturn in 2004, also collected UV data on the atmosphere over several years. Additional data came from Hubble and the *International Ultraviolet Explorer*, which launched in 1978.

The key to assembling the jigsaw puzzle came in Ben-Jaffel's decision to use measurements from *Hubble Space Telescope*'s Imaging Spectrograph (STIS). Its precision observations of Saturn were used to calibrate the archival UV data from the other space missions. "When everything was calibrated, we saw clearly that the spectra are consistent across all the missions. This was possible because we have the same reference point, from Hubble, on the rate of transfer of energy from the atmosphere as measured over decades," Ben-Jaffel said. "It was really a surprise for me. I just plotted the different light distribution data together, and then I realized, wow—it's the same."

Four decades of UV data covered multiple solar cycles, helping astronomers to study the Sun's seasonal effects on Saturn. By bringing all the diverse data together and calibrating it, Ben-Jaffel found that there is no difference to the level of UV radiation. "At any time, at any position on the planet, we can follow the UV level of radiation," he said. This points to the steady "ice rain" from Saturn's rings as the best explanation.

"We are just at the beginning of this ring characterization effect on the upper atmosphere of a planet. We eventually want to have a global approach that would yield a real signature about the atmospheres on distant worlds. One of the goals of this study is to see how we can apply it to planets orbiting other stars. Call it the search for 'exo-rings.'"

Compiled with material provided by the Goddard Space Flight Center, NASA.

Neptune's Trojans favour red colours

Asteroids sharing their orbits in resonance with the planet Neptune have been observed to exist in a broad spectrum of "red" to "very red" colours according to a new study by an international team of researchers.

The team of scientists from the USA, California, France, the Netherlands, Chile, and Hawaii observed 18 such asteroids, known as Neptunian Trojans. They are between 50 and 100 km in size and are located at a distance of around 30 astronomical units (au) from the Sun. Because of this distant faintness, only about a dozen Neptunian Trojans had been studied beforehand, requiring the use of some of the largest telescopes on Earth.

The new data were gathered over the course of two years using the WASP wide-field camera on the Palomar Observatory telescope in California, the GMOS cameras on the Gemini North and South telescopes in Hawaii and Chile, and the LRIS camera on the Keck Telescope in Hawaii.

Of the 18 observed Neptunian Trojans, four were much redder than most asteroids. Redder asteroids are expected to have formed much further from the Sun; one population of these is known as the Cold Classical trans-Neptunian objects found beyond the orbit of Pluto, at around 40 au from the Sun. The newly observed Neptunian Trojans are unlike asteroids located in the orbit of Jupiter, which are typically more neutral in colour.

The redness of the asteroids implies that they contain a higher proportion of more volatile ices such as ammonia and methanol. These are extremely sensitive to heat, and can rapidly transform into gas if the temperature rises, and so are more stable in the distant reaches of the Solar System. The presence of the asteroids at Neptune's distance also implies that they are stable on timescales comparable to the age of the Solar System, effectively acting as a time-capsule, recording the initial conditions of the Solar System.

Redder asteroids among the Neptunian Trojans suggests the existence of a transition zone between more neutral-coloured and redder objects. The reddest Neptunian asteroids may have formed beyond this transition boundary before being captured into the orbit of Neptune. The other Neptunian Trojans would have been captured into the same orbit as the planet Neptune, when the icy giant planet migrated from the inner Solar System to where it is now.

Lead author Dr. Bryce Bolin of the NASA Goddard Space Flight Centre said, "In our new work we have more than doubled the sample of Neptunian Trojans studied with large telescopes. It's exciting to find the first evidence of redder asteroids in this group."

"Because we have a larger sample of Neptunian Trojans with measured colours, we can now start to see major differences between asteroid groups. Our observations also show that the Neptunian Trojans are also different in colour compared to asteroid groups even further from the Sun. A possible explanation may be that the processing of the surfaces of asteroids by the Sun's heat may have different effects for asteroids at varying solar distances."

Compiled with material provided by the Royal Astronomical Society.

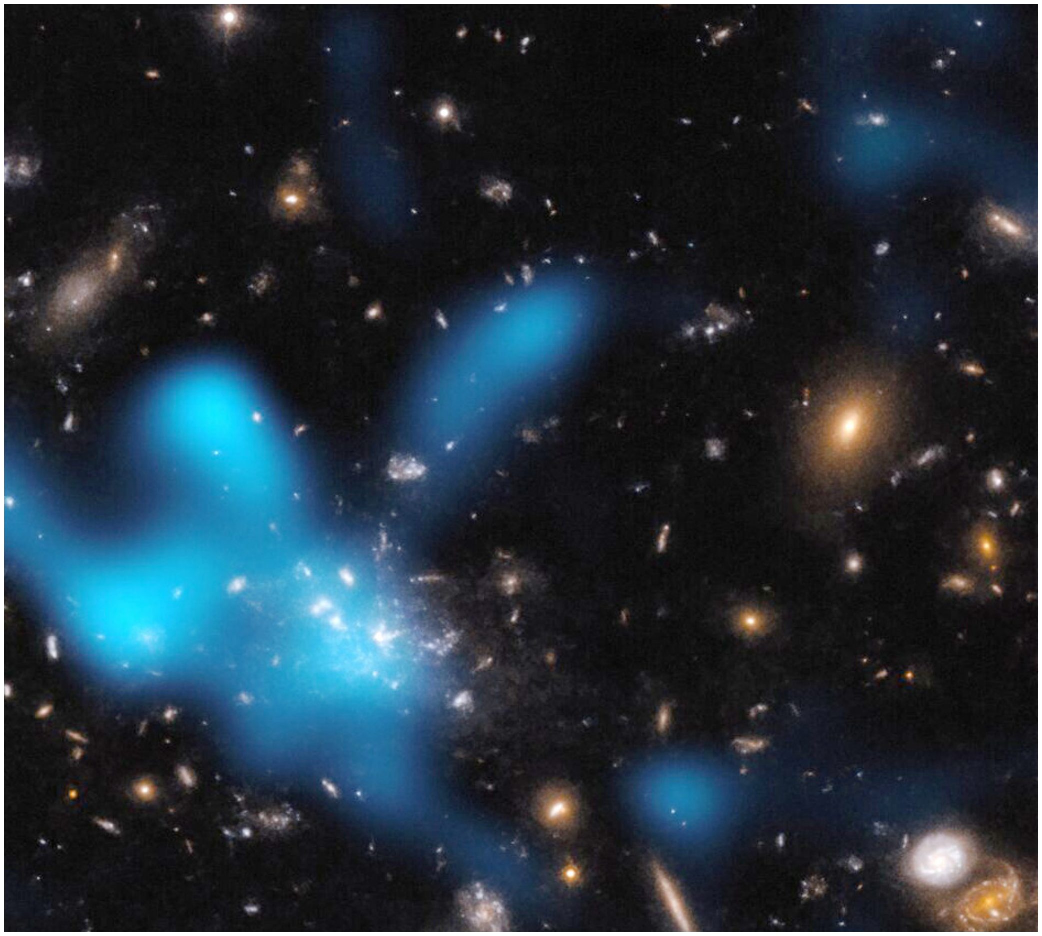


Figure 3 — This image shows the protocluster around the Spiderweb Galaxy, seen at a time when the Universe was only 3 billion years old. Most of the mass in the protocluster does not reside in the galaxies that can be seen in the centre of the image; the intracluster medium is shown in blue. Credit: ESO/Di Mascolo et al.; HST: H. Ford

Spiderweb Galaxy has a big cloak

Using the Atacama Large Millimetre/submillimetre Array (ALMA), astronomers have discovered a large reservoir of hot gas in the still-forming galaxy cluster around the Spiderweb Galaxy. Galaxy clusters are massive structures, embedded in a diffuse, hot, intracluster gas that may outweigh the cluster itself. Their evolution is thought to be dictated mostly by mergers with neighbouring galaxies and the accumulation of the intracluster medium (ICM). Much of the physics of galaxy clusters and their interaction with the ICM is well understood for older and closer galactic assemblies, but considerable mystery remains about those in an earlier epoch.

Galaxy clusters are massive and heat up the gas as it falls inward. "Cosmological simulations have predicted the presence of hot gas in protoclusters for over a decade, but observational confirmations has been missing," explains Elena Rasia, researcher at the Italian National Institute for Astrophysics (INAF) in Trieste, Italy, and co-author of the study. "Pursuing such key observational confirmation led us to carefully select one of the most promising candidate protoclusters."

That candidate was the Spiderweb protocluster, located at an epoch when the Universe was only three billion years old. Despite being an intensively studied system, the characterization of its ICM has remained elusive. Finding a large reservoir of hot gas in the Spiderweb protocluster would indicate that the system is on its way to becoming a proper, long-lasting cluster rather than dispersing.

A team led by Luca Di Mascolo, first author of the study and researcher at the University of Trieste, Italy, found the ICM of the Spiderweb protocluster through what's known as the thermal Sunyaev-Zeldovich (SZ) effect. This effect occurs when light from the cosmic microwave background—the relic radiation from the Big Bang—passes through the ICM. As this light interacts with the fast-moving electrons in the hot gas, it gains a bit of energy and its colour, or wavelength, changes slightly. "At the right wavelengths, the SZ effect thus appears as a shadowing effect of a galaxy cluster on the cosmic microwave background," explains Di Mascolo.

By measuring these shadows, astronomers can infer the existence of the hot gas, estimate its mass, and map its shape. "Thanks to its unparalleled resolution and sensitivity, ALMA is the only facility currently capable of performing such a measurement for the distant progenitors of massive clusters," says Di Mascolo.

The team of astronomers determined that the 112-member Spiderweb protocluster contains a vast reservoir of hot gas at a temperature of a few tens of millions of degrees Celsius. Cold gas had been previously detected in this group, but the mass of the hot gas found in this new study outweighs it by thousands of times. This finding shows that the Spiderweb protocluster is on its way to becoming a massive galaxy cluster in around 10 billion years, growing its mass by at least a factor of ten. Observations also showed that the ICM was offset from the centre of the galaxy cluster, implying that the core of the protocluster is undergoing a dynamic evolution: the cluster is more than just a collection of galaxies, as it is assembling its own halo of diffuse gas.

Tony Mroczkowski, co-author of the paper and researcher at ESO, explains that "this system exhibits huge contrasts. The hot thermal component will destroy much of the cold component as the system evolves, and we are witnessing a delicate transition." He concludes that "it provides observational confirmation of long-standing theoretical predictions about the formation of the largest gravitationally bound objects in the Universe."

Composed with material provided by the European Southern Observatory.

Margaret Bryan, a 19th-century astronomy scholar

Around 1800, an English schoolmistress named Margaret Bryan wrote several well-regarded textbooks on astronomy and physics for young women. While Bryan corresponded with some of the most illustrious astronomers and mathematicians of her time, relatively little was known about her until now. She ran a boarding school for girls in Blackheath, London, from 1795 to 1806, and the curriculum included mathematics and sciences—rarely offered to young women. She first published her lecture notes on astronomy in 1797, and after their positive reception, she decided to undertake another volume of lectures.

New research by Gregory Girolami, the William and Janet Lycan Professor of Chemistry at the University of Illinois Urbana-Champaign, uncovered previously unknown details about this enigmatic scholar's background and family.

"Although Bryan's published work and her efforts to educate young women have long been appreciated, now for the first time Bryan the person—along with her family—begins to emerge from the dark shadows in which she has been shrouded for over two centuries," he wrote.

Girolami's research sprang from his interest in the history of science—and women scientists in particular. His wife, Vera Mainz, also a chemist, shares his interest.

"When I started my investigation, Margaret Bryan was just this cipher," he said. "It was known that she wrote these textbooks, she had two daughters and ran a boarding school, but that was about it. I like sleuthing challenges of this sort, so I decided I would try to find out more about her life."

Basic facts about her seemed lost to history, such as her birth and death dates, maiden name and her family members' names. Although the frontispiece of her first work, *A Compendious System of Astronomy* (available online), included an engraved portrait of the author and her daughters, the names of the latter were not disclosed. Likewise, while the book's preface implied that Bryan was a widow at the time of publication in 1797, the name of her husband has never been known, Girolami said.

Bryan's other works included the physics textbook *Lectures on Natural Philosophy*, published in 1806; a smaller volume, *Astronomical and Geographical Class Book for Schools*, in 1815; and a revised edition of an educational board game, *Science in Sport or The Pleasures of Astronomy*, in 1804.

Noting that numerous people with the surname Nottidge—many of whom also were listed as residents of the village of Bocking—were among the subscribers to Bryan's books, Girolami began his search there, hypothesizing that these individuals were likely relatives.

By combing through online genealogy databases and other sources, he found information about the Nottidges, a prosperous family of wool merchants who operated mills in several towns northeast of London. One of the family members, Thomas Nottidge, wrote a will in 1794 that not only mentioned Bryan, it revealed the names of her daughters—Ann Marian and Maria. Unfortunately, though, the will did not indicate how the families were related.

In investigating the family tree of Thomas Nottidge's wife, Ann Wall, Girolami found that in 1768 her father, James Wall, left bequests to his three grandchildren—Oswald, James, and Margaret Haverkam. Girolami said he proved conclusively through his research that Haverkam was Bryan's maiden name. Further research identified the name of Bryan's husband—William Bryan—whom she married on 1783 July 12, in London. The births of Ann Marian and Maria followed, possibly in 1784 and 1786, respectively, Girolami said.

The date and place of Bryan's death remain unknown, complicated both by her commonplace name and the vagueness of many public and church records. However, a notice of the death of "a much beloved and lamented, Mrs. Margaret Bryan, age 79," on 1836 March 30, in Fortress Terrace, Kentish-Town, London, is a possible fit, Girolami said.

With many questions about Bryan's life and death unanswered, Girolami said he hopes his research will lead to even more discoveries about her—including how her interest in astronomy was piqued and nurtured to an extraordinary level during an era when women scientists were few.

Compiled with material provided by the University of Illinois at Urbana-Champaign. ✶

Figure 4 — Portrait of Margaret Bryan from Lectures on Natural Philosophy. American Heritage Center, University of Wyoming.

Research Article / Article de recherche

The last years of the David Dunlap Observatory: Personal Reminiscences

by Slavek Rucinski, Professor Emeritus
David A. Dunlap Department of Astronomy & Astrophysics
University of Toronto

The text describes my association with the David Dunlap Observatory in years 1985–2008. It is a highly personal view: The DDO evolved from the first place of my employment in Canada to a research facility that I managed on a daily basis before the sale of the grounds and the DDO closure.

A bit about my own history prior to 1984

It may be useful to review my own life choices on the way from Poland to Canada—my peregrination between two distant astronomical observatories: the Warsaw University Observatory and the David Dunlap Observatory.

Our first stay in Canada took place in 1975–1977. I was then a Research Associate at the Dominion Astrophysical Observatory in Victoria, B.C., arriving straight from Poland to become the first NRC Plaskett Fellow (astroherzberg.org/about-us/plaskett-fellowship/former-plaskett-fellows). This was my second long-term stay abroad; the first was a Post-Doctoral Fellowship at the University of Florida in 1970–1971. My wife and I had no intention to emigrate from Poland to Canada in 1975–1977; we indeed returned there, and I continued at the Warsaw University Observatory.

In 1980, I was invited to the Max Planck Institute for Astrophysics in Munich, Germany. This is where I worked for the next two years, from 1980 to 1982. Following that stay, I took another two-year research position at the Institute of Astronomy in Cambridge, UK (1982–1984). The continuing political instability in Poland at that time could lead to various outcomes. Among them, we considered the possibility of a massive Soviet military intervention of the type we are now witnessing in Ukraine. These thoughts forced us to think about emigration. Canada—known to us from the stay in Victoria in 1975 to 1977—seemed an excellent place for a permanent settling. We had really enjoyed our previous stay in Victoria. Importantly, thanks to my experience with several early astronomical satellites, Professor Gordon Walker from the University of British Columbia offered me the position of a Scientific Manager of the astronomical satellite project "StarLab," with him as a Principal Investigator. It would have been a major research facility estimated to cost a few hundred million dollars at that time. It would be an excellent opportunity for me. Unfortunately, the Canadian portion of the funds were cut off by the federal agencies in 1984 and the project was cancelled. But this happened when all official procedures were advanced, and we were emigrating to Canada. Fortunately Professors Tom Bolton and Stefan Mochnacki arranged for me a "cushion," which, on our arrival in Toronto in December 1984, took the shape of a temporary Research Associate position at the David Dunlap Observatory supported from their research grants. I was given a desk at the DDO and could continue my own projects. This is when DDO started to become part of my life.

The first years in Toronto: 1985–1997

I felt confident enough to start teaching at the Department of Astronomy of the University of Toronto in the 1985 academic year. My employment was on a contractual basis as an Assistant Professor. This gave me an opportunity to learn about differences in teaching between Poland and Canada. It also permitted me to look around and see possibilities for further employment. While I kept a desk space at DDO, I did not use the 1.88-metre telescope, which seemed to me rather heavily utilized. I did try—over a few months—to use the photometric system consisting of the 0.5-metre and 0.6-metre telescopes developed by Prof. Don Fernie. But I did not like running between these two, somewhat distant telescopes, and I gave up on that. I had plenty of material collected in previous years: I worked mostly on the data acquired at the European Southern Observatory in Chile and the data from various first-generation astronomical satellites (IUE, ANS, OAO-2, OAO-3). The assistant professor position permitted me to apply for federal research grants. This arrangement continued to 1987 when, unexpectedly, Professor Donald MacRae, the former Head of the Department[1] told me about a newly created Provincial Centre of Excellence, the Institute for Space and Terrestrial Science (ISTS). Possibly, I could find a more stable position there. I had not known Professor MacRae but heard about him and he apparently knew about me. I also sensed that, although he was retired, he was well informed about the departmental personnel situation at Toronto. I followed his advice and took the new job at ISTS in 1987.

The work environment at the ISTS was nice, and I did not mind an obvious lack of research atmosphere: I could freely continue my own work, while research contacts continued through my Adjunct Prof. position at UofT. In fact, I obtained an identical position at York University where I did some graduate-level teaching. My main employment-related activity at the ISTS was aimed at establishing contacts with the space industry of Ontario. I quickly realized that astronomical applications—e.g. a small photometric telescope in an orbit focused on small-amplitude variability—were not generating much interest among engineers. I was usually very politely listened to but then nothing came out of my attempts to continue contacts. In fact, these efforts eventually resulted in success in the form of the MOST satellite, but this happened much later (see below). Thus, for several years, my liaison duties at ISTS were limited to appreciating the high expertise level of Ontario space companies that were not interested in federally funded, presumably poorly supported, small-scale projects.

My DDO connection continued through these years. I typically spent two to three days of every week working on my data in the peaceful and research-conducive atmosphere of the DDO. During the decade of 1987–1997, I spent about equal amounts of time at ISTS, DDO, the downtown UofT offices, with occasional visits to York University. Somehow, I had time for all those places and for rather productive research resulting in several publications. During that time one of my graduate students at York, Mr. Wen Lu started using the 1.88-metre telescope. He later became the telescope night assistant. Through Wen, I tried to implement a new technique of spectral analysis that I had started developing on data acquired at the Canada-France-Hawaii Telescope in 1985–1986. I

Figure 1 — The three main components of the close-binary radial-velocity program belonged to three generations of astrophysical instruments: (1) The telescope—representing the 1930's technology—utilized the first fused-Pyrex mirror, but was long and subject to large mechanical stability issues. (2) The Cassegrain spectrograph (the semi-triangular structure, with red-painted counter-levers, below the main-mirror cell) was designed in the 1960s with high efficiency in mind as an all-reflection instrument. (3) The CCD detectors reflected the 1990s technology with quantum efficiency exceeding 80%; they were still relatively small in terms of the number of pixels.

called it the Broadening Functions Technique, and it later became my main data-analysis tool.

I looked forward to each visit to the DDO where I had excellent conditions for research work, far from the business atmosphere kept at ISTS. It was also nice to meet interesting people. I was sharing my office with Professor Helen Hogg. She was very kind and polite. She liked pointed, well-focused conversations. She would come for one or two hours and usually seemed very busy. My visits to the DDO also gave me an opportunity for encounters with the departmental professors. In addition to my former "employers," Bolton and Mochnacki, I was meeting the former Chairman of the Department, Don Fernie and the current (at that time) Chairman, Ernest Seaquist. I was also meeting Robert (Bob) Garrison and John Percy. Karl Kamper did research in astrometry and was in charge of photography and optics. Several fourth-year and graduate students working with these professors and using the 1.88-metre telescope were coming and going; the atmosphere was friendly and pleasant. The technical staff were interesting to interact with: the mechanics Dave Blyth and Archie Ridder, the electronic specialists Shenton Chew and Vlodek Kunowski, the janitor Frank McDonald, the 1.88-metre telescope night assistants, Jim Thomson and Wen Lu. Later, the night assistant Heide DeBond and the versatile technician Yakov Voronkov joined the technical DDO staff. While the matter of a closure of the DDO surfaced in discussions from time to time, the observatory seemed to operate quite unperturbed through those years; at least I did not notice any obvious change over those ten years, from 1987–1997.

I went three or four times to Las Campanas Observatory in Chile to use the University of Toronto 0.60-metre telescope of the department. The discoverer of the famous Supernova 1987A, Ian Shelton (the former UofT student), was then the U of T Resident at Las Campanas. I was privileged to partially give my observing time to permit Ian to continue photometric observations of the supernova until the end of its observing season. These were the early times of computer use for observations and the internet was still to be brought to the public. Voice communications between the U of T station at Las Campanas and Richmond Hill were done using the short-wave receivers with antennas on the DDO grounds.

The first Canadian astronomy satellite: MOST

A major change in my life took place in 1997. The ISTS started its phased closure a year before. It was exactly at that time when I met an engineer who was willing to listen to my ideas of a small astronomical satellite able to observe variability of stars continuously utilizing a special Sun-synchronous, dawn-dusk orbit. An idea of a small astronomical satellite was not generally popular. It was assumed that—for proper stability—orbital telescopes must be large and massive. The *Hubble Space Telescope*, with dimensions of a school bus, was a mental standard here: the computers and stabilization system devices were bulky and heavy. In contrast, Dr. Kieran Carroll, associated with the UTIAS (University of Toronto Institute for Aerospace Studies) and working at Dynacon Enterprises Ltd, was involved in development of miniaturized stabilization systems—a necessary subsystem for a small satellite. He was enthusiastic about the idea of a small photometric satellite as a first platform to implement a novel system developed in Toronto: inherently sharp images of stars seemed ideal targets for first experiments. This resulted in a series of meetings starting in 1995 and continuing once a week for about a year when we tried to solidify details of a possible proposal to the Canadian Space Agency (CSA). In 1996, the agency opened up a competition for funds where our idea of a satellite was facing the strong, well-established sounding-rocket community distributed among several Canadian universities. After a few exploratory meetings at CSA, I concluded that chances for our astronomical satellite were very low. But we still tried. The team I was able to organize included professors from several Canadian universities distributed from Halifax to Vancouver; the skeletal and shrinking administrative crew of the ISTS helped in formatting a professionally looking book of the proposal. If successful, the application would result in the first small satellite of this type in the world; it would also be one of few research satellites fully developed and funded in Canada. Such a project would fully consume the allocated funds of the Canadian Space Agency competition (about $10M of that time) and could severely impact continuation of the sounding-rocket program in the country. But it would open up an entirely new technical expertise of small-size research and commercial satellite payloads.

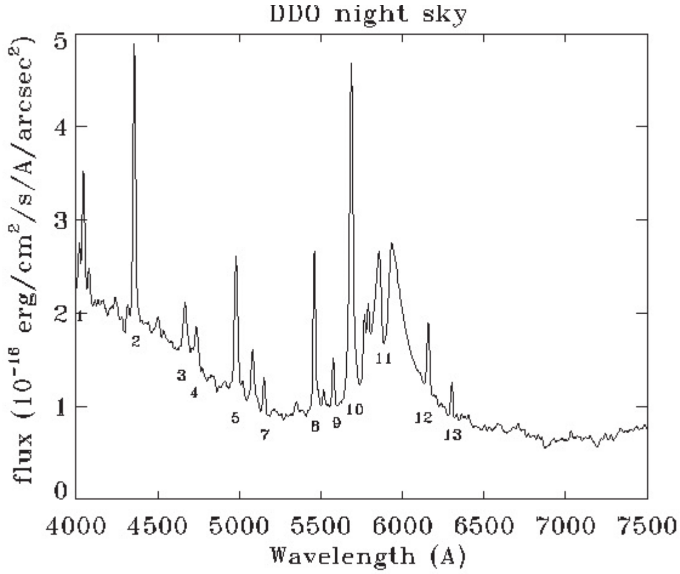


Figure 2 — The night–sky spectrum taken in 2002 at the DDO showed several sources of city illumination. The binary-star program utilized a dark window between features marked as #7 and #8. The strong emission in the centre (#11) is due to high-pressure sodium lamps.

In 1997, the ISTS ceased to exist and my employment there ended. I had to look for a place to earn a salary. It was a difficult time for me. I found a place for myself far from our newly established home in Toronto: My new job was that of a Canadian Resident Astronomer at the Canada-France-Hawaii

Telescope (CFHT) in Hawaii. Although this meant yet another move between countries, I liked the idea of working in such a special place. My wife, with her newly established high-school teaching position, was much less enthusiastic, but she fully supported me.

I felt well established at CFHT after a few months of work there. It seemed that CFHT would be my place of permanent employment until my retirement in Hawaii. But things were never very stable in my life. Suddenly and unexpectedly, news was conveyed to me by phone from Ottawa: the small satellite project won the Canadian Space Agency competition! After a brief cooling-off period, I went to the director of the CFHT suggesting that I would be happy to split my time between the CFHT work and the satellite involvement. But he rather quickly shattered my excitement: I was hired by CFHT to help run the observatory, not to develop satellites.

Not having any permanent job in Canada, I had no other choice but to find somebody to lead the satellite project. A new leader of the project was chosen after contacts with the satellite team. It was Professor Jaymie Matthews at UBC. I think it was he who invented the name MOST (*Micro-Oscillations of STars*) for the satellite. He ably directed the project through the successful construction of the satellite, the launch and the main, 11-years-long data-acquisition stage. I remained in the MOST team and fully enjoyed obtaining extensive data from the satellite.

1999: Back to the DDO

Although the CFHT still operated as before with astronomers coming from Canada or France after long overseas flights, my work at the CFHT coincided with first changes taking place in large, overseas observatories: The internet—after about a decade of experiments—started becoming able to transfer progressively larger amounts of data.

The goal was to transfer voluminous data produced by electronic detectors in real time reducing the necessity of the overseas travel. While we still had visiting astronomers during my time there, the CFHT started preparations for a routine "queue-observing" mode of operations; future observations would be more similar to the use of programmed astronomical satellites. I was directly involved in those preparations. But, at home, things looked less positive: my wife was not happy in Hawaii. She missed contacts with our son's family in Toronto and her high-school teaching.

In 1998, I was happy to meet at the CFHT Professor Seaquist, the Chairman of the U of T Department of Astronomy, during his visit to Hawaii on a federal-agency supervisory meeting. He told me about a DDO vacant position previously filled by the late Karl Kamper, who had been the DDO resident astronomer for many years. I knew Karl from my association with the DDO in 1984–1997: Karl supervised the daily operations at DDO and spent much time on continuing instrumental issues there. I applied for the position and was accepted with the starting date of 1999 January 1. The

Figure 3 — The west administration building at the DDO.

position, while less attractive than that at the CFHT, would solve my home problems. We would be back in Toronto.

Professor Peter Martin became the Chairman of the Department of Astronomy and Astrophysics—and thus the Director of the DDO—in July 1999. His intentions were to accelerate the process of the DDO grounds sale. This would lead to the establishment of a new research institute continuing the Dunlap legacy but would also result in the DDO closure. This process was expected to take a few years. Quite unexpectedly to me, Peter offered me a position as his associate director at DDO. He also generously offered to us the use of the director's house on the DDO grounds. My duty was to steer the DDO through its final years by managing its operations on a day-to-day basis.

Administration and management of the DDO were new activities to me. I had worked in many employment environments and in different countries but had no experience in administrative matters. The solution was to rely on common sense and on my relative ease with interpersonal relations. Fortunately, the most serious and most difficult personnel issues were dealt with by the chairman/director. By being accessible on a daily basis, I did experience some staff and nearby resident discontent, but this was unavoidable and, from the start, taken into account in my decision. I was happy to be again at the Department of Astronomy and Astrophysics and to be useful there. My wife Anna and I moved to the director's house in the fall of 1999, and we happily lived there until the sale of the DDO grounds in 2008.

The short-period binary star program: 1999–2008

The observatory lost several technical staff during the final years of its existence through retirement and staff restructuring. Graduate students stopped working on projects based on DDO data, the overall level of activity was reduced. But the 1.88-metre telescope was there and just begged to be used. I felt that I should invent a reasonable observing program for a few years, a program that could deliver useful data even if terminated after a few years. This led to the DDO short-period binary-star program.

A somewhat technical commentary is needed here to explain the specifics of the binary-star program at the DDO: With the bright sky and the weather far from ideal astronomical conditions, spectroscopy of bright stars seemed to be the best option. The Cassegrain spectrograph on the telescope had a decent efficiency, delivering various, moderate spectral resolutions thanks to a large selection of diffraction gratings. With the original detector system based on a rather typical (at that time) CCD detector of 1024 pixels per side, the highest spectral resolving power R was about 17,000 ($R = c/\Delta v$, where c is the velocity of light and Δv the velocity resolution). This was sufficient for a program of systematic observations of bright (<10 mag.), short-period ($P < 1$ day) binary stars with the number of identified targets on the Ontario sky estimated at about 180 stars.

The point is that a systematic and uniform spectroscopic survey did not exist at that time. In fact, even at this very moment (early 2023), the DDO survey is the only such survey. The short-period binaries with orbital periods shorter than a day have components rotating and orbiting each other very rapidly with velocities reaching several hundred km/s; for such large velocities, the spectral resolution resulting from the above R-number is fully sufficient. The main problem is not the resolution, but the extremely heavy blending of strongly rotationally broadened, dense spectra. This unique problem has been slowing progress for the particular group of objects for a long time and is with us even now. I felt that DDO could contribute something new: The digital spectra of the 1980s–1990s were usually "deconvolved" using the Fourier-quotient, highly non-linear technique. This technique is known to have many traps so that observers are confronted with difficult decisions at data processing stages; different results for different observers for the same data are not uncommon. As an improved alternative, I developed a linear algebraic method taking advantage of the progress in the desk-computer power: Solutions of sets of thousands of linear equations for typically hundreds of unknowns became possible with computers of the 1990 technology. The Broadening Functions Technique had been developed on the CFHT data, but the first experimental application at DDO was on the data collected at DDO by Wen Lu [1][2].

The binary star program at DDO started in full in 1999 and continued to the closure of the observatory in 2008. My original expectations were modest. At the rate of 10 stars per publication—in the expected three to five years—we would contribute data for about 40–60 bright (m<10 mag.), short-period (P<1 day) binaries, thus roughly 25–35% of the targets accessible at the DDO location. Since only about 25 binaries already had published spectroscopic data, this would be a useful contribution to an improvement of statistical sample for future studies of such stars. The program would also be an excellent testing ground for my Broadening Functions technique. It should be stressed that short-period binaries are

Figure 4 — The DDO dome. Credit: Nicole Mortillaro.

astrophysically interesting objects. About two-thirds of those solar-neighbourhood, short-period binaries are the so-called contact binaries (also known as the W UMa-type): two stars glued together and forming a surprisingly stable, double-nucleus structure. While they are rather common (1 among typically 500 solar-type stars in the galaxy) and easy to detect because of their continuous variability, they still remain to be understood in their internal structure and evolution paths.

The short-period binary program dominated DDO activities in the years 1999–2009. By the time the program ended, we collected about 4,500 spectra for 163 binaries; this corresponded to a target completeness level reaching about 85–90% (some binaries ended up with incomplete data). Most of the research papers were in the *Astronomical Journal*, which is an internationally well-recognized publication. A few additional papers with summaries and descriptions of the DDO program appeared in various conference proceedings. The main analyses appeared in 15 numbered papers of the "Radial Velocity Studies of Close Binaries" series containing 10 objects per paper. Additional papers dealt with special objects or were published outside the series because a few of our visitors insisted on having separate publications. A serendipitous discovery of very common visual companions to the majority of our objects led to an additional small program "Contact Binaries with Additional Components" [24–26]. The DDO program was publicized in a few conference papers

[27–31]. Lists of the papers are given in tables at the end of this manuscript. The final paper directly based on the DDO binary program appeared in 2013 [23]. Interestingly, the Broadening Functions technique seems to have been progressively accepted by the community: Dr. Dennis Crabtree (acting as a member of the Canadian Astronomical Society) informed me that his analysis indicates a continuing, but somewhat peculiar increase in my early citations related to that technique, a tendency that is unlike a standard decline observed for publications as they "age."

The observer labour for the DDO binary program was provided in various ways. While Wen Lu and I were the original observers, Stefan Mochnacki was interested in the program and substantially contributed to observations. Most of the observers were the local graduate and summer students: Chris C. Capobianco, E. Liokumovich, George Conidis (York), Mel Blake (York), Kosmas Gazeas from Greece, and the night assistants: Heide deBond, James R. Thomson, Toomas Karmo. A large fraction of observations was also collected by three Post-Doctoral Fellows funded by my NSERC research grant and staying in Toronto for typically two years: Theodore Pribulla from Slovakia, and Michał Siwak and Wojtek Pych from Poland. The extensive use of our equipment gave them exposure to practical spectroscopy. Such an exposure was also useful to shorter-term (typically a month), self-supported visitors from Poland: Waldemar Ogloza, Piotr Ligęza, G. Maciejewski, Bogumił Pilecki, Grzegorz Stachowski, Piotr Rogoziecki, Krzysztof Kamiński. Poland did not belong to the European Astronomical Observatory at that time, but it seemed likely that this would happen soon. It should be noted that we also accepted additional 1.88-metre-telescope observers from the Czech Republic, Slovakia, Hungary, Turkey, Lithuania, Ukraine, and Spain, but—similarly to several Polish observers—they came to do observations of their own targets, not of our binary-star program. My main intention was to have observers utilizing the 1.88-metre telescope as extensively as possible. Our statistics showed a reasonably efficient utilization of the telescope at a level of about 65% of all nights; however, because of the variable weather, full, clear nights were much less common, so that—when expressed as a fraction of all available night hours—the overall efficiency in terms of the actual observing time was about 27%.

The program started with a Thomson/Photometric CCD detector of 1024 pixels (as mentioned above) installed in the focus of the Cassegrain spectrograph. This detector stopped working after a couple of years and was replaced by an identical chip. A substantial improvement in the quality of the data happened in 2004 when a new larger detector by Jobin-Yvon with 2048 pixels and very high quantum sensitivity (>80%) was purchased; it had been specifically developed for spectroscopic applications. We used it mostly with a new, high-quality diffraction grating purchased specifically for our program. These acquisitions happened thanks to site-rental arrangements for commercial cinematographic uses. The filming companies paid well, but we had to tolerate usually demanding and occasionally arrogant personnel of the filming crews. Most frequently Archie Ridder was directly dealing with their requests. Such "visits" were infrequent, typically perhaps fewer than one per year.

The binary-star program had some additional benefits for the telescope operations: We installed a small CCD detector on one of the finder telescopes to help in object acquisition and to monitor variability of target stars. Also, the extensive use of the telescope over different sky directions permitted development of 2-D lookup maps to take into account the large flexure corrections of the telescope in its coordinate setting. The coordinate target setting became easier and less dependent on the accumulated experience of the telescope operators.

The DDO operations and the telescope program were not my only activities. I typically spent two days per week on the St.George campus on teaching and seminars. In terms of my own research, I was busy analyzing data from the MOST satellite; I also organized a team of researchers from several Canadian universities interested in formulation of a smaller reincarnation of MOST that later took shape in the BRITE Satellite Constellation. More information about the early days of BRITE is available at: www.astro.utoronto.ca/~rucinski/BRITE

The observatory closure in 2008

My attitude toward the expected closure of the DDO did not change during my work there: It could happen anytime, and we were ready for that. Gossip about the imminent agreement of the involved parties was circulating in Richmond Hill, but became more common in the spring of 2008. While I was very aware of the local-resident discontent that took the form of the "DDO Defenders" group, I tried not to be influenced by these forms of protest: this was simply not my business.

My lack of involvement was perhaps particularly visible on 2008 July 2, when the sale of the grounds was announced: I simply withdrew from any activities. We left the director's house within a couple of months after that date. We remained appreciative to the chairman of the department for letting us use the house for the nine memorable years. Since we had retained our own house in the city, the DDO closure did not drastically impact our lives. I retired from U of T one year later, in agreement with the contract signed in 1999. At that time, Ontario regulations specified the 65th year as the time for retirement. I highly valued being elected professor emeritus of the department, which permitted me continuing collaboration with graduate students; I could also apply for the NSERC research grant. The grant was particularly useful for my continuing involvement in the MOST and BRITE satellite missions. The last time when the funds were used for ground–based observations was in 2018; the data collected in Chile eventually resulted in my currently last published paper in 2020.

After the DDO closure, I have visited the observatory only a couple of times. I preferred to keep in my mind an image of an active place. The sad story of the McLaughlin Planetarium the feeling of a rather poor appreciation of our own history was always on my mind. A more detailed visit depressed me: I found that the CCD detectors with their electronics and the dedicated computers were gone, and with them the possibility of spectroscopic observations. Arguably, since the telescope was never meant to be used as a visual instrument, it would be the spectrograph that could become most attractive for any further educational applications. Spectra of bright stars and of the Richmond Hill sky would best illustrate the ubiquitous light pollution and its specific sources (incandescent bulbs, a variety of metal-halide lamps, low- and high-pressure sodium lights, etc.). Society now learns faster and is ready for more intellectual challenges. An exposure to elementary spectroscopy of celestial objects could be a step beyond appreciating beautiful sky images so abundant now in the media. ✶

Publications of the DDO program "Radial Velocity Studies of Close Binaries"

#	#	Authors	Year	AJ (vol & page)	Title/subject	ADS Link	Cit
	DDO						
1		Lu & Rucinski	1993	106, 361	AH Vir	1993AJ....106..361L	33
					(exploratory study)		
2	1	Lu & Rucinski	1999	118, 515	GZ And, V417 Aql, LS Del, [EF Dra], V829 Her, FG Hya, AP Leo, UV Lyn, BB Peg, AQ Psc	1999AJ....118..515L	92
3	2	Rucinski & Lu	1999	118, 2451	AH Aur, CK Boo, DK Cyg, SV Equ, V842 Her, UZ Leo, XZ Leo, V839 Oph, GR Vir, NN Vir	1999AJ....118.2451R	87
4		Rucinski & Lu	2000	MNRAS	W Crv	2000MNRAS.315..587R	26
				315, 587			
5	3	Rucinski, Lu & Mochnacki	2000	120, 1133	CN And, HV Aqr, AO Cam, YY CrB, FU Dra, RZ Dra, UX Eri, RT LMi, V753 Mon, OU Ser	2000AJ....120.1133R	78
6	4	Lu, Rucinski & Ogloza	2001	122, 402	44 Boo, FI Boo, V2150 Cyg, V899 Her, EX Leo, VZ Lib, SW Lyn, V2377 Oph, DV Psc, HT Vir	2001AJ....122..402L	98
7	5	Rucinski, Lu, Mochnacki, Ogloza & Stachowski	2001	122, 1974	V376 And, EL Aqr, EF Boo, DN Cam, FN Cam, V776 Cas, SX Crv, V351 Peg, EQ Tau, KZ Vir	2001AJ....122.1974R	83
8	6	Rucinski, Lu, Capobianco, Mochnacki, Blake, Thomson, Ogloza & Stachowski	2002	1,241,738	SV Cam, EE Cet, KR Com, V401 Cyg, GM Dra, V972 Her, ET Leo, FS Leo, V2388 Oph, II UMa	2002AJ....124.1738R	75
9	7	Rucinski	2002	124, 1746	DDO program description.	2002AJ....124.1746R	142
10	8	Rucinski, Capobianco, Lu, DeBond, Thomson, Mochnacki, Blake, Ogloza, Stachowski & Rogoziecki	2003	125, 3258	V410 Aur, V523 Cas, QW Gem, V921 Her, V2357 Oph, V1130 Tau, HN UMa, HX UMa, VY Sex, DZ Psc	2003AJ....125.3258R	72
11	9	Pych, Rucinski, DeBond, Thomson, Capobianco, Blake, Ogloza, Stachowski, Rogoziecki, Ligeza & Gazeas	2004	127, 1712	AB And, V402 Aur, V445 Cep, V2082 Cyg, BX Dra, V918 Her, V502 Oph, V1363 Ori, KP Peg, V335 Peg	2004AJ....127.1712P	58
12		Maciejewski & Ligeza	2004	Inf.Bull.Var. Stars, 5504	V404 Peg, V407 Peg, HH Boo	2004IBVS.5504....1M	6

13	10	Rucinski, Pych, Ogloza, DeBond, Thomson, Mochnacki, Capobianco, Conidis & Rogoziecki,	2005	130, 767	V395 And, HS Aqr, V449 Aur, FP Boo, SW Lac, KS Peg, IW Per, V592 Per, TU UMi, FO Vir	2005AJ....130..767R	48
14	11	Pribulla, Rucinski, Lu, Mochnacki, Conidis, Blake, DeBond, Thomson, Pych, Ogloza & Siwak	2006	132, 769	DU Boo, ET Boo, TX Cnc, V1073 Cyg, HL Dra, AK Her, VW LMi, V566 Oph, TV UMi, AG Vir	2006AJ....132..769P	64
15	12	Pribulla, Rucinski, Conidis, DeBond, Thomson, Gazeas & Ogloza	2007	133, 1977	OO Aql, CC Com, V345 Gem, XY Leo, AM Leo, V1010 Oph, V2612 Oph, XX Sex, W UMa, XY UMa	2007AJ....133.1977P	53
16		Kaminski, Rucinski, Matthews, Kuschnig, Rowe, Guenther, Moffat, Sasselov, Walker & Weiss	2007	134, 1206	V471 Tau	2007AJ....134.1206K	30
17	13	Rucinski, Pribulla, Mochnacki, Liokumovich, Lu, DeBond, De Ridder, Karmo, Rock, Thomson, Ogloza, Kaminski & Ligeza	2008	136, 586	EG Cep, V1191 Cyg, V1003 Her, BD+7 3142, V357 Peg, V407 Peg, V1123 Tau, V1128 Tau, HH UMa, PY Vir	2008AJ....136..586R	51
18		Pribulla & Rucinski	2008	MNRAS, 386, 377	AW UMa	2008MNRAS.386..377P	41
19		Rucinski & Pribulla	2008	MNRAS, 388, 1831	GSC1387-475	2008MNRAS.388.1831R	48
19	14	Pribulla, Rucinski, DeBond, De Ridder, Karmo, Thomson, Croll, Ogloza, Pilecki & Siwak	2009	137, 3646	TZ Boo, VW Boo, EL Boo, VZ CVn, GK Cep, RW Com, V2610 Oph, V1387 Ori, AU Ser, FT UMa	2009AJ....137.3646P	44
20	15	Pribulla, Rucinski, Blake, Lu, Thomson, DeBond, Karmo, De Ridder, Ogloza, Stachowski & Siwak	2009	137, 3655	QX And, DY Cet, MR Del, HI Dra, DD Mon, V868 Mon, ER Ori, Y Sex, TT Cet, AA Cet, CW Lyn, V563 Lyr, CW Sge, LV Vir, MW Vir, GO Cyg, V857 Her,V752 Mon, V353 Peg (some binaries with incomplete data)	2009AJ....137.3655P	56
21		Pribulla, Rucinski, Kuschnig, Ogloza & Pilecki	2009	MNRAS	HD 73709, GSC 0814-032 (MOST satellite support)	2009MNRAS.392..847P	12
				392, 847			
22		Siwak, Zola & Koziel-Wierzbowska	2010	Acta Astr., 60, 305	BX And, DO Cas, BV Eri, VV Cet, WZ Cyg (PhD in Poland)	2010AcA....60..305S	20
23		Rucinski, Pribulla & Budaj	2013	146, 70	Metallicity determinations for W UMa binaries (combined DDO data)	2013AJ....146...70R	28

Explanations:

The first two columns give the consecutive number of the publication and the "Radial Velocity Studies of Close Binaries" series number (1 to 15). The consecutive publication number is used in the text in square brackets [ ]. Most papers were published in *Astronomical Journal* (AJ). The volume and page are given for the AJ papers; for other publications an established acronym is used.

Links in the SAO/NASA Astrophysics Data System (ADS) citation database ui.adsabs.harvard.edu/classic-form are listed in the penultimate column of the table.

The last column gives the number of citations as of 2022 December 20.

Publications based on the program "Contact Binaries with Additional Components"

#	Authors	Year	AJ (vol & page)	Title/subject	ADS Link	Cit
24	Pribulla & Rucinski	2006	131, 2986	The Extant Data.	2006AJ....131.2986P	266
25	D'Angelo, van Kerkwijk & Rucinski	2006	132, 650	A Spectroscopic Search for Faint Tertiaries	2006AJ....132..650D	122
26	Rucinski, van Kerkwijk & Pribulla	2007	134, 2353	A Search Using Adaptive Optics	2007AJ....134.2353R	105

Explanations:

The three papers of this program were published in *Astronomical Journal* (AJ). They were partly based on the DDO (papers #24 and #25) and partly on the CFHT data (paper #26).

For other explanations see the previous table.

Conference and symposium publications related to the DDO program "Radial Velocity Studies of Close Binaries," all authored by Rucinski

#	Year	Publication	Title	ADS LInk	Cit
27	2004	Stellar Rotation (IAU Symp. 215), p.17	Advantages of the Broadening Function (BF) over the Cross-Correlation Function (CCF)	2004IAUS..215...17R	39
28	2006	Close Binaries in the 21 Century (Coll.)	The DDO Short-Period Binary RV Program	2006Ap&SS.304..323R	4
29	2010	International conference on Binaries (CP1314)	Contact Binaries: The Current State	2010AIPC.1314...29R	16
30	2010	Binaries - Key to Comprehension of the Universe (ASP Conf. 435)	The DDO Close Binary Spectroscopic Program	2010ASPC..435..195R	5
31	2012	From Interacting Binaries to Exoplanets: Essential Modeling Tools (IAU Symp. 282)	The Broadening Functions Technique	2012IAUS..282..365R	6

Endnotes

1 Profesor MacRae was the last Head of the Department. Now the position name is the Chairman.

2 Numbers in square brackets give the publication numbers in the table at the end of this paper.

Skyward

Skyward: A Magic Beagle, the Stars, and Comet Shoemaker-Levy 9 30 Years Later

by David Levy, Kingston & Montréal Centre

It is my honour to introduce you, dear readers, this month to my latest book, *Clipper, Cosmos, and Children: Finding the Eureka moment*. It is a book specially designed to inspire young people to enjoy the night sky. Whether you are physically young, or even just young at heart, this new book is meant to inspire you to reach for the stars.

This book's genesis was one day a few years ago. As I strolled into the office in the east wing of our home, I saw Wendee engrossed in the reading of an old book entitled, *Clipper*.

"When did you write this book?" she inquired.

"I wrote it when I was 10. Around 1958." Not a word about the stars in it.

"David, this is the best book I have ever read of yours. In fact," she laughed, "all your other books have gone downhill since this one."

She asked me that day to rewrite *Clipper* as an astronomy book. I did, and the book is now published by RJI publishing in 2022 and is available from Amazon for about $20.

Figure 1 — A drawing of Clipper on the Moon.

Figure 2 — Clipper as a puppy.

As I wrote and revised the book during these recent years, my mind frequently wandered back to the simple, carefree time of my youth. The original *Clipper* was a Bar Mitzvah present for my older brother, Richard. Perhaps my fondest memory of this little beagle dates back to the cloudy evening of 1965 December 17. That was the night I had planned to begin my search for comets. At around 11 p.m., I took Clipper for a walk up the hill near our house. As I ambled up the streets nearby, I began to notice a small clearing to the west. I quickly decided to hurry home. Clipper had other ideas. As I headed south, Clipper tried to go north. Our tug-of-war lasted a few unforgettable seconds until a quick jerk on the leash persuaded him who was boss. (He was, but he turned around anyway.) At 11:50 that evening, I began my comet-search program through a break in the clouds that lasted less than 10 minutes. Now, 58 years later, I am still searching for comets.

Each chapter of my book begins with a passage from the original *Clipper*. In the story, a young boy named Stephen (the original name, now termed for my grandson Matthew Stephen) goes on a nightly adventure with a magic beagle

Figure 3 — An older Clipper

who, with an equally enchanted telescope, takes him on a frolic through the cosmos, seeing the planets, comets, and asteroids, then the stars of our galaxy, and finally to the massive filaments of galaxies that mark the edges of our known Universe. Stephen is soon joined by Kaia, a young girl student named in honour of my granddaughter Summer Kaia.

There is also a strange extraterrestrial girl named Tania who lives on the Moon. Tania comes from a dream I enjoyed decades ago, at the height of the appearance of my brightest comet in 1990, when I encountered a creature shaped like a box, with four feet and four hands and a small head.

"I do not have the power to send comets your way," Tania told me, "but I can change their orbits just a bit so there is a greater chance that you might find them."

There is even a chapter about nothing, in which Clipper takes the children on a tour across the great voids, bereft of galaxies, that are an integral part of our cosmos.

You are likely all familiar with Peter, Paul, and Mary's wonderful song about a magic dragon, and how it describes "a dragon lives forever, but not so girls and boys." The book's closing chapter explores what happens when the children grow up and pursue their lives.

The book might be fun, but actually, every telescope, from the tiniest department store telescope to the *James Webb Space Telescope*, is charmed. All it takes is a single, thoughtful gaze that launches you on your own life's journey across the endless wonder of space and time.

Comet Shoemaker–Levy 9 30 Years Later

A lot can happen in 30 years, especially when it involves comets and asteroids that creep across the sky, and even more particularly with comets that go bump in the night. Such is the case with Comet Shoemaker–Levy 9, which is by far the most important and seminal of the 23 comets I have discovered.

The Jupiter/comet story began for me on 1960 September 1, when I looked through a telescope for the first time. Jupiter was my target, and I still recall that view. Years later, Gene Shoemaker proposed that Comet Shoemaker-Levy 9 might have been orbiting Jupiter as early as 1929, and that it made a close approach to Jupiter during the year I first sighted the planet. Obviously, I did not see the comet that night; neither did anybody else.

On the first night of our March 1993 observing session at the 18-inch Schmidt telescope at Palomar Observatory, Gene Shoemaker developed the first four exposures and found them all blank. It appeared that someone had opened the film box since our February session and exposed the films to light. Examining the pile of films, I suggested that the ones near the bottom might be partially usable. Gene developed one of them and agreed. We continued most of the rest of that night with the partially damaged films until about 3 a.m., when we switched to a new set of prepared films.

On that same night, I guided an eight-minute exposure. It was difficult to stay centred on the guide star since the glow from nearby Jupiter was interfering. We then did three other fields of sky. Clouds arrived before we had a chance to begin the second set of exposures (so that each field would have two exposures). We stopped observing and left the building to examine the sky. I noticed a slight break in the clouds to the southwest. Gene teased me as being the "eternal optimist." We had a strange discussion about money. Gene said that it costs $8 each time we load a film into that telescope. When I suggested that $8 was not too much, Gene quipped, "That's eight American dollars! Not that Canadian play money you try to get away with!" But after Carolyn agreed that there was a break coming, Gene said, "Let's do it!" We somehow managed to take four exposures before more clouds came and ended the night.

On the afternoon of March 25, the sky was completely cloudy with snow flurries. Gene was reading *Time Magazine*. I was working on a book about my favourite subject, comets. Carolyn was scanning the two Jupiter films. Suddenly she stopped, looked towards me, and exclaimed, "I think I have found a squashed comet."

As Gene got up to look, Carolyn approached me.

"You are joking, of course?" I said.

Carolyn shook her head. Gene then looked toward us with the most unusual expression I had ever seen on his face. Then I

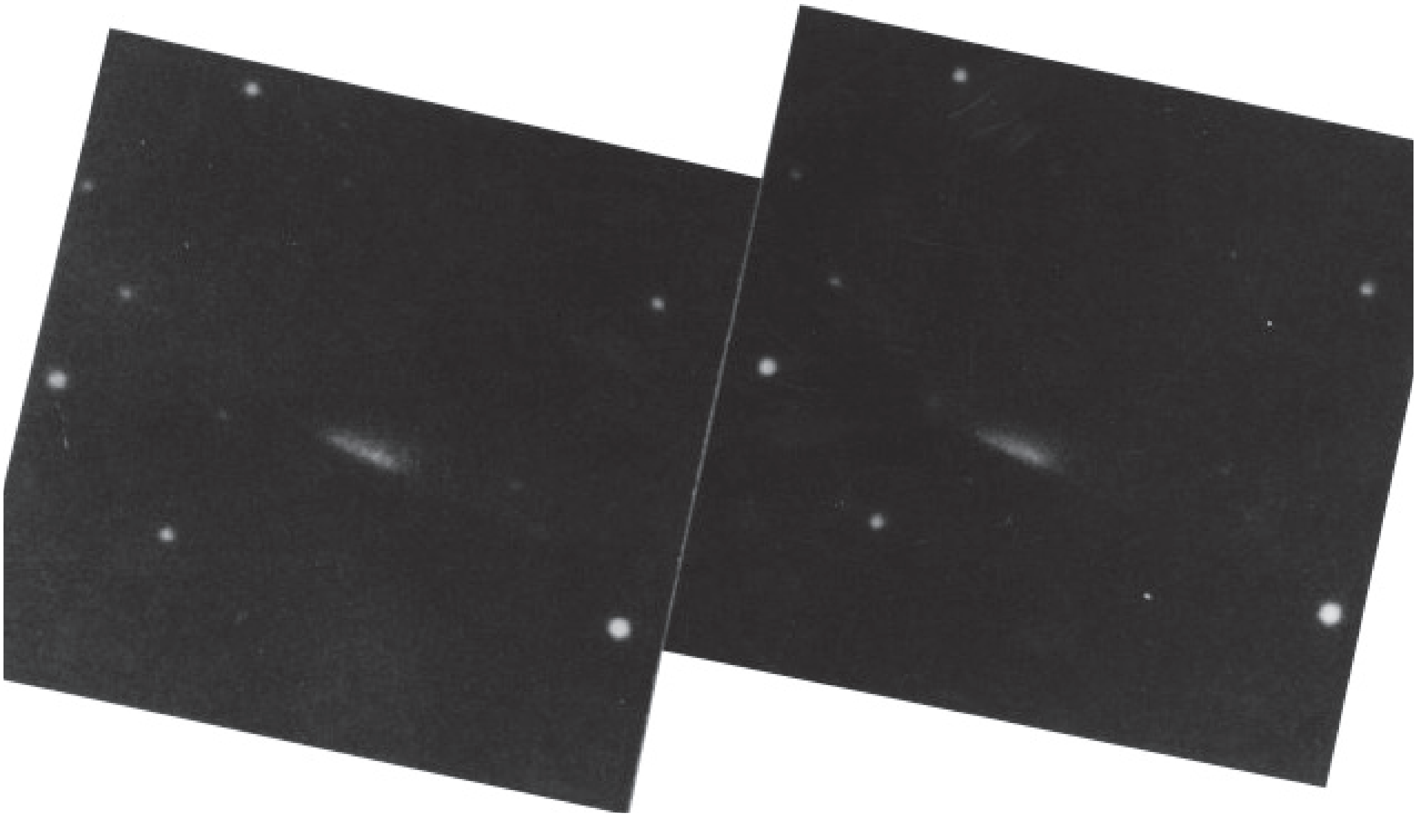


Figure 4 — The discovery images of Comet Shoemaker-Levy 9. Photographs by David Levy using the Palomar 18-inch Schmidt camera, two 8-minute exposures separated by about 1 hour and 45 minutes.

looked. There was a long bar of cometary smudge, with at least five darker centres, each with a tail going toward the top of the films. There was also a trail of cometary light stretching off either side of the central structure.

We needed to get a confirming image. I telephoned my friend Jim Scotti, who was observing on the 36-inch diameter Spacewatch camera atop Kitt Peak in Arizona. He simply did not believe me when I explained what we had. He said he would try to find the time to take a confirming picture.

Two hours later, I telephoned him again. Jim simply grunted. "The sound you just heard," he explained, "was me trying to lift my jaw off the floor.

"Do we have a comet?"

"Wow, do you guys ever have a comet," he said.

That is the story of how we discovered Comet Shoemaker–Levy 9 in the pinnacle moment of our professional lives. Sixteen months later we watched, along with the rest of the world, as the pieces slammed into Jupiter at the incredible velocity of 60 kilometres a second (a plane travelling that fast would cross the United States in just over a minute). We spent some time with both then-Vice President Al Gore and President Bill Clinton. Impact week was unforgettable. And it all began with a single look at Jupiter through my first telescope, a cloudy night, and some damaged film, on the never-to-be-forgotten night of 1993 March 23. ✶

David H. Levy is arguably one of the most enthusiastic and famous amateur astronomers of our time. Although he has never taken a class in astronomy, he has written more than three dozen books, has written for three astronomy magazines, and has appeared on television programs featured on the Discovery *and* Science *channels. Among David's accomplishments are 23 comet discoveries, the most famous being Shoemaker–Levy 9 that collided with Jupiter in 1994, a few hundred shared asteroid discoveries, an Emmy for the documentary* Three Minutes to Impact, *five honorary doctorates in science, and a Ph.D. that combines astronomy and English Literature. Currently, he is the editor of the web magazine* Sky's Up!, *has a monthly column, "Skyward," in the local* Vail Voice *paper and in other publications. David continues to hunt for comets and asteroids, and he lectures worldwide. David was President of the National Sharing the Sky Foundation, which tries to inspire people young and old to enjoy the night sky.*

Astronomical Art and Artifact

A Complementary Mode of Doing Science, a Complementary Mode of Doing History—Restaging Astronomical Experiments, Part Two

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Abstract

The first part of this study was published in the February issue of *JRASC*. It set the broader context by noting a curious paradox; while very capable and advanced equipment has been more readily and inexpensively available than ever before to the amateur community, that circumstance doesn't appear to have led to a commensurate increase in active amateur contributions to science. One route to actively engaging in science that has hitherto been under-utilized, and under-appreciated by amateurs is via the restaging of historical astronomical experiments. The nature and recent trend of this practice outside astronomy is described, along with some principles for its potential use in astronomy, and some topics it can elucidate.

Terms of engagement

Before considering some instances of the restaging of historical experiments, something should be said about terminology. As with experimental archaeology, within archaeology and anthropology, in the history and philosophy of science, several terms have been used to designate the use of historical experiment as a research tool; these have included "replication," "restaging," "repetition," "recreation," "re-enacting," "redoing," "reproducing," and "repeating." Some have attempted to imbue the terms with distinctions, sometimes quite subtle, to indicate differences in approach, while others use the terms interchangeably. At times one can encounter variations (usually minor) in their use by a single writer. None of these labels is perfect, but the plurality of terms has not led to confusion.

In light of this, the practice below will be to use the term "restaging," although some of the other terms could just as aptly have been used (for an alternative approach to nomenclature, see Fors et al. 2016, 93).

Engaging with the past as a route to discovery

Restaging historic astronomical experiments, exercises in the experimental archaeology of astronomy, are not unknown to the modern discipline, although they are far from frequent.[1] Recent examples range from Donald G. Bruns's 2017 restaging of the 1919 Principe and Sobral experiments to measure the deflection of light from stars seen near the solar disk, to Leif Svalgaard's project to determine whether the differences between sunspot umbra and penumbra, and the Wilson effect were visible in ca. 1750 refractors with ca. 16-mm diameter *f*/50 singlet O.Gs., to a proposal in this very publication to combine experimental archaeology with cognitive archaeology to assay how far one can progress in trying to see with the eyes of the past (Bruns 2016; 2018a; 2018b; 2019; Svalgaard 2017; Svalgaard et al. 2021; Briggs 2021; Rosenfeld 2018).

In light of these instances, it's readily apparent that liberal differences in materials and means can be accommodated in the practice of restaging experiments. Bruns opted to redo the eclipse experiment, not with surviving equipment from 1919, or close reproductions and observational techniques of that day, but with up-to-date equipment, methods, databases, and programs

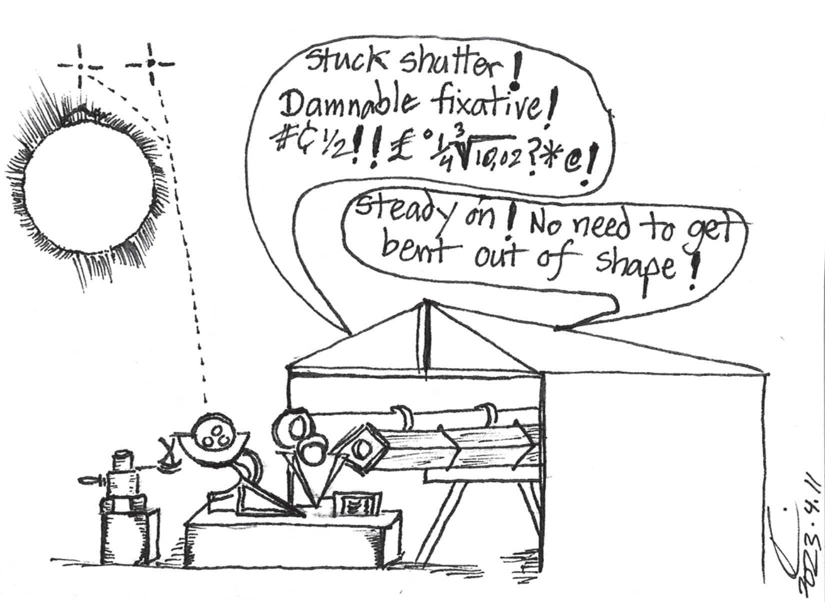


Figure 1 — Restaging historical experiments or observations can uncover "tacit" knowledge, the sort of information that isn't customarily written down, but can be revealed through acquiring expertise in using historical equipment, or applying historical techniques of observation. Reproduced courtesy of the Speculum astronomica minima.

Continues on page 114

Figure 1 – This image is a wonderful collaboration between Soumyadeep Mukherjee and Lucy Yunxi Hu. The pair had planned for roughly six months to photograph a moonrise from both the Northern and Southern Hemispheres, and they were finally able to make it happen. The Moon's path rises at different directions due to Earth's tilt, which the images illustrate. Both images were taken on 2023 March 7 with a 600-mm focal length full-frame camera. The image at top was taken from Dhanbad, India, while the image at the bottom was taken from Canberra, Australia.

Both used a Sigma 150-600mm ƒ/5-6.3 DG OS HSM Contemporary lens at 400-mm (equivalent focal length in full-frame camera = 600 mm). For the image from the Northern Hemisphere, Soumyadeep used a Nikon D5600 (APS-C sensor) shot at ƒ/6, 1/3s, ISO 400 × 6 (5 for Moon, 1 for the focus stacked foreground). Lucy used a Canon R5, full-frame sensor, shot at ƒ/6.3, 1/10s, ISO 100 × 5.

Figure 2 – Katelyn Beecroft imaged the Cone Nebula in false SHO palette using her Askar FRA400 and ASI533MC camera on a Sky-Watcher HEQ5 mount. "I used the L-Extreme filter for the majority of the time (16h of 5min exposures) with an additional 40 min using the Astronomik L3 filter to get the RGB stars in the image," she says. She used a ZWO 30-mm guidescope and ASI120MM camera), an EAF, and the ASI Air Plus. She says, "This is easily one of my most favourite images that I've taken. I love the various textures and details found throughout the nebula area."

Continues on page 113

What's Up in the Sky?

May/June 2023

Compiled by Scott Young

The Sky for for May

This month, Venus and Mars dance with twin stars Castor and Pollux in the evening sky, with a special guest appearance by the Moon. Saturn rises near midnight while Jupiter, still low in the southeast before sunrise, undergoes a rare occultation by the Moon. Meanwhile, Mercury's morning elongation is mostly invisible for Canadian observers.

Observing Highlights for May 2023

May 5: Full Moon. A penumbral lunar eclipse occurs, but it is a minor event and not visible from North America.

May 7: This year's annual eta Aquariid meteor shower will largely be washed out by the light of the near-full Moon. Dedicated observers or all-sky cameras might still spot up to a dozen meteors per hour.

May 12: Last-quarter Moon – the evening sky is now free of moonlight!

May 13: The waning crescent Moon sits 5° below Saturn in the morning sky.

May 17: The thin crescent Moon passes in front of Jupiter this morning, a rare planetary occultation visible for most of Canada except for western B.C. and the Yukon. The event occurs in the daytime for most observers and is very low in the sky, making this a challenging observation.

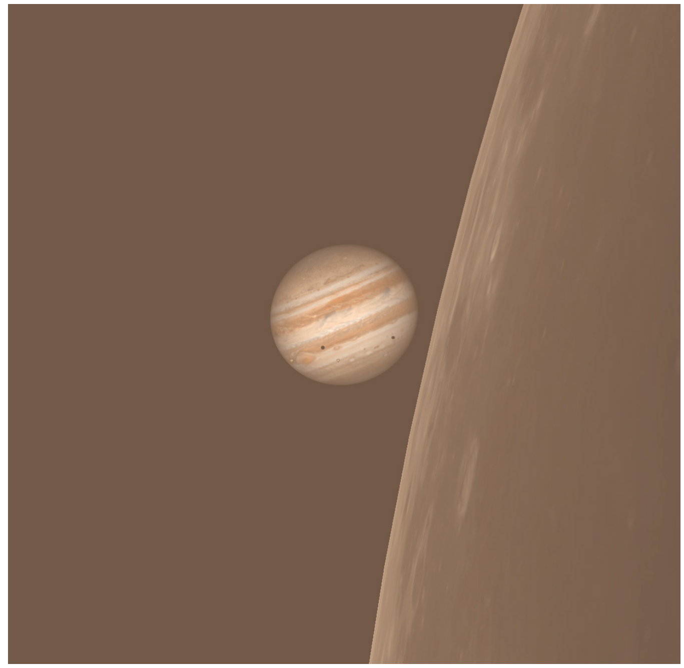


Figure 1 – Jupiter just before its daytime occultation on May 17. For local times and circumstances of this challenging event, see www.lunar-occultations.com/iota/planets/0517jupiter.htm.

May 19: New Moon

May 21 through 24: A trio of Solar System objects gathers in the western sky after sunset for the next several days, against the backdrop of the constellation Gemini, The Twins. On the 21st, the thin crescent Moon, Venus, and Mars form a roughly straight line in the west after sunset. The two brightest stars in Gemini, Castor and Pollux, are above Venus. Over the next few nights, the Moon passes Venus and then Mars, while Venus slowly creeps closer to Castor and Pollux.

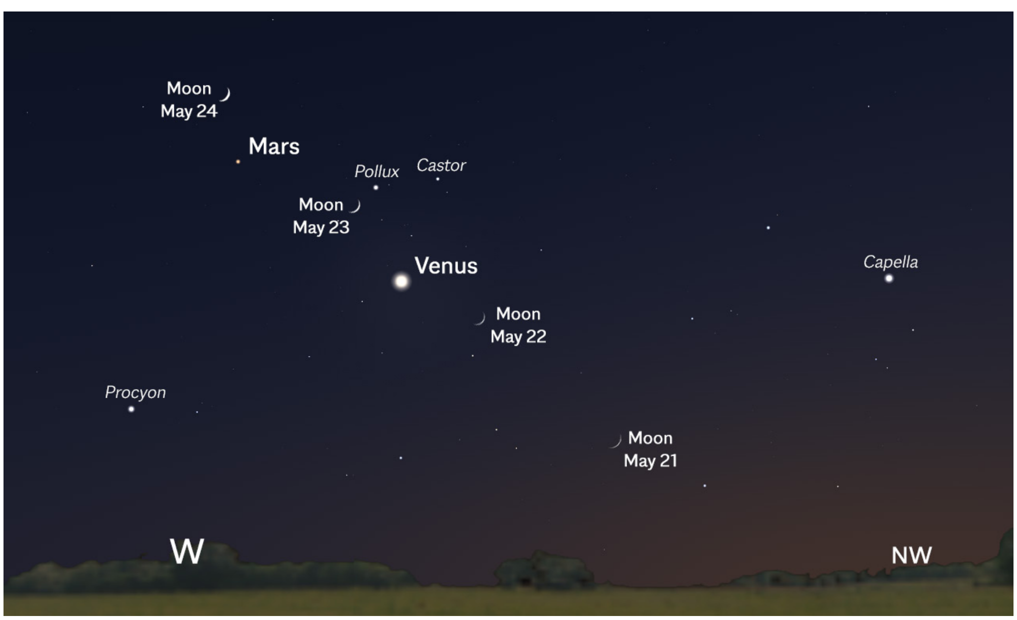


Figure 2 – May 21–24 (evening, facing west): The crescent Moon passes Venus and Mars in the western sky after sunset. The view is shown at 10 p.m. local time (Moon positions will vary slightly depending on the viewer's longitude).

May 25 through 31: Mars, Venus, and the bright stars Castor and Pollux form a nice grouping in the west after sunset. Through the end of the month, Venus flirts with Castor and Pollux while Mars moves closer to the Beehive Cluster in Cancer.

May 27: First-quarter Moon

May 29: Although today Mercury reaches its greatest elongation from the Sun in the morning sky, the low angle of the ecliptic will keep it very close to the horizon and difficult to see for Canadian observers.

May 31: Mars enters the Beehive (see entry for June 1)

Continues on page 112

The Sky May/June

Compiled by James Edgar with cartography by Glenn LeDrew

Celestial Calendar *(bold=impressive or rare)*

May 5 Full Moon at 1:34 p.m. EDT

May 6 eta Aquariid meteors peak at 11:00 a.m. EDT

May 7 Antares 1.5° south of Moon

May 9 Venus at greatest heliocentric latitude north

May 9 Venus 1.8° north of M35

May 11 Moon at perigee (369,343 km)

May 12 Moon at last quarter

May 13 Saturn 3° north of Moon

May 14 Neptune 2° north of Moon

May 19 New Moon, 11:53 a.m. EDT (lunation 1242)

May 20 **Double shadows and transits on Jupiter**

May 23 **Venus 2° south of Moon**

May 24 **Pollux 1.6° north of Moon**

May 24 Mars 4° south of Moon

May 26 Moon at apogee (404,509 km)

May 27 Moon at first quarter

May 28 **Double shadows and transits on Jupiter**

May 29 Mercury at greatest elongation west (25°)

Jun. 2 Mars 0.1° south of Beehive (M44)

Jun. 3 Antares 1.5° south of Moon

Jun. 3 Mercury at greatest heliocentric latitude south

Jun. 3 Full Moon at 11:42 p.m. EDT

Jun. 4 **Double Shadows on Jupiter**

Jun. 6 Moon at perigee (364,861 km)

Jun. 9 Saturn 3° north of Moon

Jun. 10 Moon at last quarter

Jun. 11 **Double Shadows on Jupiter**

Jun. 13 Venus 0.6° north of Beehive (M44)

Jun. 14 **Jupiter 1.5° south of Moon**

Jun. 15 **Uranus 2° south of Moon**

Jun. 15 **Moon 1.8° south of Pleiades (M45)**

Jun. 18 New Moon (lunation 1243)

Jun. 20 **Pollux 1.7° north of Moon**

Jun. 21 Summer solstice at 10:58 a.m. EDT

Jun. 21 Venus 4° south of Moon

Jun. 22 Mars 4° south of Moon

Jun. 22 Moon at apogee (405,385 km)

Jun. 26 Moon at first quarter

	DATE	MAGNITUDE	DIAMETER (″)	CONSTELLATION	VISIBILITY
Mercury	May 1	—	11.8	Aries	—
	Jun. 1	—	7.7	Aries	—
Venus	May 1	–4.2	17.0	Taurus	Evening
	Jun. 1	–4.4	22.6	Gemini	Evening
Mars	May 1	1.3	5.4	Gemini	Evening
	Jun. 1	1.6	4.7	Cancer	Evening
Jupiter	May 1	–2.0	33.3	Aries	Dawn
	Jun. 1	–2.1	34.4	Aries	Dawn
Saturn	May 1	1.0	16.3	Aquarius	Morning
	June 1	0.9	17.2	Aquarius	Morning
Uranus	May 1	—	3.4	Aries	—
	Jun. 1	—	3.4	Aries	—
Neptune	May 1	7.9	2.2	Pisces	Dawn
	Jun. 1	7.9	2.2	Pisces	Dawn

Cartography by Glenn LeDrew

Continued from page 109

The Sky for for June

June brings the official beginning of astronomical summer in the Northern Hemisphere, and the least number of nighttime hours for the year. Venus and Mars draw closer together in the evening sky as they sink lower into the sunset glow, both planets passing near the bright star cluster M44, also known as the Beehive Cluster, in Cancer. Saturn and Jupiter rise earlier but still hug the southern horizon, and Mercury is invisible as it swings around to the far side of the Sun.

Observing Highlights for June

Jun. 1: The planet Mars enters the Beehive star cluster, M44. For the next two nights the reddish planet shines against a backdrop of the cluster's hundreds of mostly blue-white stars.

Jun. 4: Venus reaches its greatest elongation from the Sun, which explains why it is visible so high above the horizon and for so late into the night.

Jun. 9: The waning crescent Moon appears about 7° degrees to the lower-right of Saturn, low in the southeast in the pre-dawn sky.

Jun. 10: Last-quarter Moon

Jun. 12 & 13: Venus sits just above the Beehive Cluster, M44, on both nights, with much fainter Mars 7° to the east (left).

Jun. 14: The waning crescent Moon is 3° to Jupiter's lower left (east) in the morning sky.

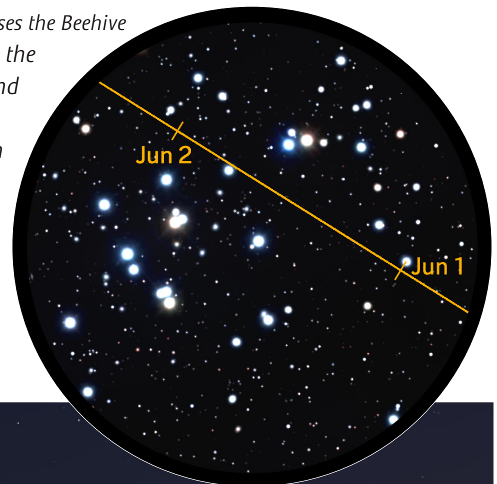
Jun. 17–18: New Moon (the date depends on which time zone you are in)

Jun. 21: Summer Solstice in the Northern Hemisphere. Although mostly irrelevant, the exact time summer begins is 7:58 a.m. PDT = 8:58 MDT (and Saskatchewan's CST) = 9:58 CDT = 10:58 EDT = 11:58 ADT (12:38 in Newfoundland and Labrador).

Jun. 21 (evening): The crescent Moon, Venus, and Mars form a tight triangle in the western sky after sunset.

Jun. 26: First-quarter Moon

Figure 3 – Mars crosses the Beehive star cluster, M44, on the nights of June 1 and 2. The position for each date is shown at 3:00 Universal Time on the given date; the field of view is 1 degree.



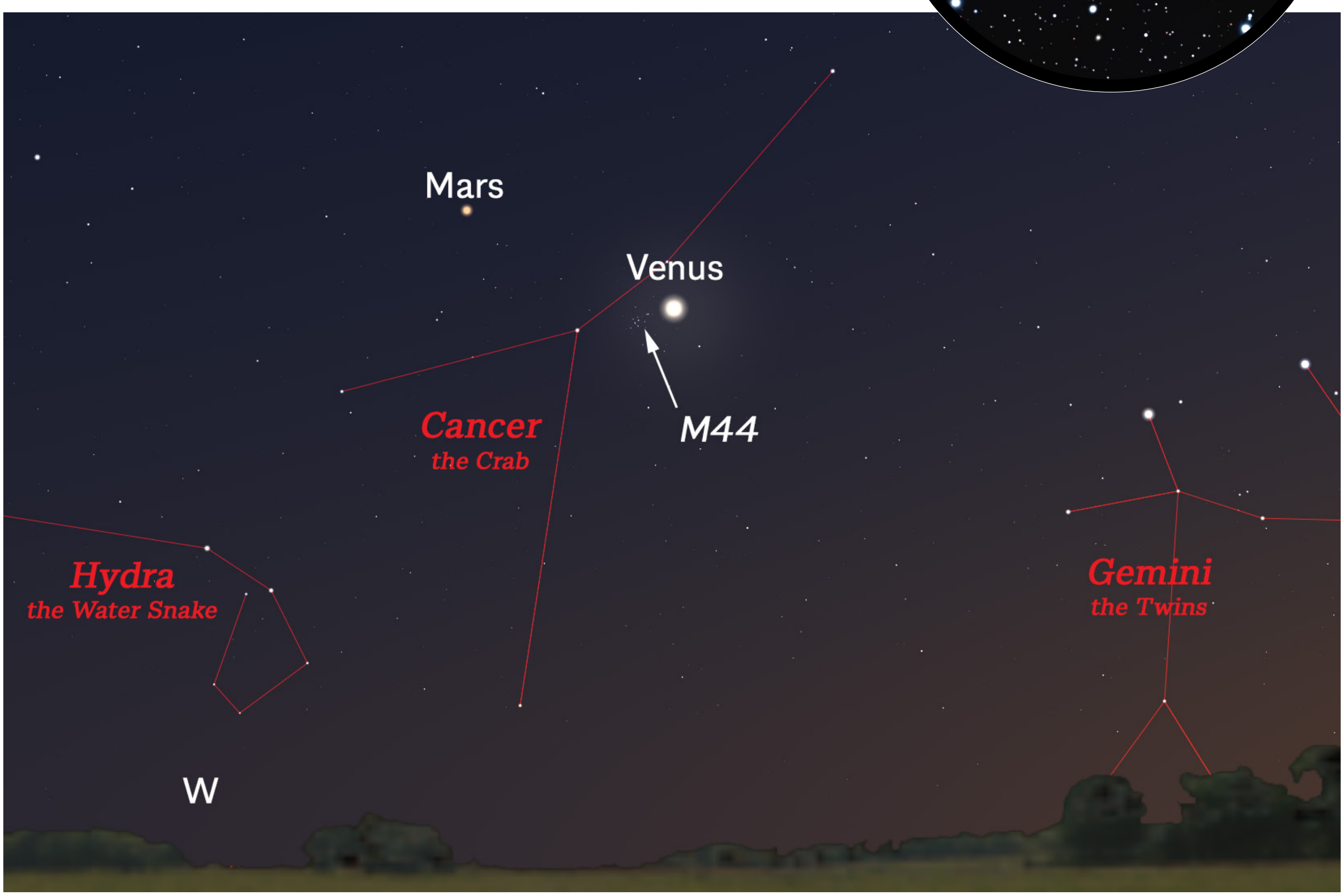


Figure 4 – Venus passes near the Beehive cluster later in June, although not as closely as Mars did earlier in the month. This image shows the view on the evening of June 12 at 10 p.m. local time, but the view is similar for a day on either side of this date.

Continued from page 108

Figure 3 – Winter may be behind us, but this image of the Orion Nebula was far too stunning not to include in this summer issue. Rob Lyons took this from his roof deck in Vancouver on the nights of 2023 January 29 and February 14 for a total of 8 hours of exposure. He used his Sky-Watcher Quattro 150P, ASI533MM Pro, ASI533MC Pro, Optolong L-Pro filter, and Antlia 3-nm hydrogen-alpha filter and, he says, he "blended the hydrogen data into the reds a little bit, but mostly used it as luminance data to help bring out more of the structure within the nebula." Amazing work.

Figure 4 – The Pinwheel Galaxy (M101) was taken by accomplished astrophotographer Ron Brecher from his SkyShed in Guelph, Ontario, on the nights of 2023 March 15–29, under a Moon-free sky. He used a Sky-Watcher Esprit 150 ƒ/7 refractor and QHY600M camera with Optolong UV/IR, 3-nm H-alpha filters and a Takahashi FSQ-106 @ ƒ/5 (530mm), QHY-367C Pro One-shot colour, Optolong UV/IR filter, along with a Paramount MX mount with N.I.N.A. and TheSkyX, unguided. Focus was done using Optec DirectSync motors and controller, and equipment control was done with the PrimaLuce Labs Eagle 4 Pro computer. All pre-processing and processing was done in PixInsight. Integration of 84x5m Luminance; 117 × 5m Hα; 164 × 5m OSC.

Continued from page 107

of our time, while Svalgaard specifies the use of apparatus either from the mid-18th century, or close replications, and Rosenfeld's experimental protocol would allow a pluralist choice of instrumentation and method running from that of Bruns to Svalgaard, with an emphasis on reasoned consistency in whichever approach is chosen, to which is added the requirement to develop familiarity with the relevant visual observational vocabulary of the period being investigated. That is, the differences between the three are determined by the specific requirements of the experimental designs of the individual programs, which in turn are set by their goals. This flexibility is very much a virtue.

Bruns's goals included confirming the first ever successful test of Einstein's general theory of relativity, and improving on the accuracy of the historic results.[2] For that end the use of available high-end amateur equipment was the appropriate choice. The success of his results justified his choices (Bruns 2018a; but see Bruns 2019 on experimental difficulties remaining).

Svalgaard's prime concern is to characterize the capabilities of mid-18th century mid- to lower-end amateur equipment, by subjecting it to actual field use, rather than having to rely on modelling alone. Given that goal, there is no choice but to use original apparatus, or close replicas sharing the operational features of the originals. The results will answer whether Waldmeier sunspot groups A & B (the smallest sunspots in that typology) could have been detected with such instruments. The answer will decide the normalization factor enabling 18th-century amateur solar observations to be used in modern determinations of long-term solar activity. Being able to include that valuable data will improve space weather predictions, and climate modelling.

Rosenfeld, although advocating using equipment as close as possible to that which had been originally employed, acknowledges that different degrees of "modern…analogues" to original equipment could be justified, depending on the level of desired rigour, and experiment design (i.e. it may be desirable to control for only those experimental factors directly under investigation, and modern apparatus can be used for others). In retrospect this is particularly so if the emphasis is on developing familiarity with certain 19th-century observing techniques, and visual vocabularies, in trials to see if "are there skills practiced by observers of 1868 that have fallen out of use, which if reintroduced could benefit modern observing?" (Rosenfeld 2018, 153, 155).

As interesting and productive as the restaging of experiments has proved to be under Urania's aegis, the world of astronomy has not been the principal theatre for this active engagement with the past. Physics enjoys that distinction, but the most interesting and instructive use of the technique has latterly occurred in Vulcan's laboratory.

The alchemy of restaging experiments

Over the past quarter century retrying historical experiments has become an important tool in investigating the history of "chymistry" on its way to becoming chemistry, from the 16th to the 19th century.[3] In the front rank of researchers who have used this approach are William R. Newman, Lawrence M. Principe, and Hasok Chang (e.g. Newman 2019; Principe 2000; 2013; Chang 2012; 2017). Their innovative examples show that taking the time to go to the lab from the library, and back again, pays handsome dividends (to quote the title of Fors et al. 2016).

The characteristics of chymistry texts rendered them difficult to understand for those who were not adepts, and even for many who were. The passage of time has not made the texts any easier of comprehension; rather the opposite. Chymistry's technical terminology was highly developed, very elusive, and at times highly personal. Add to that the common practice of deliberate omission in the original texts of experiments, and one can get a sense of the difficulties in unlocking that science. Through restaging historical experiments, Newman and Principe have managed wonders in advancing modern understanding of the nature of early modern chymistry, revealing differences in practice across place and time, and how the actual conduct of work among alembics, books, and letters generated knowledge. As a result the doors to Robert Boyle's and Isaac Newton's chymical laboratories stand open to us as never before.

Hasok Chang, currently the Hans Rausing Professor of History and Philosophy of Science at the University of Cambridge, has used the restaging of experiments to investigate topics in the practice of chemistry of the late Enlightenment and first half of the 19th century, in the work of De Luc, Priestley, Lavoisier, Volta, Dalton, Count Avogadro, Lord Kelvin, and now lesser-known contemporaries. He has explored how systems of measurement were established experimentally (e.g. thermometry in the 18th century), and the relative merits and demerits of phlogiston-based and Lavoisierian chemistry (e.g. the former dealt much more successfully with chemical potential energy than the latter, while the latter made much of precise measurements of weight as a key element of analysis). Chang explains that:

> The dominant tendency in historical experiments, among historians and science educators alike, has been to

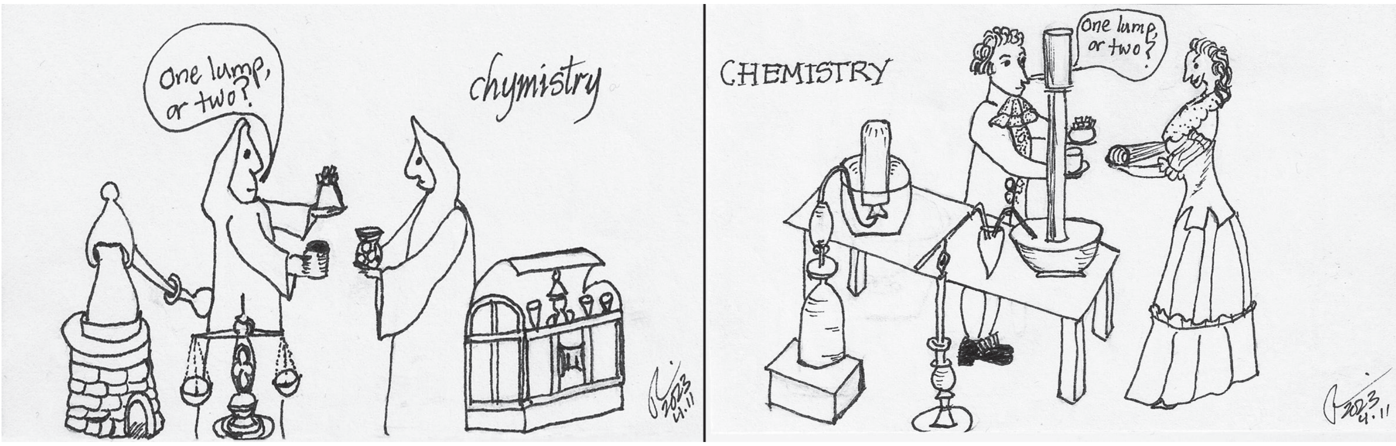


Figure 2 — Historians of science now use the term "chymistry" to indicate the practice of chemistry from the late Middle Ages up to the early 18th century, in which alchemy still played a role (as for instance in the scientific practice of Isaac Newton and Robert Boyle), and use the term "chemistry" to denote the science of the latter 18th century to the present. The connections and continuities of technique between the periods are very real. Reproduced courtesy of the Speculum astronomica minima.

> replicate the classic experiments that form the basis of modern science. This has been the trend even for many scholars who are very critical of the common ideology of science and the standard practices of science education. My own inclination, on the contrary, is to examine strange reports that seem to go against current scientific wisdom, perhaps in line with the spirit of Principe's and Newman's efforts to see if alchemical claims can be validated (2011, 323).

As an illustration of the efficacy in his hands of this curiosity-led approach, one can cite its application to an early episode in the history of electrochemistry.

Toward the end of his life, Joseph Priestley became involved in disputes about the nature of electrolysis. His experiments produced "an intriguing case of apparently absurd results reported by an able and reputable scientist" (115). What are they?

> First, he [Priestley] claimed that electrolysis of water took place only in the presence of dissolved oxygen. Second, he reported that the anode (made of various metallic wires), instead of serving as a site of oxygen-production, dissolved in the water and formed various compounds (Chang 2012, 115).

In regard to Priestley's first result, through restaging the experiment, Prof. Chang found that:

> …it seems that in pure water there is a pre-threshold reaction in which the external voltage applied to the water only serves to disengage dissolved oxygen gas, without breaking down the water molecules into hydrogen and oxygen.…This is not quite a confirmation of the result that Priestley reported, but at least it is a vindication of the explanation that Priestley offered in order to make sense of his result (116, 118).

And, in the case of the second:

> …if we assume that some of his water samples contained impurities that would have combined with the metals to form soluble salts, particularly any chlorides…I have easily dissolved gold anodes in the electrolysis of saturated solutions of NaCl (common salt), using just two ordinary batteries in series (3 V).… According to some further tests that I have carried out in September 2011, the dissolution of gold anode (with graphite cathode) can take place with NaCl concentration as low as 1/25 of saturation (119, 121).

If nothing else, in this case, restaging experiments of two centuries ago provides real insights into the original reported observations, insights not available to us through any other means.

The recent overview article by Fors et al. (2016) provides a good overview of the rationale for restaging experiments, with some good advice on various aspects of practice. As some readers might not have ready access to their discussion, some of their views and advice are quoted below.

The principal surviving artifacts of past experimental activity are texts (including numerical "texts"), images, and apparatus. Each of these have their limitations.

Regrading the shortcomings of textual sources, Fors et al. note that:

> The physical engagement with processes or objects of the past provides insights that cannot be obtained simply by reading about them. Experimental reproduction, in short, can help bridge the unavoidable gap that exists between

> the actions and ideas of historical actors and the textual descriptions or artefactual residues of those actions and ideas that have come down to us (89).
>
> Historians rightly feel very fortunate when the notebooks or diaries of past experimenters exist, but even when highly detailed, these textual witnesses cannot provide a full description of past events, and often do not suffice to perform the experiment, let alone to get access to the working knowledge involved (90).
>
> The sensual experiences of reproducing an experiment can thus offer the historian otherwise unobtainable hints regarding the origins of ideas, theories, conclusions, or the subsequent pathways of investigation followed by historical actors. Such direct experience can also resolve ambiguities or clarify uncertain meanings in textual records, providing a clearer and surer indication of what the author meant. In some cases, the sensual experience reveals an unexpected significance or relevance to what had seemed casual or relatively insignificant remarks in the text (90).
>
> Documentary gaps often exist between texts, and these too can sometimes be bridged by reproduction (91).

and,

> The final result can be access to missing information arising from documentary limitations—gaps in laboratory records, the conscious withholding or unconscious omission of information by the original experimenters, tacit knowledge, no longer extant objects or texts, and so forth (96).

Visual sources are also not without their difficulties:

> Visual representations of past experiments, when they exist at all, can be as problematic as textual ones despite their more direct appeal to the sense of sight. Illustrations in scientific publications have a life of their own and do not reveal fully the reality of past laboratory life. Historians have pointed to this fact time and again, particularly when following attempts to historically investigate artisanal knowledge…[some], for example, have noted the troubles with the images in Diderot's encyclopaedia, showing how artisans sometimes did not even recognise their own workshop life as it was depicted in the images (91).[4]

Their advice on experimental design is equally perceptive:

> Such undertakings offer the experimenting historian special practical insight regarding the properties, limitations, and ways of handling original construction materials as well as the crucial gestural knowledge connected with a particular instrument, all of which can lead to the uncovering of details, difficulties, and solutions left unrecorded or only hinted at by the original experimenter. This high level of fidelity to the original process, apparatus, or experimental protocol is not, however, always necessary to carry out a historically informative reproduction. In many cases it is more appropriate to undertake a reproduction by first abstracting what are considered to be (at least in a first approximation) the essential features of the historical process. This approach is especially useful in preparative contexts, where obtaining, explaining, or identifying a particular material product or object is the central goal. Original features that the historian considers to be irrelevant to the final outcome are initially ignored in order to simplify the reproduction. For example, one might use vessels made of modern Pyrex glass instead of early modern soft glass, or employ thermostatically controlled electrical heat sources rather than putrefying dung, or a Bunsen or Meker burner rather than bellows and charcoal, or a starting material obtained from a modern manufacturer rather than something derived closer to the original source. A stripped-down or streamlined version of the process can then be carried out more easily than if a higher degree of "fidelity" were demanded from the outset. If the outcome is not successful, then previously omitted variables can be returned one at a time, and the results reassessed (94).
>
> ...failures frequently serve to identify the relevant aspects of a past experimental performance (94).

and

> "... reworkers cannot get everything right from the start. Initial trials almost always need to be altered and re-performed in order to obtain the desired results. In this respect, there is little difference between historical reworking/reproduction and the doing of experimental science itself (95).

They also touch on the limitations of results:

> …a central endeavour of historical investigation, [is] to learn to see through the eyes and think alongside the minds of past figures to the best extent we can. This endeavour requires patient and constant application, and is continuously honed over a historian's lifetime using whatever tools come to hand. It is no less possible or valuable if it only continues to approach its goal without ever fully reaching it (92).

> Reworking/reproducing experiments has unquestionably revealed dimensions of the past…that have peremptorily been declared "forever lost" (92).

Among their views quoted here, the last is the most intriguing. It unequivocally states that the restaging of experiments can lead to the recovery of lost science. Simply put, restaging experiments can be a route to scientific discovery.

Recovering lost science

Thomas Kuhn's *Structure of Scientific Revolutions*, first published in 1962, is the work in the philosophy of science most likely to be known to readers of the *Journal*, if they know no other (Kuhn 1970; 2012). Some scientists, including quite prominent physicists, have acknowledged its existence, and even felt the need to respond to it, a quite unusual circumstance for a work on the philosophy of science.[5] Equally unusual for such a work, it has left its mark on our common language. The currency of the terms "scientific revolutions" and "paradigms" owes more than a little to *Structure*.

Kuhn is said to have noted that when paradigms change, some scientific knowledge and capacity may be lost: "There are losses as well as gains in scientific revolutions, and scientists tend to be peculiarly blind to the former" (1970, 167). Among the few examples he offers is one we've already met from chemistry:

> Before the chemical revolution, one of the acknowledged tasks of chemistry was to account for the qualities of chemical substances and for the changes these qualities underwent during chemical reactions. With the aid of a small number of elementary "principles"—of which phlogiston was one—the chemist was to explain why some substances are acidic, others metalline, combustible, and so forth. Some success in this direction had been achieved...Lavoisier's reform, however, ultimately did away with chemical "principles," and thus ended by depriving chemistry of some actual and much potential explanatory power (1970, 107).

This loss of scientific knowledge has been dubbed "Kuhn loss" (or "Kuhn-loss;" Devlin & Bokulich 2015, 4 n. 8, 31, 33, 178). Most people who register its existence may note a few examples, but don't pursue it further; few seem to want to make up for Kuhn loss by actively discovering and recovering the lost science. The outstanding figure who has taken the challenge seriously is Hasok Chang:

> Replications of past experiments can serve the function of the recovery of scientific knowledge, if the past results being replicated are not previously known to us. Many primary sources from the past of science are full of observational reports that sound very wrong from the modern point of view. This is reminiscent of a well-known and controversial thesis in the philosophy of science, which says that the progress of science results in some loss of knowledge as well as obvious gains (Chang 2011, 323).

The recovered knowledge can occur in areas we thought we all knew. The boiling point of water is nearly 100 ˚C, except that experimentalists during the third quarter of the 18th century to the first half of the 19th century discovered that one could achieve surprising variation in the boiling point depending on variables such as the material of the vessel, its surface qualities, its shape, the medium it was heated in, the presence or absence of other substances in the water—virtuosos could drive superheating of water to well above 200 ˚C(!) (Chang 2004, 1–40, 241–243).

One of the most dramatic recent recoveries of lost science happened in the realm of medicine. A microbiologist and a philologist of Old English and Norse were curious about a recipe in a 10th-century Anglo-Saxon medicinal collection, known as *Bald's Leechbook* (London, British Library, Royal MS 12 D XVII, Winchester, ca. 925–950). They decided to recreate and test it, with the assistance of other colleagues. In limited trials thus far, it has proven remarkably successful against *Staphylococcus aureus*, a notorious antibiotic-resistant pathogen (Harrison et al. 2015; Anonye et al. 2020; human trials have not yet begun). This is an instance of recovery of lost science with a potentially very practical use.

It would be prudent not to expect the recovery of lost science of such potential through the restaging of astronomical experiments (observations), although one should not rule that out. That being said, one should not to be surprised at being surprised by such a development, should it happen.

Astronomical quests

The best way to start is by choosing the report of an observation, or the graphic record of an observation, that always seemed puzzling, odd, or anomalous, and try the observation using whatever level of replicated or original instruments and techniques seem sufficient for the restaging. The instrumental or technical aspects can always be made more formal, or strict in later trials, depending on the first results of restaging the experiment.

General guidance can be found in the published examples cited earlier. For the convenience of those wanting to restage experiments, the general protocols published in Rosenfeld 2018 are given here in a modified form (Table 1).

The older observational literature contains an abundance of reports that could form the basis of experiment. *Popular*

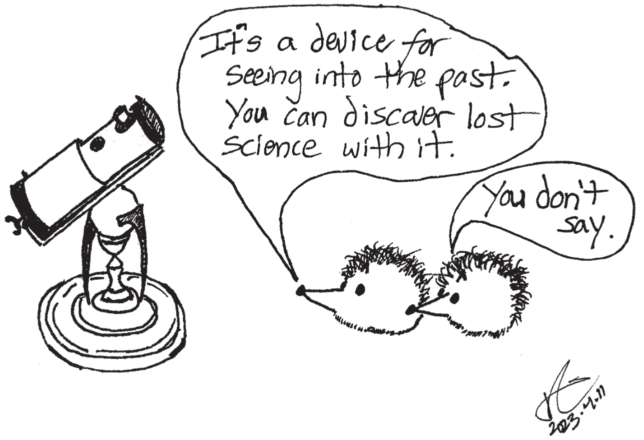


Figure 3 — One of the most promising aspects of restaging historical experiments is the potential to recover lost science. Several examples are cited in the text. Reproduced courtesy of the Speculum astronomica minima.

Astronomy, *The Journal of the British Astronomical Association*, the *ALPO Journal*, or the RASC's own *Journal* could be mined for this purpose. This list is not exhaustive.

I present two cases below, of the sort of thing that could be done through restaging astronomical experiments.

Cyril Wates (1883–1946), of the Society's Edmonton Centre, an experienced observer, telescope builder, and recipient of the Chant Medal, reported some anomalous observations during a lunar occultation of Jupiter on 1944 January 13 (Wates 1944a; 1944b). He'd been asked by a colleague, a Mr. E.K. White, to "to watch for any signs of a lunar atmosphere" (1944a, 171), which seems like a quixotic quest even at that date, but belief in its possibility appears to have been something amateurs wanted to hang on to as long as possible(!). F.P. Morgan of the Montreal Centre observed:

> ...something entirely unexpected—a narrow blue band following the rim of the moon, separating it from the planet so that the planet appeared quite detached... This was during emersion...I observed this effect, and in addition I noted a very marked broadening of the "band" at the limbs of the planet; that is to say, the band being about twice as wide as the central part. This appearance persisted throughout emersion...[other observers were "struck" by] the band itself, which was very obvious. We concur in describing the band as "grey"...[one of the observers] estimates the width of the band as about 5 seconds of arc" (171).

Wates is unwilling to attribute the phenomenon to a purported lunar atmosphere, however tenuous, or to "...Mr. Morgan's theory of mirage [presumably originating in the Earth's atmosphere]... (172).

Some of the drawbacks to restaging a historical observation of a lunar occultation of another Solar System object is its relative rarity, and that it is unlikely to occur under identical observing conditions. Nonetheless, as with the observational effects associated with the transit of Venus (an even rarer phenomenon), such as the black drop and Venus aureole effects, it would be worth looking for what Wates and colleagues reported if opportunity should allow. There is something invaluable in witnessing the actual phenomena in "real time" with appropriate equipment under as similar as possible conditions and recording them. Insight can be gained through this beyond what modelling alone can offer. And the experience gained through doing ("tacit knowledge") ought to better equip one to account for what Wates and his colleagues reported seeing.

A more significant example, which enjoyed non-trivial cultural "reverberation," is that of the canals of Mars. How did so many observers from ca. 1877–ca. 1962 convince themselves that they saw such features? Many of those observers were skilled, and experienced, as is evident from their work in other areas of astronomy. Bill Sheehan has spent decades wondering about this and has made good use of his training in neuroscience, and knowledge of the history of observing, to try to understand what observers reported. Another tool he has had recourse to is observing the restaging of an astronomical experiment to benefit from experiencing something of what those from the classic age (or rather, one of the classical ages) of visual observing encountered at the eyepiece (sometimes at the very eyepiece used by the relevant historical observers) (Sheehan 2023; Dobbins & Sheehan 2004). Given that some canalists at the period used apertures no bigger than those many observers now possess, it would be worth spending some time at the next favourable Martian opposition attempting to gain some of that tacit knowledge of the problem.

Finally, I leave readers with this thought. The restaging of experiments can be a very effective tool for public engagement (education and public outreach): "It is also our experience that the inherent interest of reproducing processes and experiments from the past serves to engage a wider public" (Fors et al. 2016, 95). ✶

Acknowledgements

This research has made use of NASA's Astrophysics Data System.

Endnotes

1 It could with some justice be asserted that every observation of an astronomical object, or phenomenon, that has been seen before and noted in the scientific literature, is a historical restaging to some extent, even if novel techniques, or technologies, are employed. It would be interesting to explore the

implications of this view, but it lies beyond the immediate confines of the present discussion.

2 See Chang 2011, 320–321, who provides a typology that can comfortably accommodate Bruns's experimental restaging of the 1919 eclipse experiment, under the type termed "extension," in which the experimenter "attempt[s] quantification or higher precision."

3 It has now become the practice in the literature to refer to early modern chemistry as "chymistry" to acknowledge and signal the differences between the discipline as conceived and practiced by Tycho Brahe or Robert Boyle, and the nature of the science of Priestley, and Faraday. For example, from the 16th to the beginning of the 18th centuries, alchemy was still very much a productive part of the science, but that significantly waned after the time of Newton. The terms Chymistry and Chemistry will be used in this sense here.

4 Silk weavers from Lyon, whose workshop had provided the model for the *Encyclopédie*'s copper-plate engraving, failed to recognize their workshop in the depiction!; Koepp 1986, 251. The *Encyclopédie* of Diderot and D'Alembert has become one of the best known iconographic sources for 18th-century tools, and workshops; for an introduction to the work *Encyclopédie*, see Cernuschi et al. 2017.

5 A recent example is Jim Peebles, who does so intelligently; 2022, 29–33. Kuhn's theory has been modified (by Kuhn amongst others), and criticized over the six decades since its first appearance, as is right and proper.

1. The equipment used should be that available to the original observers, or its equivalent. In some cases modern analogues can be used if they answer the experimental requirements, e.g. an achromat may be required to restage some observations, but it needn't be a late-19th-century example because period glass types, grinding and polishing techniques, and mechanicals are deemed to have played no role in the features of the original observations being restaged for assessment;
2. Techniques should be those of the time, place, and activity under investigation;
3. Modern technicians should not be incompetent, inexperienced, or inexpert in their handling of 1 and 2 above;
4. Modern technicians must be fully informed of the goals of the experiment, and be sympathetic to its aims, unless the experimental design requires them to be uninformed;
5. In regard to 1 and 2 above, modern materials and technologies should play as little a role as possible in the crucial elements of the experiment, unless they form part of the experimental design. Where they are necessary, their use should be controlled, and recorded;
6. Parameters, qualifications, and limits to an experiment should be clearly formulated and stated;
7. Experiments in sequence should be consistent, unless the experimental design dictates otherwise;
8. Experiments should be developed and run with reference to previous trials (if any);
9. All possible ways documented from historical sources that something may have been done should be considered for investigation where practicable;
10. The experiment should be reproducible if at all possible, should the opportunity for similar experiments present themselves;
11. Results must be stated as accurately as possible, with all necessary qualifications, chief among which is that a successful experiment provides only one possible way something may have been done;
12. The experiment should be scrupulously recorded (including any failures of technique, equipment, or observers), using the most appropriate modern technology;
13. The experiment must be published as fully, transparently, and rigorously as possible.

Table 1 – the general protocols published in Rosenfeld 2018 are given here in a modified form.

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Letters to the Editor

Dear Editor:

I was pleased to read the president's message on citizen science in the April 2023 edition of the *Journal* of the RASC. I love promoting science work that can be completed by amateur astronomers.

But once again I noted an omission. There was no mention of double stars as a target or subject! Why not?!

Double star separation and position angle can be easily measured or captured by a variety of means and can be done anywhere, anytime, as doubles are light-pollution resistant—in the backyard, while the Moon is up, if inclined. Notably, citizen scientists can get started measuring doubles without breaking the bank.

As I pointed out in my talk at the 2022 General Assembly, we desperately need amateur observers. In that presentation I quoted Ron Tanguay, an author, advocate, and veteran double-star observer: "Because so few professionals remain in this field, qualified amateurs are badly needed."

I also recommended the excellent book by Bob Argyle, *Observing and Measuring Visual Double Stars, Second Edition*.

Also in my talk to the RASC Toronto Centre in September 2018 I showed how to accurately measure double stars with an astrometric eyepiece. www.youtube.com/watch?v=pb5phhUYXrY

I provided additional details in the adjunct article on their website. rascto.ca/content/missing-data-double-stars

So, let it be known that citizen scientists can also measure double stars and contribute to and extend our body of knowledge at star formation, open-cluster morphology, and stellar distances to refine the cosmic ladder, all while having some fun along the way.

Blake Nancarrow

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

Binary Universe

Retrospective

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

Review of Reviews

I'm suffering a bit of writer's block of late. Or I've lost my mojo. Or I'm procrastinating. Are there health factors? Perhaps it is a little bit of everything all at once.

Let us peer into the lens of the Way Back Machine.

Barriers

It might be disingenuous to say I'm experiencing writer's block, for there is a lot of software out there and new stuff coming along all the time so, in theory, I should have no lack of things to write about.

I keep a list of computer programs and mobile apps that I've heard about and it is not short. But for many, I would need to download them and install them and use them for a while. At least, that's my *modus operandi* such that I may speak with some authority on how an app works, what benefits it offers, and what sets it apart.

While I have a few "in the hopper," they need some more work. Of course, that means more time, more seat time, more trials, more planning. And then, naturally, the writing.

Before I move on from this item, I do want to say again, to you, my readers: If there's some app or software tool you use and you think others might enjoy using it or benefit from it, let me know. Send suggestions to astronomy@computer-ease.com and I'll happily add to my list.

It certainly has been distracting and disheartening all the things happening in the RASC the last few months, and while that should not affect me, more correctly I should not let it affect me, it does. It should be water off the duck's back, but the negativity and secrecy dampens my mood and interferes with my thoughts on astronomy and astronomical matters. Too sensitive for my own good, I guess. The only way I can seem to manage this is to put it in a box.

Am I lazy? There's a dash of that. Sometimes I just put it off because I don't feel like it, it seems a chore, and something else distracts me. Writing does not just happen all the time, for me. It takes a certain mood, a feeling, a *je n'est ce quoi*, a nexus (see Figure 1). Or a final deadline. That I can't find my Switch console after the recent pack-and-move is probably a good thing. I'd be deep in the woods of Hyrule battling dark forces.

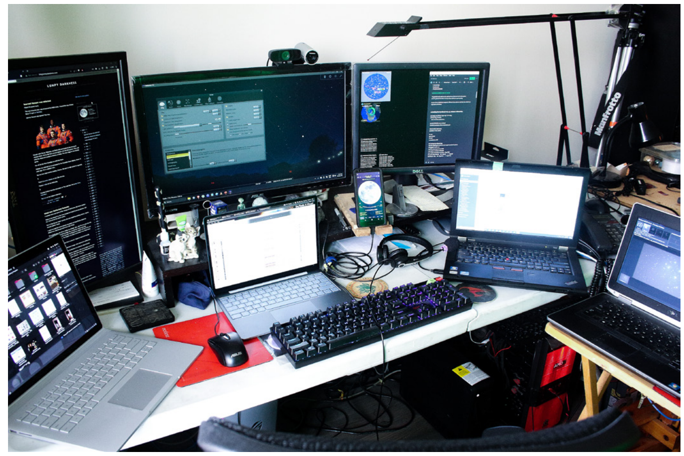

Figure 1 — John Valuk (running GIMP*), John Starbird (below, driving the 3 screens, running* Rainmeter, Stellarium, *and* Evernote*), John Grim (*SkyTools*), Mnemosyne (*Daff Moon*), the Lenovo work computer (*Evernote Legacy*), John Max (below), and John Gomez (*Backyard EOS*).*

And some days, I just can't do anything productive per physical issues. I'm tired, sore, sleep deprived, uncomfortable, aching, or I can't think straight in the brain fog of multiple meds and chemical cocktails. I might be over the hump, but as I write this the pain is taking up two to three tenths of my concentration.

"It's in the *Journal*!"

A common refrain from lifers or long-time members of RASC is "It's in the *Handbook*!" Fans of the RASC premier publication like to remind members that things they are curious about, information they are seeking, an astronomical fact or figure, is often found in the pages of the *Observer's Handbook*. It is a trusted resource used around the world.

I joined the RASC in 2007, but I was buying the OH for about a decade before that. I scour every edition for specific data. Every year I read portions of it. I re-read sections gleaning more information. This winter I learned about the exit pupil. The Handbook is a treasurer trove, and now I, too, have taken up the mantra, pointing out to others that despite all our software resources and tools and internet access to vast repositories, sometimes, you'll find what you're after in the paper tome.

It is in the same vein that I have occasionally blurted "It's in the *Journal*."

I've felt this while delivering or watching astronomy presentations, reading Centre or National astronomy forums, and while talking with astronomers in-person (remember that?). Members ask about the existence of a software tool. Or they're trying to solve a problem. Sometimes they're comparing products and want an opinion. A good number of times it is a new member, invariably green in the hobby, and looking for advice and assistance.

Very recently, Frank of the Toronto Centre, an accomplished visual observer and member with a meteorological background, asked a question on the national RASCals forum: "What apps, software and web resources do aurora watchers use to help with predicting aurora, and is it helpful?"

A few of us jumped into the fray suggesting websites. I recommended setting up email notifications triggered by the NOAA Space Weather website. And then I referred to my recent review of the "*hello aurora*" app, which could be found in the February 2023 issue of this *Journal*. I hoped he'd dig out his copy to read my column. I hoped it would trigger others too. It's a touch awkward promoting myself but that's not my main goal. I'm a big proponent of "teach a man to fish."

Similarly, I participated in a thread on Cloudy Nights a while ago when someone wanted to know if there was a software tool for planning their observing sessions. How much time have you got?

To be honest, sometimes I feel a little irked. I like to hope that RASC members who have been around for a little while are aware of the *Journal* and look at it from time to time. But I suppose that's a narrow view on my part. Not everyone reads or likes to read, and not everyone has the time. The new RASC member? Maybe they don't know yet. Maybe they haven't discovered the cornucopia of astronomy information within the covers of the bi-monthly periodical. The new member is likely not aware of the annual index.

Intersection

And so, it came to be. I was feeling stalled on the write-up of a planning tool while a deadline was looming. I knew I needed more time on it, but there was no way I could wrap it up.

I considered something different, a new app, a different software program, something quick and easy. I was about to consult my master list, when this idea, a bit out of the blue, hit me. What about a "recap?" I thought about stepping back a bit and looking at everything that I was using. Maybe readers would be interested in what I am currently using. Or to put it another way: What do I continue to use? In the spirit of the bank commercial. "What's in your computer?" Or, "What's in your phone?" I looked at the Start menus, docks, and Home screens of my various computing devices.

And then I realized, if listing apps I was actively using, it could also serve as an index. I could point to past entries in the *Binary Universe* column to help people in a multitude of ways.

That said, I realize, ironically, I am preaching to the choir here.

Taking Stock

These are software programs and apps I am actively using. In a particular order that is hard to describe. All dated references are to the *Journal*, unless otherwise stated.

SkyTools: Arguably the best of breed in the planning arena. I continue to use this paid Windows application for my session planning, observing certificate campaigns, and imaging projects. I use it "in the field" at the telescope during visual sessions and imaging runs. I drive go-to mounts if I can. And it is heavily used "the morning after" to review, verify, corroborate, and log. Version 4 of *Visual Pro* and version 4 of *Imaging* (separate products now) live on John Grim, the light-weight Microsoft Surface Laptop Go machine. I don't leave home without it. Occasionally, I consult *Edition 3 Pro* on a couple of older computers. I reviewed *SkyTools 3* in the April 2015 issue of the *Journal*. That's a million years ago in computer time but the review is still relevant: it gives a very good sense of what the unique software can do and gives a glimpse into The *SkyTools* Way of working.

Stellarium (computer): I regularly use the free application, in large part due to teaching courses on the extraordinarily popular planetarium software. It's on all my computers, I think, but I often launch it on John Starbird, the ASUS ROG Strix tower gamer machine with multiple monitors running Windows 11, and John Valuk, the Surface Book generation 1 with its stunning display running Linux Ubuntu 22.04. I keep an updated version on my Mom's iMac. I wrote about *Stellarium* way back in February 2015 and much has changed. It is no longer beta, it offers impressive planning features (the Astronomical Calculations component) and supports observing lists. I continue to recommend it highly for people starting out.

Stellarium (mobile). Over the years, I dabbled with *Stellarium* for mobile devices, but it never really impressed me much. Today, the fully featured paid app version 1.10.4 is on Mnemosyne, the Motorola e6 smartphone running the Android OS. I quite like it and frequently use it while checking the sky, when someone asks me, "What's that?" and I don't immediately know the answer. The June 2021 *Journal* includes a review of the current app. A free edition is available, on both Android and iOS, so people can try it out, though it is limited. They have flexible payment options. I daresay I use this more than *SkySafari*.

SkySafari: I have a love-hate relationship with *SkySafari* on the Android mobile phone. I have version 6 of the Plus edition, which is good fit for my needs. I don't need the additional features and deep catalogues of the Pro edition—there's also not enough storage space on my basic phone. *SkySafari* appears to be the most highly recommended app for slates, but I caution people. The product can be intimidating and overwhelming to learn. The developers do not seem to employ best practices when coding and releasing their software (I feel sorry for everyone who jumped on the version 7 bandwagon early). Their technical support is often pejorative and abrupt. And they simply do not understand how to refer to double stars. Still, it is very powerful and feature-rich and if you wait for a sale or discount, it is fairly good value. I like the observing lists feature though loading and sharing is maddeningly convoluted. I reviewed the app in August 2015, showing version 1.8.5! That's terribly old and needs a redo.

COELIX: When I kept missing the January edition of the *Sky & Telescope* magazine and the included unique hour-glass-shaped almanac poster, I sought out a way to make my own. *COELIX* to the rescue. I reviewed the Windows application in April 2022, bought the fully powered APEX edition from the Canadian developer, and I continue to use the powerful software on a monthly basis, slowly discovering more features. Now I'm running the

"skytonight" and the "phenomena of the month" reports. The 64-bit tool was on Grim but when I ran out of space, I reinstalled it on Starbird with its huge SSD drive.

Communicator: Or more formally, the BGO/ARO/MRO *Communicator* written by past-president Dave Lane. I still use the robotic publicly accessible imaging rigs in Eastern Canada, the Burke-Gaffney Observatory, the Abbey Ridge Observatory, and the "mini-Ralph" refractor for miscellaneous astrophotography projects. While I have email account access, my preferred method for submitting jobs and monitoring the queues is to use the *Communicator* app. It was on John Max, the 32-bit Windows 10 system; now it's on Starbird. I also have it on Mnemosyne. I like the instantaneous feedback and chatting with the bot in real-time. While I have not formally reviewed the app, I did touch upon it in the "astrophotography on a budget" article for the September/October 2021 issue of *SkyNews* magazine.

FITS Liberator: Images captured by the BGO (and related) telescopes are saved as FITS files. I continue to use the free *FITS Liberator* software to pre-process and convert the image files. Initially I used version 3 on John Max and John Repeat Dance; now I have the more powerful version 4 on Starbird and Valuk. See the review of v4 in June 2022.

GraXpert: A lot of my images from the BGO have gradients. The uneven field illumination is from light pollution, catching at edge of the dome roof, moonlight, etc. I've started using the free gradient removal tool *GraXpert*, on Grim and Starbird, an early step in my workflow. I extolled the benefits of the easy-to-use tool in the April 2023 issue.

Backyard: I purchased the *Backyard EOS* software (made by another Canadian developer) at the 2014 AstroCATS show. I use it to control the Canon DSLR camera during imaging runs. I originally installed this on John Repeat Dance, the amazing ASUS netbook running 32-bit Windows XP, my astronomy field computer at the time. Recently I put the program in John Gomez, an old Dell laptop, for training purposes for when I teach the (new) *Backyard EOS* software course. I had an evaluation copy of *Backyard Nikon* on John Max. Back in October 2015, I compared and reviewed both the EOS and Nikon editions of the remote-control and capture software. Broadly, the software is the same, so the old write-up is still indicative.

Photoshop. I have copies of Adobe *Photoshop* for my old Macintosh computers. Currently I use the dusty, old CS2 version on my John Max computer. This is my primary tool for LRGB assembly and post-processing. I've never written a review of this and never will. I'm not qualified.

GIMP: The *GNU Image Manipulation Program*. I have version 2.10.30 is on John Valuk and 2.10.32 is on John Starbird. For years I have used this free program for various things. I've wanted to dive deep and develop a high level of mastery in the program so to supplant Ps. Then I'd be able to speak with some confidence to imagers wanting a solution that did not require an allegiance to Adobe. But there is much to learn. And, notably, without adjustment layers, curtailing non-destructive edits, GIMP still has a way to go. Once again, I've never reviewed this software.

DPP: I believe Canon *Digital Photo Professional* is an underrated application. The software (free to Canon camera owners) is quite powerful and offers many digital darkroom features. I regularly use it to pre-process images and perform non-destructive edits on RAW files. It also supports batch conversion! Version 4.12.20.3 is installed on Starbird. I drafted a review a long time ago and one day I'll dust it off. More people need to know about this.

StarStaX: Currently on John Max; I need to load up on the new Starbird computer. The awesome free program is for making star-trails still shots or time-lapse movies. I reviewed *StarStaX* in November 2016.

Daff Moon: I continue to use, rely on, the *Daff Moon* app on my mobile phone. A widget showing the current Moon phase sits on the main Home screen of Mnemosyne so every time I unlock the Android, I know what's going on. One tap launches the useful app and gives access to extensive lunar information. I often check the phases monthly calendar view or use the main display to get rise and set times. I reviewed *Daff Moon* in December 2020.

Virtual Moon Atlas: Over the years I have used VMA to retrieve information about our nearest neighbour. Recently I used it to check selenographic colongitude values. I recall having it on John Smallberries, my first tiny netbook computer, my first field astronomy computer. Then I loaded it onto John Repeat Dance, the replacement machine. I reviewed the free Windows program back in December 2015. I'm actually on a bit of a mission to find some new tools that provide detailed cartographic information for the Moon, as a modern replacement for classic paper atlases (e.g. Rükl). I heard about the *Lunar Terminator Visualization Tool* (LTVT) so I'm going to give it a whirl soon. Stay tuned.

hello aurora: More and more, as our Sun becomes increasingly active, I'm using the *hello aurora* app on Mnemosyne to monitor auroral and solar activity. While the app can be used for free, I selected one of the medium-level charges to contribute a little bit to the developers. I appreciate the notifications as I hope to not miss out on significant events. I recently reviewed the app, as noted above. Again, see the February 2023 issue.

123D: I haven't worked on anything for a number of months but that's not for lack of interest. I have a lot of projects I'd like to complete and I'm looking forward to trying out the 3-D printing resources at my new local public library. I need more replacement parts for the telescopes and bicycles, a new stand for the mobile phone, and I want to finish up the David Dunlap Observatory telescope model. Call me old fashioned but I still really like the *123D Design* application by *AutoDesk*. You won't be able to find it; I kept the original installer for free version 2.2.14. I used it on John Charles then John Max. Now it is on Starbird and works wonderfully on the fast CPU in a 64-bit OS with tons of RAM. They want you to buy a subscription to *Fusion 3D* but I'm not taking the bait. I briefly referred to 3-D printing design applications in the January/February 2022 issue of *SkyNews*.

TinkerCAD: This is not strictly an application; it is a website. I've started dabbling in *TinkerCAD* as an alternative to the aforementioned *123D*. Early impressions are that it is suitable for my light-weight DIY projects. It was very helpful when I made the replacement focuser tube for Alister Ling's telescope. Once again, I referred to this tool in my *Getting started in 3D printing* piece in the Jan/Feb 2022 *SkyNews*.

BOINC: In the April 2017 issue, I wrote about BOINC, the application for sharing your free computer time. The *Berkeley Open Infrastructure for Network Computing* initiative is used by scientists and researchers around the world when they need computing power that exceeds what they would normally have access to. I am one of millions of contributors on the grid that allows my home-office computers to be used, while idle. I've used this primarily on my Windows computers but occasionally I've provided cycles from Macintosh and Linux machines and even a mobile phone. I started out assisting the SETI project; today I help in MilkyWay@Home and Rosetta@Home and some medical research.

Rainmeter: When Windows Vista strutted briefly, I noted the widgets feature and was intrigued. So was Brian Gibson, making the *Clear Sky Chart* widget. Afterwards, I used *Yahoo!Widgets* and a couple of other tools but for years now, on various Windows computers, I have relied on *Rainmeter*. This is essentially a platform product for it allows you to display customizable skins on your desktop. I use predefined system monitors, weather, Moon, and RSS feed widgets. I have created my own custom widgets from scratch and hacked others to show data from Fourmilab, the NOAA aurora services, and various *Clear Sky Charts*. I first told people about desktop widgets in the defunct RASC Toronto *SCOPE* newsletter, the August/September 2008 edition. Fifteen years ago!

ASCOM: When I wish to use *SkyTools* at the telescope to drive the mount, I need the ASCOM products. My mount motor drive system is atypical or uncommon, so I turned to the popular Windows-based device-independent framework. The ASCOM platform is installed on John Grim along with the mount driver; it used to be on John Smallberries and John Repeat Dance. Never really thought about it but perhaps a review would be helpful, given how many need these tools. As an aside, I recently went down the INDI rabbit hole to learn how to enable mount control for *Stellarium* on the Linux OS, using John Valuk. That was a very interesting experiment.

So, there you have it. The programs and apps that I still actively use and refer to.

Hangers On

But wait! That's not all. There are some other software products on my devices. These, however, are not seeing much use. Some are falling by the wayside as my needs change; others I have not used yet.

MySiderealTime: I used the simple little app *MySiderealTime* frequently when I was volunteering at the David Dunlap Observatory. When I was the designated telescope operator, before firing up the motor drive for the 74-inch telescope, I'd run the app, acquire signals from GPS satellites overhead, and calibrate the mount. I reviewed this, and other apps, that display actual sidereal time in December 2018.

PolarFinder: I can't remember when I used this app last. But I can't set aside the feeling that if I delete it then suddenly I'll need it. I guess I don't use *PolarFinder* that much as I have other tools at my disposal and nearby. *SkyTools*, in general, is with me, at the 'scope. Anyway, *PolarFinder* will stay on Mnemosyne for the time being. It's a handy app to have on a mobile device and it's a great resource for people mystified by their new equatorial mount. See the December 2017 edition.

PhotoPills: I put the popular *PhotoPills* app on my smartphone a couple of years ago to get some seat time with it and to write up a detailed review. But I've yet to watch all the training videos and read all the guides. Milky Way season is coming so maybe I'll give the photo planner tool a go this summer. The paid app looks to be very powerful and comprehensive.

Deep-Sky Planner: I loaded the commercial *Deep-Sky Planner* software onto John Grim a few months ago with the intention of writing a detailed treatment. This would complete the trifecta of formal planning programs for computers with *SkyTools* and *AstroPlanner*. (*AstroPlanner*, for Windows and

Apple Mac, I reviewed in October 2016). Also, I highlighted these, and some other products with planning capabilities in the July/August 2022 *SkyNews*. Still, I need to wrap it up for DSP. Stay tuned (again).

Our Galaxy: Originally titled *Where Is M13?*, I occasionally use the updated *Our Galaxy* application. The most common use case is educational, helping fellow astronomers understand where celestial objects are in and around our home Universe. Currently installed on John Grim. See my take in October 2022.

KStars: Over the years I have tried the free *KStars* planetarium program. I loaded it onto various Linux implementations but never had enough time to properly review it. If I remember correctly, it is on my Mom's iMac. Now that I have a stable Ubuntu machine, I should be able to give it a fair shake. I've really wanted to highlight options for people running the other operating system.

REDUC: This free software tool by Florent Losse is rather esoteric, used primarily for double-star measurement. I don't use it on a regular basis but still I need it when I require the separation and position angle values for pairs. It lives on John Max but needs to be migrated to Starbird. I don't know if I would share a review in the *Journal* given REDUC's specialized use.

Aladin: I don't use it day to day but it's so helpful when I need it. It's been quite handy when identifying tiny little fuzzies in the background of BGO images. Both version 9 and 10 of the free interactive tool are installed on John Max. There's a new version of the *Aladin Sky Atlas* that I should download and deploy on Starbird. Check the August 2016 column.

OccultWatcher: Many years ago I had this application configured on a Windows computer to run in the background to alert me of asteroid occultations near to my home or Centre observatory. But then I got out of the occultation game. When feeds for double-star occultations stopped, I shut down the program. I only use it now ad hoc when preparing for What's Up This Month presentations. And now I ain't doing many of those. See the February 2018 copy for my assessment.

dev apps: Not strictly astronomy-related, but I have a Python IDE and *MS Visual Studio* is on John Gomez. I'm trying to learn the Python programming language. I used *Visual Studio* to develop my own Windows application coded in *Visual Basic*. I created a virtual hand controller for my IDEA *GoToStar* motor control system on my Vixen Super Polaris equatorial mount. I wanted additional controls beyond those provided by ASCOM in *SkyTools* or *Stellarium*. I was thrilled to deploy a spiral search, inspired by Software Bisque's *TheSky* application.

Retrospective

Honestly, I needed to buy some time. But something interesting happened.

It is intriguing to me, being in the Information Technology industry, how many software tools I'm still using even after a decade! Curiously, many of the software reviews still hold up.

That said, lots of programs have fallen off, I stopped using, lost interest in, or were replaced by something better. To be fair, some apps I only loaded for review purposes, and then they were deep-sixed. The Motorola doesn't have a lot of memory and *SkySafari* and *Stellarium* are chewing up a lot of space, so I have to dump apps. I'm seriously considering ditching *SkySafari* but that may be driven by spite. You may have noticed I've no weather apps loaded on Mnemosyne, such as *Good to Stargaze* (June 2020) or *Astrospheric* (August 2018).

It is also appealing to me to see how this piece will serve as an index. I envision this proving handy to new members and new astronomers. Of course, there's an index on the RASC website (but only up to volume 90). The December editions of *JRASC* include a multi-categorical index for the year. I believe my entry offers better pointers.

A bit of an unusual entry for the *Binary Universe*, but I personally found this illuminating. I hope you do too.

Bits and Bytes

AstroPlanner version 2.4b19 (that's a beta release) is now available for download. ✶

Blake's interest in astronomy waxed and waned for a number of years but joining the RASC in 2007 changed all that. He is a member of the national Observing Committee. In daylight, Blake works in the Information Technology industry.

Blast From the Past

Compiled by James Edgar
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With this new Department, we bring to life an article from a previous Journal*, most of which are available at the NASA ADS site (Astrophysics Data System). The site is searchable in several ways, one of which is by publication. In our case, search for "JRASC" at ui.adsabs.harvard.edu.*

This Blast From the Past is from a very early issue of the RASC *Journal*, published in the December issue of 1910. It's a collection of notes gleaned from various sources, all from the same era. A few of the authors will likely be known to readers by their notoriety, e.g. Hale, Russell, Darwin.

Astronomical Notes

AT THE INTERNATIONAL SOLAR UNION, Mr. C. G. Abbot, director of the Smithsonian Astrophysical Observatory, gave a brief historical outline of the study of solar radiation. The most probable value of the solar constant of radiation appears now to be about 1-92 calories per square centimeter per minute. From the last few years work at the Smithsonian Observatory at Washington and Mount Wilson, there are fairly strong indications of frequent variability of the order of five or ten per cent. in the intensity of the solar radiation outside the earth's atmospliere, and there are also indications from the study of a longer interval that there is a periodic variation coinciding in time with that of sun-spot frequency, the maximum radiation accompanying the sun-spot minimum.

Professor Schuster said that it was desirable to study the variation of intensity of the solar radiation from different parts of the disk. The photosphere and absorbing layer are not separate and the effect from the two is not the same near the limb as near the centre of the disk. One problem can be treated mathematically and that is where the heat is given out by radiation only—neglecting convection. On this supposition, calculating the absorption of air which we should expect if there were no other agency than pure air, the result for the solar radiation agrees with that obtained by Abbot.

REGARDING THE SPECTRA OF SUN-SPOTS, Professor Hale said : —In the spectra of sun-spots certain lines are double and others are triple. 'The same lines are always affected in the same way in different spots. The iron line at A 6303 is triple, sometimes wide, sometimes less eparted. To show this requires high resolving power and extremely high dispersion. Experiments in the laboratory show that doubling, tripling, and even higher multiplication of metallic lines is produced by passing the light through a powerful electro-magnetic field. In a spot spectrum the components of some lines may be parallel and those of others may be convergent at the same time, showing differences of the electric field at different levels. It is possible from these differences to determine the direction of the axis of a vortex about a sun-spot.— Publications, Astronomical Society of the Pacific, No. 133.

THE DISTANCES OF RED STARs.—Dr. H. Norris Russell classifies the parallaxes of stars measured at Cambridge according to spectral types, and finds that the percentage of orange and red stars increases with the distance from our system. A comparison of parallaxes of stars with large proper motions with parallaxes computed from Kapteyn's formula shows that the observed parallax of the red stars is nearly twice the computed value, and hence that redness is accompanied by intrinsic faintness, the reddest stars averaging one-fiftieth of the brightness of the sun. On the other hand the bright red stars Arcturus and Antares are known to be at great distances, and are probably at least 100 times as bright as the sun. This is in agreement with the hypothesis that there are two classes of red stars, one getting hotter and the other cooling.— Proceedings American Philosophical Society, No. 195.

REGARDING THE DISCOVERY OF COM, W. F. Denning, in Journal of British Astronomical Association, No. 2, remarks :— This is a field of labor specially suited to amateurs; it is one which promises ample reward, and they cannot be too strongly encouraged to take it up. Comet-seeking is easy work, not involving the employment of expensive instruments, and is sure to be successful if performed by a capable observer. Moreover, it is highly interesting, for, in the process of sweeping, attractive objects are picked up, many beautiful fields of stars, star clusters, and nebulae are encountered, and there is an excitement as well as a feeling of expectation about the work which afford a welcome stimulus to the observer and prompt him to pursue it in spite of, possibly, long-delayed success.

Many young amateurs are naturally ambitious, and would like to perform some meritorious feat bringing their names prominently before the scientific public. They should take up comet-seeking, for it will prove very instructive, entertaining, and probably successful.

ARISTARCHUS—The inner slope of the E. wall is crossed by three broad dusky bands, apparently radiating from the centre and broadening as they mount the slope; these objects do not show in old drawings of this formation, and, so far as I know, the appearance is quite unique on the moon's surface.

I have traced some of them over the crest in the direction of Herodotus. It would be interesting if some observers would watch these dark markings, noting the time when they first appeared, and also when they disappeared, and if they varied at all in size or shape in the interval.

On the floor of Aristarchus, Schmidt shows a distinct crater let close to the slope of the N.W. wall. This requires confirmation.—W. GOODACRE, Journal of British Astronomical Association, No. 2.

THE TIDAL OBSERVATIONS OF THE BRITISH ANTARCTIC EXPEDITION, 1907.—In the curve for Madras there are considerable irregularities, but it seemed impossible even to imagine any periodicity. At Karachi there does seem to be an inequality with a period of two to three days and a range of two or three inches. A succession of waves with three to five crests one after the other is observable at several parts of the curve. It seems quite likely that sea-seiches may exist in the Indian Ocean, and Karachi would be well placed for observing them.

These Indian results were not corrected for barometric pressure, and it may be worth while hereafter to submit them to a more systematic examination. For the present, however, I am satisfied with the conclusion that periodicity is not to be seen in all cases, and that the oscillations of mean sea-level in the Antarctic Sea are many times as great as those in the Indian Ocean and Bay of Bengal. Thus it seems unlikely that imagination is responsible for the existence of the Antarctic sea-seiches, and we may hope that the investigations of Captain Scott's second expedition will throw some further light on the subject, and possibly also on the existence of a deep bay behind the barrier.— SIR GEORGE DARWIN, Proceedings Royal Society. Series A. No. 572.

A PROJECTION ON SATURN'S OUTER RING. —During the total eclipse of the moon on November 16, M. Jonckheere directed the 35-cm equatorial of the Hem Observatory to Saturn, and found a bright projection extending outwards from the eastern extremity of the exterior ring. 'The projection was best seen with low powers (100 and 200), and its intensity decreased gradually, going from the outer edge of ring A on to the background of the sky. On November 20 and 24 the same projection was seen with difficulty (Astronomische Nackhrichien, No. 4461).

METEOROLOGY IN JAPAN.— In the Bulletin of the Central Meteorological Observatory of Japan (No. 5, 1910) Mr. T. Okada discusses in great detail the rainy season in Japan, which usually extends from about the middle of June to the middle of July, and is the most important period for the cultivation of rice. To make the investigation more complete, five-day means are given for the whole year for a large number of stations in Japan and adjacent districts, with charts and a short discussion of each of the principal elements. The figures show that in Japan proper the rainfall reaches a maximum at the end of June or in the first part decade of July; it then falls to a minimum in August, and again increases to a maximum in September or October. The rainfall of the season in question is chiefly caused by cyclonic disturbances from the Yangtse Valley and Formosa, and is not a simple onsoon rainfall. 'The period is characterised by continued cloudy weather, large relative humidity, comparatively high temperature, small wind-velocity, and more or less rainfall every day.—MNature, No. 2147.

THE AVERAGE UNIFORMITY OF CERTAIN MARKINGS ON THE PLANET JUPITER.— The equatorial current of Jupiter thus possesses features which, if at times intermittently visible, bear a permanent character. Also the uniformity of such markings has been evinced from a series of continued longitudinal determinations, which have proved that at certain points of the surface the apparently ejected matter from a hidden kernel is displayed, on the average, at regular intervals along either side of the equator. An unprecedented swift axial rotation, such as we perceive in Jupiter, together with his huge bulk, may account for much that is brought to light through a persistent study of the planet. —SCRIVEN BOLTON, in Journal British Astronomical Association, No. 1.

John Percy's Universe

The Astronomical League

by John R. Percy, FRASC
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The RASC traces its roots to the Toronto Astronomical Club, formed in 1868 by eight amateur astronomers. After some ups and downs, the organization became The Royal Astronomical Society of Canada. Initially, it needed to serve both amateur and professional astronomers, until the formation of the (professional) Canadian Astronomical Society in 1971. Before that, there was grumbling among some of the amateur members, especially about the perceived cost, to the members, of the technical papers in the *Journal*. Their costs were actually covered by page charges and government grants. There was also the challenge of serving both the anglophone and francophone members. This was alleviated by the formation of the francophone L›Association des Groupes d›Astronomes Amateurs in 1976, which was succeeded by La Fédération des Astronomes Amateurs du Québec in 1993.

The RASC was initially headquartered in Toronto, whereas amateur and professional astronomy were spread across our vast country. So, the Society began sprouting branches or Centres, with the formation of the Ottawa Centre in 1906. There are now 30 centres. See Broughton (1994) for an excellent history of our organization; it can be found online at rasc.ca/looking-up-book.

Our Society continues to evolve, with the inevitable ups and downs. The current challenge with publications and finances is one of these. It›s important to think and plan carefully for the future. One useful step would be to also consider the nature and state of organizations like ours.

Our counterpart in the U.S. is The Astronomical League (AL: astroleague.org). In the USA, the professional American Astronomical Society had been founded in 1899, avoiding the challenge of one organization having to support both amateur and professional members. The AL was formed in 1947, after several years of discussions, and five meetings of members of 11 primarily amateur astronomical clubs. They realized that clubs could mutually cooperate in ways that would benefit all. So, unlike the RASC, which grew and sprouted from one small club, the AL came into being fully grown. The interim president, in its inaugural year, was the eminent professional astronomer Harlow Shapley.

The AL is a federation or "umbrella organization" of about 300 local clubs, along with members-at-large, patrons, and supporting members, with a total membership of about 22,000. This "bottom up" structure may reflect deeper societal differences between Canada and the U.S. The AL is divided into 10 regions, which have their own governance and meetings. There is an annual get-together called ALCON (to be held in Baton Rouge, Louisiana, in 2023) which attracts a few hundred members, and also a monthly *Astronomical League LIVE* broadcast, combining AL news with an engaging speaker presentation. Like other organizations, the AL has discovered some benefits of virtual or hybrid operation. The AL is a strong supporter of Astronomy Day(s) and the International Dark-Sky Association. These activities, and its publications and awards, help to unite a geographically dispersed membership. In its magazine, and on its website, the AL also has some very useful information about how to establish and operate a club effectively.

The AL's stated objective is to promote astronomy by fostering astronomical education, providing incentives (and support) for astronomical observation and research, and assisting communication among amateur astronomical societies. It is a primarily volunteer organization—which is beneficial to both the finances and the volunteers. These volunteers include five national officers, regional officers, committee chairs, and observing section leaders. There is a national office in Kansas City, Missouri, with a very limited staff. The AL is funded by annual dues of the member clubs, which are based on the number of members in the club. Additional revenue comes from sales of publications and memorabilia, advertising, the annual conventions, and donations and sponsorships.

The Reflector

The Reflector is the AL's quarterly magazine/newsletter, now in volume 75. The level and content are well suited to the

Figure 1 — Crest of The Astronomical League.

interests of the average AL member—no highly technical stuff. We should remember, though, that the members of the AL—and of the RASC—range from newbies to advanced amateurs with near-professional equipment and skills.

The December 2022 issue of *The Reflector* is typical. There are the usual important messages from the editor and officers, and letters to the editor. Lots of ads, including for RASC products. Several beauty shots. Interesting non-trivial one- to two-page articles on astronomy news, observing, remote telescopes, promoting Astronomy Day, and human-interest stories. No sky information; presumably there are other places to get that. The magazine is attractive and easy to read, in terms of content and presentation. It should appeal to a broad audience of amateurs. It appeals to me.

The Astronomical League has also created a number of short, reasonably priced guides on astronomical objects and observation, supporting the various observing sections and awards. They range from lunar to galaxy clusters. These books are available from the AL online store, along with the usual hats, t-shirts, and tote bags.

Awards

The AL offers a number of awards of different kinds, of which the RASC may wish to take note. There is the prestigious Leslie C. Peltier Award, presented to an amateur astronomer who has done astronomical work of lasting significance. It›s like our Chant Medal. The Astronomical League Award is presented to an amateur or professional astronomer who has made worthwhile contributions to astronomy. I was honoured to receive this award in 1996 for my contributions to pro-am partnerships. It gets me a complimentary copy of *The Reflector*, which I read faithfully. There is a service award, an imaging award, a club newsletter editor award, and a club webmaster award. Considering the number of clubs in the AL, these awards are quite competitive! The citations for the 2022 awards occupy a full four pages in the September 2022 issue of *The Reflector*. Women are well-represented among the winners.

Most significantly, I think, there is a series of quite substantial awards for young people. The National Young Astronomer Award recognizes amateur astronomers of high school age, in any of several areas of astronomy research, education, observation, or leadership. Then there are several youth awards for service, outreach, and communication. These awards help to address a fundamental problem in amateur astronomy today: the lack of young people in the field. It's not that young people are not interested; they are. Astronomy is in the school curriculum, but very few teachers have any background in astronomy, or astronomy teaching. Outreach to young people is therefore worthwhile and rewarding—if it is done effectively. There's also the problem of the lack of women and other under-represented groups in amateur astronomy. That also needs to be addressed somehow.

Observing Awards

The December 2022 issue of *The Reflector* contains two whole pages of listings of 49 observing awards, from Active Galactic Nuclei, to Variable Stars, with a total of 215 recipients—some of them qualifying for several awards. These awards serve members ranging from those under pristine skies, to the climatically underprivileged. There›s also a "master observer progression", which leads members to the highest level of observing achievement. Progress toward these various awards is supported by the AL's section leaders and publications. Perhaps the awards could be called "recognitions"; I am a great believer in "paper medals." This is an interesting way to encourage and recognize observing achievements. They do not need to be expensive; a simple certificate, or just publication in a newsletter would suffice.

In Conclusion

I invite every RASC member to reflect on the organization and governance of our Society, as compared, for instance, with the AL. We must remember, of course, that there are differences between our two histories and cultures. On average, Americans are less enamoured with central governance. There is even a touch of colonialism involved. When the RASC was founded, the Royal Astronomical Society was well established and respected in "the mother country." The U.S. rebelled against colonialism. Perhaps the difference between our two crests reflects some of those cultural differences. Still, our motivation is the same, so comparison is worthwhile—with the AL and other organizations. What can we learn? What can we do better?

I also encourage the RASC Board and Centres and members to engage in strategic thinking and planning each year, to ensure the good health of our 155–year-old Society. Unlike the case with old folks like me, great age does not have to mean declining health! ✶

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John Percy FRASC is Professor Emeritus, Astronomy & Astrophysics and Science Education, University of Toronto, and a former President (1978–1980) and Honorary President (2013–2017) of the RASC.

Dish on the Cosmos

Cosmology in Crisis?

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

Cosmology is the scientific study of how our Universe has evolved from its beginnings into what we see around us today. The current scientific consensus has developed around the Big Bang theory, which holds that the Universe was once hot and dense and has since expanded and cooled off. The Big Bang theory was once just this statement, and the original term was coined by astronomer Fred Hoyle to insult the simplicity of the theory. However, in the ensuing decades the Big Bang model has been extensively developed and quantified to explain many of the basic features about our Universe. Over time, the data seemed to point to a "Concordance Cosmology," where all the observations pointed to a single consistent description of the Universe. However, recent observations have become so precise that two main lines of measuring the expansion of the Universe may not agree with each other, raising the question of whether we are missing something in our studies.

There are two main approaches for measuring the evolution of our Universe. The first approach is to measure how fast the local Universe around us is expanding right now. This approach involves making precise distance measurements to galaxies and measuring how fast they are moving away from us due to cosmic expansion. The second approach is to study the leftover radiation from the time when the Universe was hotter and denser. This radiation is now mostly found in the microwave part of the radio spectrum, typically with a wavelength of about 1 mm, so these observations are typically made with radio telescopes.

One of astronomer Edwin Hubble's greatest discoveries is that the Universe is expanding. He studied the properties of nearby galaxies and discovered that nearly all galaxies appeared to be receding away from the Milky Way. He further discovered that the more distant galaxies appeared to be receding away from the Milky Way faster. In making a few simple assumptions: that the Universe was similar throughout and that we don't occupy a special location within the Universe, Hubble's data led to a conclusion that the whole Universe was expanding with each group of galaxies getting progressively more separated from its neighbours. Hubble characterized this expansion with a number that has later come to be called the Hubble constant. Current measurements of the Hubble constant from nearby galaxies estimate this constant with a value of 71 km/s/Mpc, which means that a galaxy that is 1 megaparsec (Mpc) away and outside of our Local Group of galaxies will be receding from the Milky Way at 71 km/s. Similarly, a galaxy that is 10 Mpc away will be receding at 710 km/s.

While the value of the Hubble constant is determined by measuring the distances to nearby galaxies, the actual practice of measuring those distances is complicated. The best modern measurements pin their results on two different types of "standard candles," which means that there are astronomical objects with known total light outputs. Since more-distant standard candles will appear fainter, even though they put out the same amount of light, we can use the faintness of the observed light to determine how far away the objects are. The two standard candles in use are the brightest red-giant stars and a class of bright variable stars called Cepheid variables, which are named after the star Delta Cephei. Figure 1 shows an example of one such variable in Andromeda. The variability of these stars directly translates into how much total power they produce. These standard candle measurements ultimately lead to a conclusion that the expansion rate is 71 km/s/Mpc.

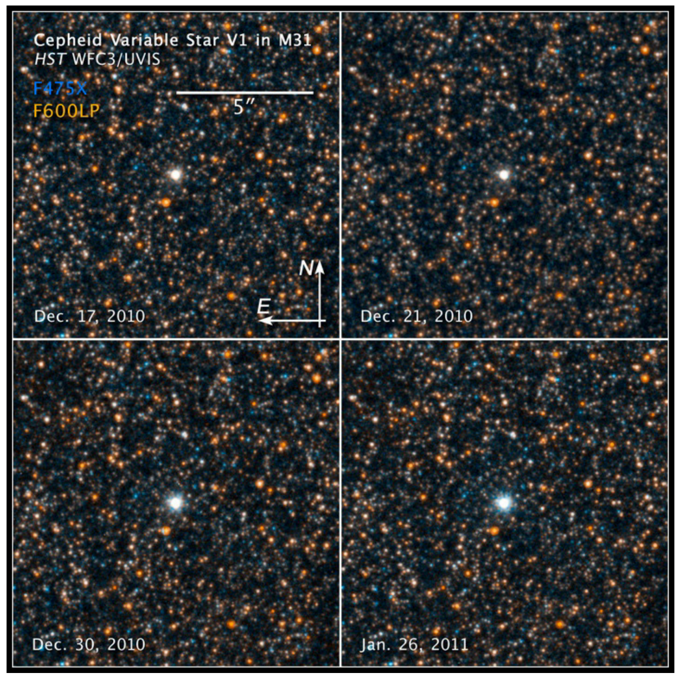


Figure 1 — A Cepheid variable in the Andromeda Galaxy that was imaged by the Hubble Space Telescope *over several different days. The changing brightness is apparent in this star. Image credit: NASA, ESA, and the Hubble Heritage Team (STScI/AURA)*

While this is an amazing feat of measuring the expansion of the Universe so precisely, there is another approach to this measurement that relies on radio-astronomy measurements of light from the early Universe. The Big Bang theory holds that the Universe once expanded from a much denser state. In that state, all the matter and energy were packed into space that held it closer together. This also means that the Universe was much hotter in the past. The earliest stages in the Universe are shrouded behind the mysteries of unknown physics, but our understanding becomes much clearer around 300,000 years after the Big Bang. At this point, all the gas in the Universe was in the form of a plasma and it was sufficiently hot and

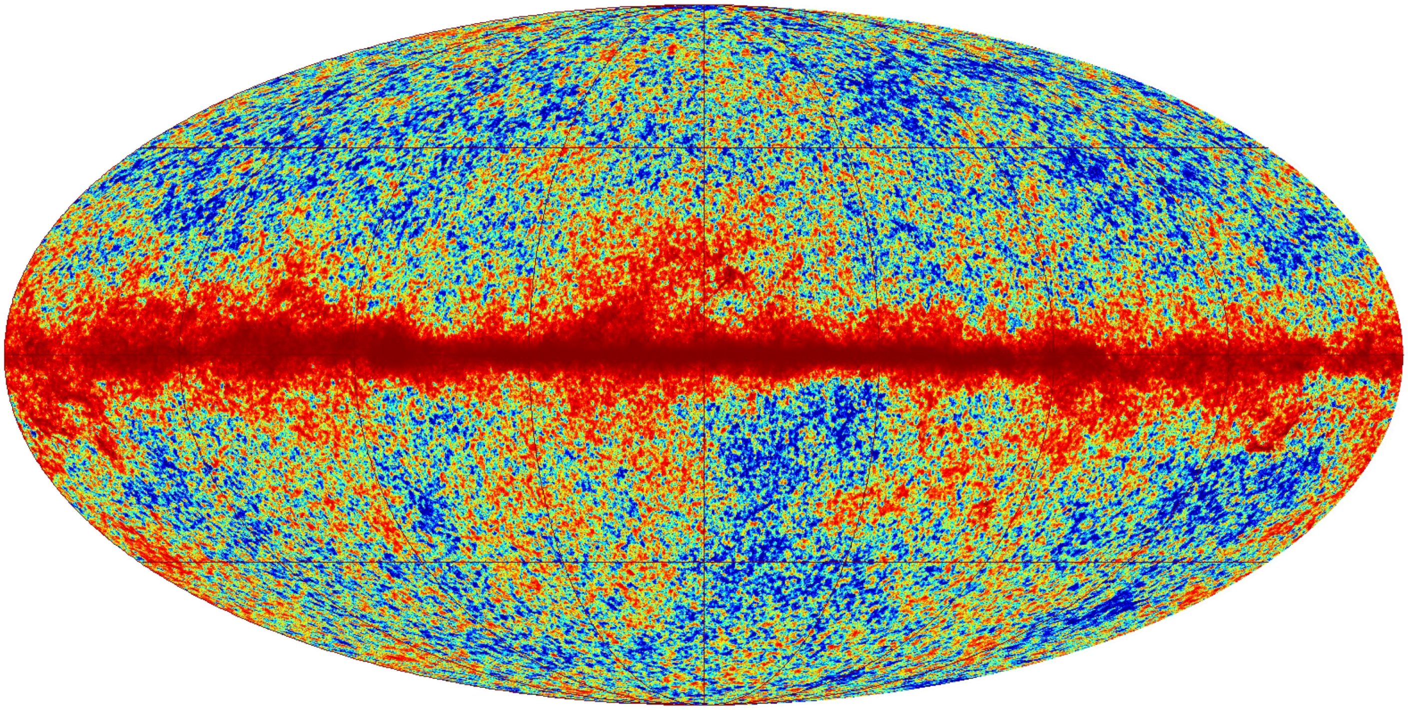


Figure 2 — An image of the sky measured at the radio frequency of 143 GHz measured by the **Planck** *satellite. The bright band of radiation across the middle of the map is the radio emission from the plane of the Milky Way Galaxy. The speckled pattern at the top and bottom of the map, away from the Milky Way, shows the Cosmic Microwave Background radiation from the early Universe. Image credit: ESA and the Planck Collaboration*

dense that the Universe was opaque to the passage of light. The photons of light bounced around, scattering off the plasma so that the conditions resembled the relatively cool outer layers of stars. Much as we cannot see through the outer parts of the Sun, light did not flow freely through the Universe. The temperature at this point was about 3000 K, the temperature of a cool, red-giant star.

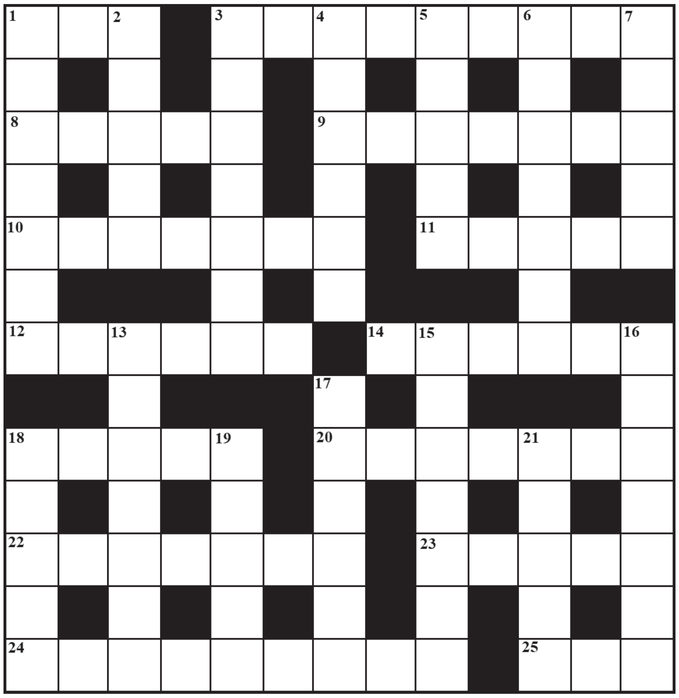
The Universe was cooling off since its inception, and at this time and temperature, the Universe was sufficiently cool that the hot plasma combined the free protons and electrons together into neutral hydrogen. Neutral hydrogen only absorbs light at very specific colours, and most light will simply pass through hydrogen gas. For this reason, hydrogen and many other gases are clear and transparent. This change in the chemical state of hydrogen also changes how light moves through the Universe: it no longer bounces off the plasma progressing slowly. Instead, the light streams in a straight line moving across the expanding Universe. Between that early time and the present day, the cosmic expansion of the Universe stretches out the light. What was originally red light gets stretched into the radio spectrum. We use satellite radiometers to carefully map out this radio light, leading to a sky map like what is seen in Figure 2. This map shows the Milky Way Galaxy across the middle, but the mottled pattern of brightness that appears at the top and bottom of the map comes from the radiation that has been freely moving since the earliest time in the Universe. This radiation is called the Cosmic Microwave Background (CMB). Without going into details, the characteristic size of these bumps, about 1°, depends sensitively on how the Universe has expanded over time. If we translate that rate of expansion to the current day, we get a measurement of the Hubble constant of 68 km/s/Mpc.

These two approaches ultimately lead to different estimates of the Hubble constant. They are not so different as to prompt a major crisis. However, as measurements get progressively more precise, it is becoming clear that the standard candle approach leads to higher measurements of how the Universe expands compared to the measurements of the CMB. Discrepancies like these are the drivers of scientific progress: these answers should agree, and they prompt us to challenge the assumptions that led to these differing conclusions. A multitude of explanations have been proposed. One set of concerns suggest that we may not understand the details of stars as well as we would like: if we compare the values of the Hubble constant derived from red giants to those from Cepheids, we find that only using red giants leads to a measurement close to that of the CMB value. Alternatively, we may have neglected important effects in the early Universe, such as how the transition from plasma to neutral hydrogen releases energy into other photons. So, far from the Hubble constant "tension" prompting us to reject our understanding, we are now energized to refine the chains of reasoning that describe how our current Universe came to be. ✶

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.

Astrocryptic

by Curt Nason



ACROSS

1. The editor's employer from Come By Chance, initially (3)
3. Repair a fault Ohm found in a fishy mouth (9)
8. Solar activity on a Riviera beach (5)
9. English maid over time became Dejah Thoris (7)
10. Harvard computer with audiovisual component in disputed title (7)
11. The Spanish altar sent to orbit Jupiter (5)
12. Big truck follows gold to a driver with kids in hand (6)
14. Bet a peg that Simon will not play fairly (6)
18. Such a bucket for us is ironically heavy (5)
20. Adaptive mirror resulting from a pinball error (3-4)
22. Third leap from a bare foot, I hear (7)
23. Hubble was seen working in the dwindling hours (5)
24. Historian got up, faced north and fled away (9)
25. Global hazard initially detected in Moon-Earth region (3)

DOWN

1. LaPlace was a star or goat, maybe both (7)
2. Dog star was a joy for Hevelius (5)
3. She would mingle about on Friday with Harvard computers (7)
4. Emcee math competition nominally with Pierce at Kitt Peak (6)
5. Early form of a harp with highlights (5)
6. Self-proclaimed Greatest led father east to measure stellar altitudes (7)
7. Bipolar double takes a second leap (5)
13. Lure Gus around to see the little king (7)
15. Variable HD piece used as a standard candle (7)
16. It ain't a little one orbiting Uranus (7)
17. Methane loses mass but still makes Uranus look green (6)
18. Relate endlessly about Tycho's formation relative to Copernicus (5)
19. Little bird with a nitrogen atmosphere around Saturn (5)
21. Fred Whipple was one like Hawkeye (5)

Answers to previous puzzle

Across: **1** IKEYA (IKE(Y)A); **8** EQUULEUS (an(L)ag)+us); **9** STADE (anag); **10** WILD DUCK (2 def); **11** SPARK (anag); **12** CAM (rev); **16** MADORE (M+adore); **17** ISABEL (anag); **18** PSC (2 def); **23** LYMAN (anag); **24** ERIDANUS (anag+syn); **25** BEALS (Beatles-ET); **26** SCORPIUS (S+co+anag); **27** PEASE (hom)

Down: **2** KITT PEAK (Kitt+hom); **3** YED PRIOR (anag); **4** AQUILA (anag); **5** FUNDY (2 def); **6** SEGUE (anag); 7 ASUKA (as(hom)k+a); **12** CEP (2 def, rev); **13** MIC (2 def); **14** GANYMEDE (anag); **15** HERACLES (2 def); **19** SCUTUM (S(cut)um); **20** MENSA (anag); **21** MINOR (MI(no)R); **22** SAIPH (anag)

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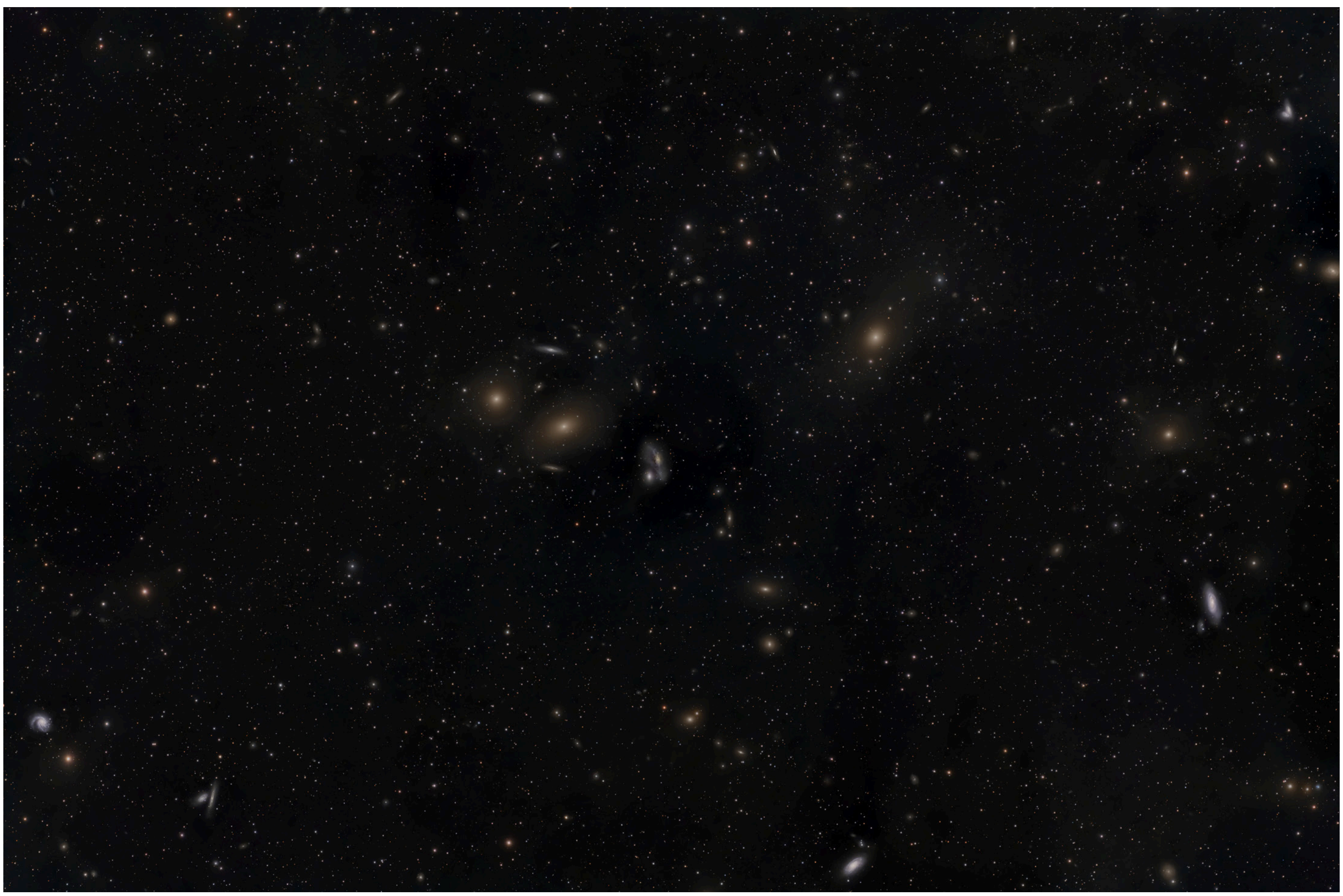
Great Images

by Shelley Jackson



Who doesn't love Markarian's Chain with its collection of galaxies? Shelley Jackson's image taken from Athens, Ontario, shows roughly 100 galaxies and colourful stars, along with the integrated flux nebula (IFN). She says, "When I first looked at the stacked image, I noticed a lot of dust in the FOV. I had no idea that integrated flux nebulosity would be present in this area of the sky, but with a quick Google search, confirmed that yes, indeed, I had captured faint IFN. I am quite pleased with this image." She used an Askar 200-mm FL astrograph lens with 30-mm guide scope, ZWO 120 mono guide camera, a Sky-Watcher AZ EQ5 pro mount with a ZWO ASI294MC Pro One Shot colour CMOS cooled to –20 °C and a ZWO EAF with Askar focus kit. The image was stacked and processed with PixInsight for a total integration of 15 hours and 22 minutes.

Journal

Basudeb Chakrabarti imaged NGC 6729 remotely using Telescope Live from El Sauce Observatory in Rio Hurtado Valley, Chile; the stunning reflection nebula is found in Corona Australis. Also within the image are NGC 6726, NGC 6727, and IC 4812, which, Basudeb says, "show a striking complex of reflection nebulae that produce the characteristic blue colour, as light from the region's young hot stars is reflected by the cosmic dust. Bernes 157 (on the left bottom corner) is a dark nebula so dense that stars inside the nebula and behind it cannot shine through." The equipment used included a PlaneWave CDK24, with a Mathis MI-1000 mount, and a Proline FLI PL 9000 camera with Astrodon Luminance, Red, Green, Blue filters for a total integration time of 14 hrs and 10 min. Post–processing was done in PixInsight and Photoshop.