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A jet-like structure
has disappeared

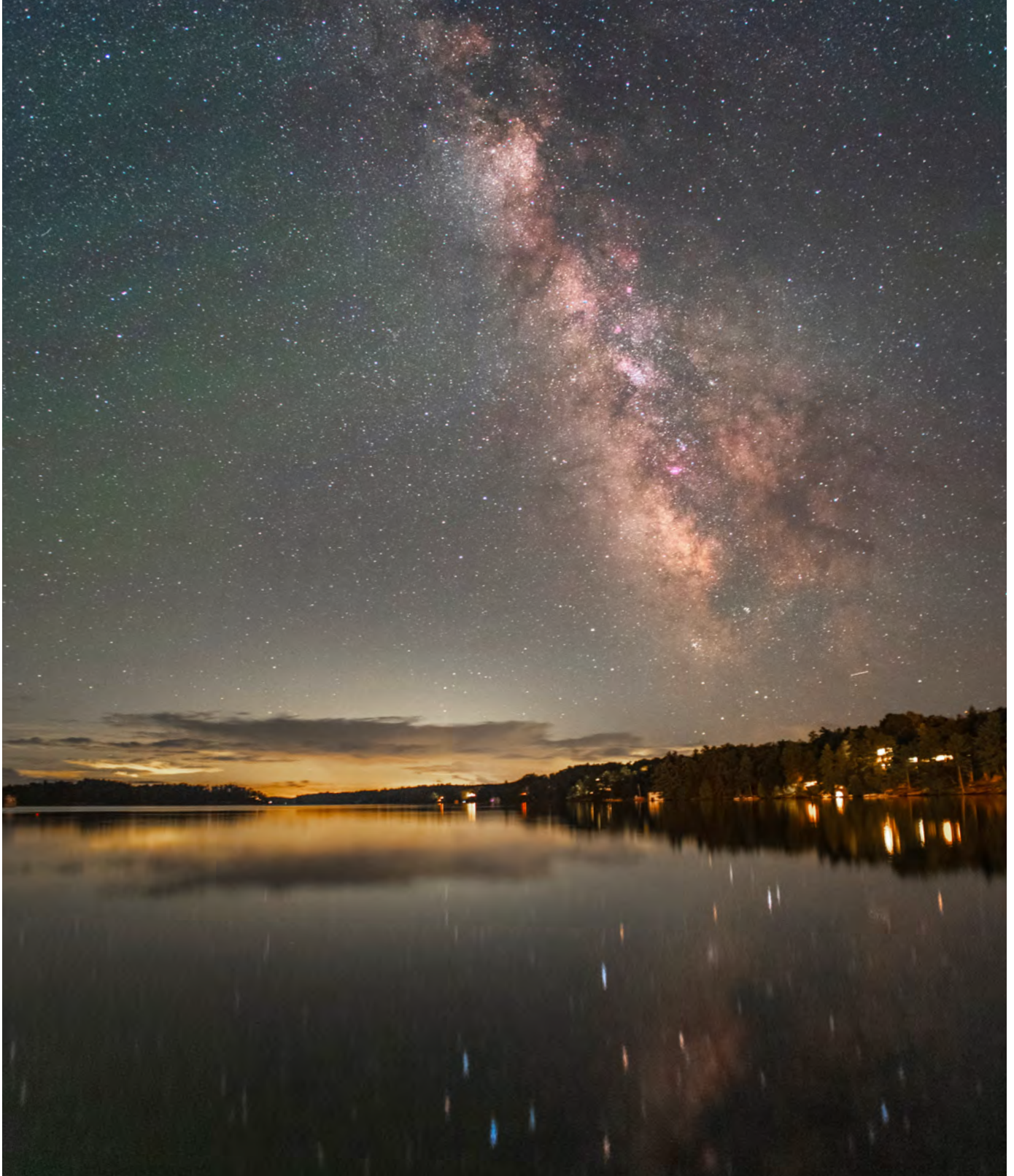
Totality

The ALIVE Model

Our Star

Great Images

By Andrea Girones



Demonstrating Andrea's versatility, she captured this image of the Milky Way on a dark, Moonless night near the Rocky Crest resort in Muskoka. A single exposure of 13 seconds, using an astromodified DSLR camera and a 20-mm lens at $f/1.8$, was enough to capture the core of the Milky Way both in the sky and as reflected in the still water.

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This incredibly detailed image of our star was taken by Andrea Girones from Ottawa, Ontario. She used a Quark chromosphere solar filter, and a Starfield optics 102 reflector.



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

A Journey in Astronomy and in the RASC



by Michael Watson, President
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Saturday, 1961 July 26, was a sunny day at our family's quite primitive half-century-old cottage on Peninsula Lake in Ontario's Muskoka region. I wouldn't turn nine years old for another month and a half. Although I went to bed in the early evening after a day of swimming and other things that kids do—or used to do—outside, my father told me that he would wake me before midnight to see something special—an eclipse of the Moon. He was a schoolteacher who taught grammar and science. Four years earlier, on Thanksgiving weekend in October 1957, he had taken the family out under the dark night sky at the cottage to watch *Sputnik 1* pass overhead. Although I was only five at the time, I remembered that special night on this July evening in 1961.

Some time after 10 p.m. (it would be another decade before I permanently switched to the 24-hour clock in my mind), my father awakened a sleepy, grouchy, pajama-clad eight-year-old and took my mother and me down to the dock. There, 10 degrees up in the southeastern sky, hung an orange-tinted partially eclipsed Moon in a slightly hazy but otherwise clear sky. I watched, quite spellbound, over the next hour as the Moon progressively advanced further into Earth's shadow until only a small sliver was visible at maximum eclipse just after 11:00 p.m. This was a 98.6% partial eclipse.

What amazed me, apart from the magic and stateliness of what I had just witnessed, was that *my father had predicted this would happen!*

Two summers later came my next astronomical rendezvous. I was at summer camp north of Huntsville for two weeks in July 1963. Some members of the RASC will still remember the total solar eclipse of July 20 that year, the path of which closely paralleled the 1972 July 10 eclipse that passed over the Northwest Territories and south across the Gaspé Peninsula and then into New Brunswick and across Nova Scotia nine years later.

By that time I had learned that my father wasn't in fact the only person on the planet who could predict when these eclipses would occur. He wanted me to see this eclipse, although it would be only 91% partial from

where I was at camp. Since he was a photographer and always had film available, he exposed a roll of black and white film to the Sun, had it developed, and packed several layers of the blackened film with my camp gear so that I could see the eclipse. This was long before people were aware that exposed and developed film, or carbon-smoked glass, were very unsafe ways to look at the Sun, eclipsed or not.

When eclipse Saturday came, the camp director kept all of the kids inside so that they wouldn't go blind or die. All except one, that is. The director, his wife, and the camp counsellors wanted to see the eclipse, but I was the only one with any means of seeing it, and I let them know. So one ten-year-old camper was allowed outside, surrounded by a group of grateful camp management and counsellors, who passed around my film filter to watch the eclipse—after I had looked first. As far as I know, none of us went blind.

These astronomical events engendered in this pre-teenager an intense interest in the U.S. and Russian space programs over the ensuing years. The culmination came on the evening of Sunday, 1969 July 20, when astronauts Neil Armstrong and Edwin Aldrin (called “Buzzer,” then just “Buzz,” by one of his sisters; to which he changed his name officially in 1988) stepped out onto the Moon's surface and into history just before 23:00 Ontario time. That summer I was working at a gas station in Huntsville, near our cottage, and got permission from the station owner to watch the moonwalk on a small, grainy black-and-white rabbit-eared television that they had mounted in the gas station's office. I so well remember watching Armstrong and Aldrin gingerly walking and jumping on the lunar surface, then going outside and looking up in wonderment at a fat waxing-crescent Moon low in the western sky. There were people walking around on it.

The next spring, I used a small amount of money that had come my way at the end of high school to order my first telescope; a Criterion 6-inch $f/8$ reflector. By that time I had been studying *Norton's Star Atlas* for months, learning star names, how constellation star patterns looked, and where the best-known deep-sky objects were located. Finally in June, the telescope arrived from Connecticut, and we took it up to the cottage. My father and I set it up during the day. Heart pounding, I took it outside that night under a dark Muskoka sky for “first light.” I looked up to aim the scope, and then ... utterly panicked. *I didn't recognize anything.* It took me a minute to understand why. There were no lines of right ascension and declination and no labels on the sky to

guide me! That was my first and most important lesson in how star atlases—as invaluable as they are both at the desk and in the field—don't exactly replicate what we behold with our eyes when we look up. Nonetheless I found Vega directly overhead. It was the first star I ever saw through my new friend, my telescope.

That spring I joined the RASC, and I've have been a member for the 53 and a bit years since then.

I learned the night sky using the old-fashioned star-hopping method, and even after I got my first computer-assisted telescope, for years I avoided using the GoTo object-finding function. Only in the last three or so years have I started—reluctantly—to use that very useful tool, but only so that I can quickly move from one astrophotographic target to another, and not waste the precious dark-sky minutes that at my age now seem to be far too few.

What followed in the decades after I joined the Society was a series of solar eclipse trips, including several eclipse expeditions that I organized or co-led, trips with my telescopes to Australia to view and photograph the southern sky, and participation in the governance of the Society as a National Council Representative, Chair of the Constitution Committee for many years, and then as Society Treasurer, Second Vice-President, and legal counsel.

I hit the pause button in my involvement in Society governance for a couple of decades when Helen's and my children arrived in the early '90s. These were some of the best years of my life, for sure. Then when a position opened up on the Board of Directors in 2017, my dear friend Randy Attwood, whom I had met at the end of the 1970s and who was then Executive Director of the Society, asked whether I would be interested in filling the vacant position. Two seconds later I said yes. Since that time I have renewed old friendships in the RASC, met new members, and moved up from director to Second and then First Vice-President, and now finally to President and still legal counsel.

But with all of that, I am still in my heart first and always an observational astronomer, and to me the RASC is most importantly an astronomy club of naturalists with an intense love of the cosmos. My best times are out at new Moon in Algonquin Park with my telescopes, my binoculars, and my eyes. I am there with my old and so intimate friend, the night sky. ✨

News Notes / En manchette

Compiled by Jay Anderson

Here's looking at *Euclid*

On the last day of July, the European Space Agency's *Euclid* space telescope sent its first images back to Earth. The initial photos, in both visible and infrared wavelengths and covering more than half a square degree, showed a sky replete with pinpoint stars, a few misty galaxies, and sparkling open clusters.

Euclid contains a 1.2-metre telescope—half the size of the *Hubble Space Telescope*—with two instruments that can photograph the Universe in visible and near-infrared light and collect spectra of objects within the field of view. Unlike Hubble and the *James Webb Space Telescope*, which are designed with narrow fields for close-up, high-resolution work, *Euclid*'s 0.57 square degree field—nearly twice the diameter of the Moon, gives a wide-angle view that can encapsulate thousands of distant galaxies at a time.

The huge expanse of sky will allow *Euclid*'s two instruments—its Visible Imager (VIS) and its Near-Infrared Spectrometer and Photometer (NISF)—to probe 1.5 billion distant galaxies

to learn more about dark matter and dark energy. According to current hypotheses, these two mysterious components make up 26.8 percent and 68.3 percent of the Universe, respectively, but astronomers do not know what they are; we only know these dark elements are there because of invisible dark matter's gravitational effect and the way dark energy is accelerating the expansion of the Universe.

Euclid will look at how galaxies cluster by conducting a survey that catalogues galaxy redshifts to create a three-dimensional map of galaxies stretching across 10 billion light-years. Galaxy clustering is related to fluctuations in the density of matter in the early Universe, and by comparing those fluctuations with the size of clusters at later epochs, can tell us how the strength of dark energy has changed over time because its repulsive force works against the gravity that causes galaxies to cluster.

Euclid will disentangle the structure of the dark Universe by looking at the shapes of galaxies. The gravity from dark matter spread across the Universe can create gravitational lenses that bend light. We see this in dramatic fashion in the strong gravitational lenses of galaxy clusters, but dark matter can also cause “weak lensing” that subtly distorts the shapes of galaxies by altering the geometry of space and the path that light takes to reach us. *Euclid* will image 1.5 billion galaxies and look for those shape distortions to allow astronomers to map dark matter in the Universe.

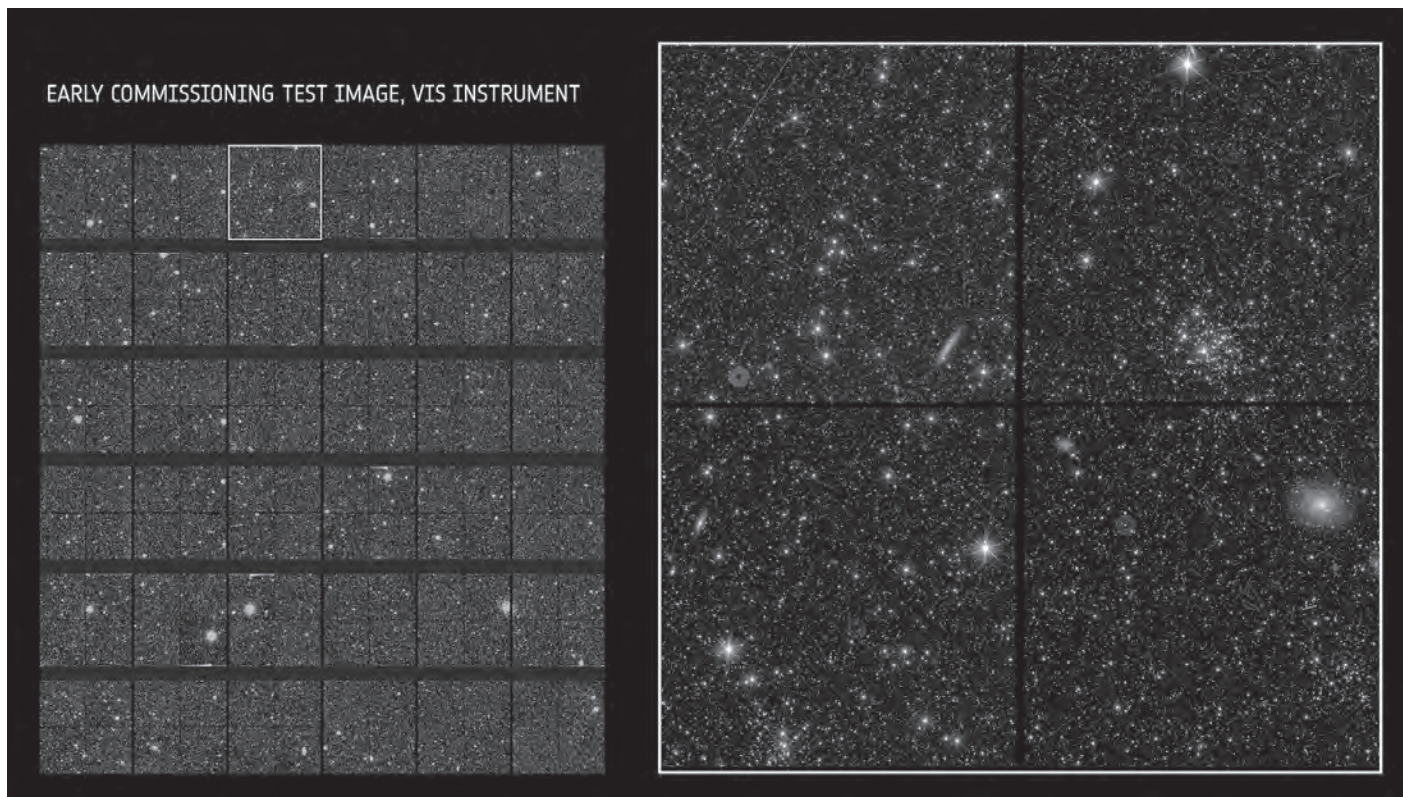


Figure 1 — This image was taken during commissioning of *Euclid* to check that the focused VIS instrument worked as expected. Because it is largely unprocessed, some unwanted artefacts remain, particularly cosmic rays that form straight lines across the scene. Image: ESA/*Euclid*/*Euclid* Consortium/NASA

Although there are months to go before *Euclid* delivers its true new view of the cosmos, reaching this milestone means the scientists and engineers behind the mission are confident that the telescope and instruments are working well.

“After more than 11 years of designing and developing *Euclid*, it’s exhilarating and enormously emotional to see these first images,” says project manager Giuseppe Racca. “It’s even more incredible when we think that we see just a few galaxies here, produced with minimum system tuning. The fully calibrated *Euclid* will ultimately observe *billions* of galaxies to create the biggest ever 3-D map of the sky.”

Reiko Nakajima, VIS instrument scientist adds: “Ground-based tests do not give you images of galaxies or stellar clusters, but here they all are in this one field. It is beautiful to look at, and a joy to do so with the people we’ve worked together with for so long.”

Euclid’s NISP instrument has a double role: imaging galaxies in infrared light and measuring the amount of light that galaxies emit at various wavelengths. This second role lets *Euclid* researchers directly work out the distance of each galaxy. By combining distance information with that on galaxy shapes measured by VIS, scientists will be able to map how galaxies are distributed throughout the Universe, and how this distribution changes over time. Ultimately, this 3-D map will teach us about dark matter and dark energy.

NISP instrument scientist Knud Jahnke says: “We’ve seen simulated images, we’ve seen laboratory test images—it’s still hard for me to grasp these images are now the real Universe. So detailed, just amazing.”

NISP instrument scientist William Gillard adds: “Each new image we uncover leaves me utterly amazed. And I admit that I enjoy listening to the expressions of awe from others in the room when they look at these data.”

It is worth noting once more that these snapshots—beautiful though they are—are still early test images, taken to check the instruments and review how the spacecraft can be further tweaked and refined. Because they are largely unprocessed, some unwanted artefacts remain—for example the cosmic rays that shoot straight across, seen especially in the VIS image. The *Euclid* Consortium will ultimately turn the longer-exposed survey observations into science-ready images that are artefact-free, more detailed, and razor sharp.

Over the next few months, ESA and industry colleagues will continue to carry out all the tests and checks needed to ensure that *Euclid* is working as well as possible. At the end of this “commissioning and performance verification phase,” the real science begins. At that point ESA will release a new set of images to demonstrate the telescope’s capabilities.

Compiled with material provided by ESA.

Next-door early-Universe stars

Observations of a star-forming region on the outskirts of the Milky Way Galaxy, where conditions from the early Universe are still preserved, found that the distribution of stellar masses is not radically different from what is observed near the Solar System. This is an important step toward understanding the effect of the local environment on the mass distribution of stars.

Most stars form in clusters with other stars of various masses, forming a distribution known as the initial mass function (IMF). Studies of the IMF have an important bearing on the formation and evolution of galaxies. While the IMF for all the clusters near the Sun have a similar character, astronomers couldn’t be sure if this was true over a wider area, or due to local conditions.

To answer this question, a research team led by Chikako Yasui, an Assistant Professor at the National Astronomical Observatory of Japan, used the Subaru Telescope to observe Sh 2–209 (hereafter referred to as S209), an HII star-forming region in the outer part of our Milky Way Galaxy. Compared to the chemical composition of interstellar gas in the solar neighborhood, S209 is closer to pure hydrogen, containing smaller amounts of heavier elements. This makes it a good analogue for the prevailing conditions in the Universe 10 billion years ago when stars were also devoid of heavy elements.



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Figure 2 — “Sh 2-209” is a rare and large-scale star-forming region in the outer region of the Milky Way. The image was obtained by using the MOIRCS instrument on the Subaru Telescope. The blue, green, and red colours correspond to the J-band (1.26 micron), H-band (1.64 micron), and Ks-band (2.15 micron), respectively. Image: National Astronomical Observatory of Japan.

The team identified two clusters in S209, one large and one small, and found that the larger cluster is composed of as many as 1500 member stars. This is the first time that such a large-scale star-forming cluster has been identified in the outer part of the Galaxy. Thanks to the Subaru Telescope’s high sensitivity and high spatial resolution, the team succeeded in detecting stars ranging from about one-tenth the mass of the Sun to 20 times the mass of the Sun. The results show that S209 has only a slightly higher fraction of massive stars compared to star-forming regions in the solar neighborhood, and it also has a higher fraction of stars less-massive than the Sun.

“The outer parts of the Milky Way are known to have properties similar to those of the early Universe.” Explains Yasui, “Our results suggest that although a relatively large number of massive stars formed in the early Universe, the number is not dramatically different from that of typical star clusters in the present day.” Because S209 is a star-forming cluster with a larger number of members (~1500) than the number (~100) in regions previously studied in such environments, it is possible for the first time to derive the IMF in a low-metallicity (~early Universe) environment with high accuracy over the wide mass range of $0.1\text{--}20 M_{\odot}$.

Compiled in part with material provided by Subaru Telescope.

AI again — this time for PHAs

An asteroid discovery algorithm—designed to uncover near-Earth asteroids for the Vera C. Rubin Observatory’s upcoming 10-year survey of the night sky—has identified its first “potentially hazardous” asteroid. Designated 2022 SF289, the new object was discovered during a test drive of the algorithm with the ATLAS survey in Hawaii. Finding 2022 SF289, which poses no risk to Earth for the foreseeable future, confirms that the next-generation algorithm, known as HelioLinc3D, will be able to identify near-Earth asteroids with fewer and more dispersed observations than required by current methods.

“By demonstrating the real-world effectiveness of the software that Rubin will use to look for thousands of yet-unknown potentially hazardous asteroids, the discovery of 2022 SF289 makes us all safer,” said Rubin scientist Ari Heinze, the principal developer of HelioLinc3D and a researcher at the University of Washington.

The Solar System is home to tens of millions of rocky bodies ranging from small asteroids not larger than a few metres, to dwarf planets the size of our Moon. These objects remain from an era over four billion years ago, when the planets in our system formed and took their present-day orbits.

From its peak in the Chilean Andes, the Vera C. Rubin Observatory is set to join the hunt for these objects in early 2025. Rubin's observations will dramatically increase the discovery rate of potentially hazardous asteroids (PHAs), scanning the sky unprecedentedly quickly with its 8.4-metre mirror and massive 3,200-megapixel camera, visiting spots on the sky twice per night rather than the four times needed by present telescopes. But with this novel observing "cadence," researchers need a new type of discovery algorithm to reliably spot space rocks.

Working with Smithsonian senior astrophysicist and Harvard University lecturer Matthew Holman, who in 2018 pioneered a new class of heliocentric asteroid search algorithms, Heinze and Siegfried Eggl, a former University of Washington researcher who is now an assistant professor at the University of Illinois at Urbana-Champaign, developed Heliolinc3D: a code that could find asteroids in Rubin's dataset. With Rubin still under construction, Heinze and Eggl wanted to test Heliolinc3D to see if it could discover a new asteroid in existing data, one with too few observations to be discovered by today's conventional algorithms.

John Tonry and Larry Denneau, lead ATLAS astronomers, offered their data for a test. The Rubin team set Heliolinc3D to search through this data and on July 18, it spotted its first PHA: 2022 SF289, initially imaged by ATLAS on 2022 September 19, at a distance of 21 million kilometres from Earth.

Most asteroids are distant objects, but a number pass close to the Earth, and are known as near-Earth objects, or NEOs. The closest of these—those with a trajectory that takes them within about 8 million kilometres of Earth's orbit, or about 20 times the distance from Earth to the moon—warrant special attention. Such PHAs are systematically searched for and monitored to ensure they won't collide with Earth, a potentially devastating event.

Scientists search for PHAs using specialized telescope systems like the NASA-funded ATLAS survey, run by a team at the University of Hawaii's Institute for Astronomy. They do so by taking images of parts of the sky at least four times every night. A discovery is made when they notice a point of light moving unambiguously in a straight line over the image series. Scientists have discovered about 2350 PHAs using this method, but estimate that at least as many more await discovery. ATLAS had observed 2022 SF289 three times on four separate nights, but never the requisite four times on one night to be identified as a new NEO.

"Any survey will have difficulty discovering objects like 2022 SF289 that are near its sensitivity limit, but Heliolinc3D shows that it is possible to recover these faint objects as long as they are visible over several nights," said Denneau. "This in effect gives us a 'bigger, better' telescope."

2022 SF289 is classified as an Apollo-type NEO. Its closest approach brings it within 225,000 km of Earth's orbit, closer than the Moon. Its diameter of 180 m is large enough to be classified as "potentially hazardous." Despite this, projections indicate that it poses no danger of hitting Earth for the foreseeable future.

"This is just a small taste of what to expect with the Rubin Observatory in less than two years, when Heliolinc3D will be discovering an object like this every night," said Rubin scientist Mario Jurić, director of the DiRAC Institute, professor of astronomy at the University of Washington and leader of the team behind Heliolinc3D. "But more broadly, it's a preview of the coming era of data-intensive astronomy. From Heliolinc3D to AI-assisted codes, the next decade of discovery will be a story of advancement in algorithms as much as in new, large, telescopes."

Compiled with material provided by the University of Washington.

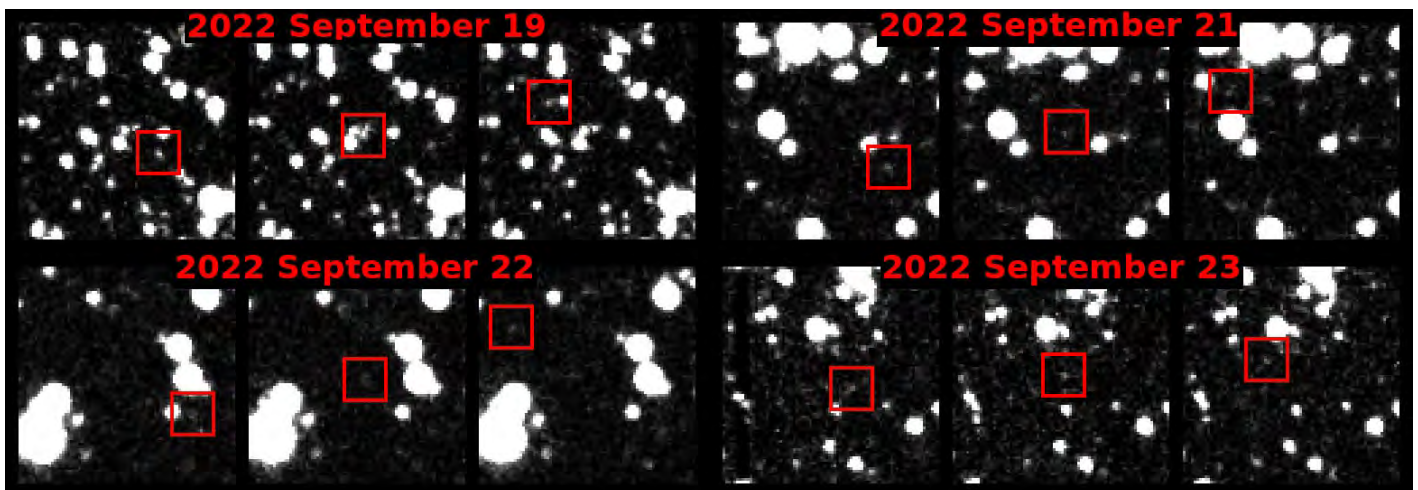


Figure 3 — Discovery images from the ATLAS survey, with 2022 SF289 visible in the red boxes. (Image: ATLAS / University of Hawaii Institute for Astronomy / NASA).

Coming soon to a Universe near you

The European Southern Observatory's Extremely Large Telescope (ESO's ELT) is a revolutionary ground-based telescope with a 39-metre main mirror and 4.2-metre secondary that will be the largest telescope in the world for visible and infrared light. Construction of this technically complex project is advancing at a good pace, with the ELT now surpassing the 50% complete milestone.

The telescope is located atop Cerro Armazones in Chile's Atacama Desert, where engineers and construction workers are currently assembling the structure of the telescope dome at a staggering pace. Visibly changing each day, the steel structure will soon acquire the familiar round shape typical of telescope domes.

The telescope mirrors and other components are being built by companies in Europe, where work is also progressing well. ESO's ELT will have a pioneering five-mirror optical design, which includes a giant main mirror (M1) made up of 798 hexagonal segments. More than 70% of the blanks and supports for these segments have now been manufactured, while M2 and M3 are cast and in the process of being polished. Progress on M4, an adaptive, flexible mirror that will adjust its shape a thousand times a second to correct for distortions caused by air turbulence, is particularly impressive: all six of its thin petals are fully finalized and being integrated into their structural unit. Further, all six laser sources, another key component of the ELT's adaptive optics system, have been produced and delivered to ESO for testing.

All other systems needed to complete the ELT, including the control system and the equipment needed to assemble and commission the telescope, are also progressing well in their development or production. Moreover, all four of the first scientific instruments the ELT will be equipped with are in their final design phase with some about to start manufacturing. In addition, most of the support infrastructure for the ELT is now in place at or near Cerro Armazones. For example, the technical building that, among other things, will be used for storage and coating of different ELT mirrors is fully erected and fitted out, while a photovoltaic plant that supplies renewable energy to the ELT site started operating last year.

Construction of ESO's ELT was kick-started nine years ago with a ground-breaking ceremony. The top of Cerro Armazones was flattened in 2014 to allow for space for the giant telescope. Completing the remaining 50% of the project, however, is anticipated to be significantly quicker than building the

first half of the ELT. The first half of the project included the lengthy and meticulous process of finalizing the design of the vast majority of components to be manufactured for the ELT. In addition, some of the elements, such as mirror segments and their supporting components and sensors, required detailed prototyping and significant testing before being produced *en masse*. Furthermore, construction was affected by the COVID-19 pandemic, with the site closing for several months and production of many of the telescope components suffering delays. With production processes now fully resumed and streamlined, finalizing the remaining half of the ELT is anticipated to take only five years. Nonetheless, building such a large and complex telescope like the ELT is not free of risks until it's finished and working.

ESO Director General Xavier Barcons says: "The ELT is the largest of the next generation of ground-based optical and near-infrared telescopes and the one that is most advanced in its construction. Reaching 50% completion is no small feat, given the challenges inherent to large, complex projects, and it was only possible thanks to the commitment of everyone at ESO, the continued support of the ESO Member States, and the engagement of our partners in industry and instrument consortia. I am extremely proud that the ELT has reached this milestone."

Planned to start scientific observations in 2028, ESO's ELT will tackle astronomical questions such as: Are we alone in the Universe? Are the laws of physics universal? How did the first stars and galaxies form? ELT will dramatically change what we know about our Universe and will make us rethink our place in the cosmos. ★

Compiled with material provided by ESO.

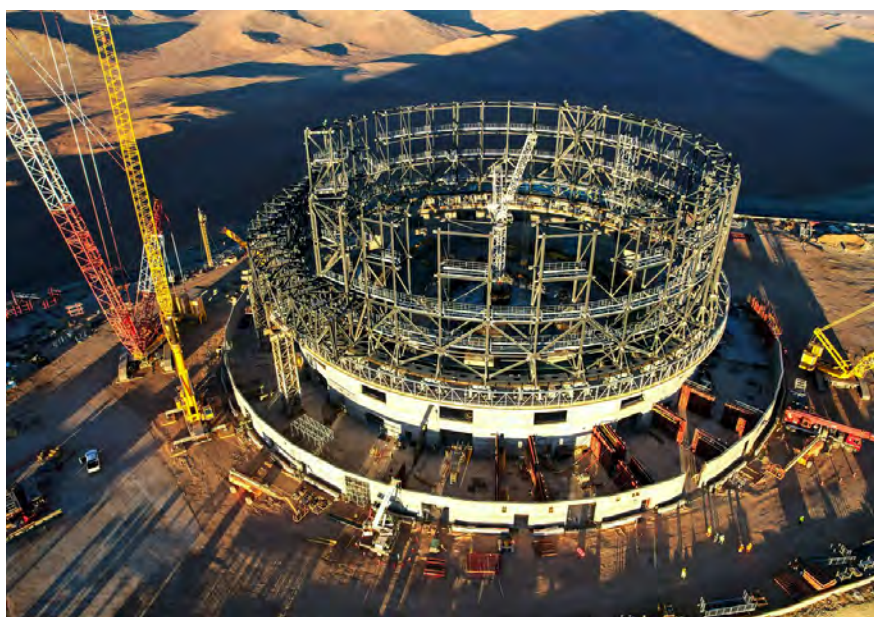


Figure 4 — Drone shot of the ELT under construction at Cerro Armazones.

Research Article / Article de recherche

In Hubble's Nebula (NGC 2261), a jet-like structure to the south has disappeared from images since 2015

by Gilbert St-Onge¹ gilberts311@gmail.com, Denis Bergeron², Denis St-Gelais³, Jean Guy Moreau⁴, Réal Gauvin⁵, Jean-Bruno Desrosiers⁶, Christian Dupriez⁷, Robert Cazilhac⁸, Alain Amsaleg⁹, Mark Hanson¹⁰, Denis Goyette¹¹, Jérôme Astreoud¹², Russell Fralich¹³, Valère Perroud¹⁴

Abstract

Most of the time observers stick to the variable aspects of the main nebula NGC 2261 to the north side of R Monoceros “Herbig Ae/Be star” (Finkenzeller & Mundt 1984), the counterpart nebula to the south which is much lower in intensity is almost never detected. This follow-up work of the nebula NGC 2261, consists in observing especially the southern region where, before ~2015, a nebula in the form of a jet was observed.

Our more intense observations since 2019, have made it possible to detect some dark traces on the southern counterpart that seem to be at the location of this jet-like structure and correspond to the morphology of it. This spring 2023 summary presents our latest observations which tend to indicate that this jet-like structure is still absent from the nebula NGC 2261 south of the star R Monoceros, RA 06h 39m 09.95s and Dec 8° 44' 09.7" (DSS).

An interesting development observed in our 2023 work is that we were able to detect significant changes in the morphology of the southern counterpart of the nebula NGC 2261 which are very close to the position where, prior to ~2015, we detected the jet-like structure!

Résumé

Généralement les observateurs s'en tiennent aux aspects variables de la nébuleuse principale au nord de l'étoile R Monoceros “Herbig Ae/Be star” (Finkenzeller & Mundt 1984), la contre-parti au sud qui est de beaucoup plus faible intensité est plus rarement détectée. Ce travail consiste à observer la nébuleuse NGC 2261, à observer particulièrement la région sud où s'observait avant ~2015 une nébuleuse longiforme d'apparence d'un jet. Nos observations plus intenses depuis 2019, ont permis de

détecter certaines traces plus sombres sur la contrepartie sud qui semblent bien à l'emplacement de cette structure en jet lumineuse d'avant 2015 et d'une morphologie correspondant à celle-ci. Ce résumé présente nos dernières observations qui tendent à indiquer que cette structure en jet est toujours absente de la nébuleuse NGC 2261 au sud de l'étoile R Monoceros, RA 06h 39m 09.95s and Dec 8° 44' 09.7" (DSS).

Par contre en cette année (2023), on a pu détecter des changements significatifs dans la morphologie de la contrepartie sud de la nébuleuse NGC 2261 qui sont tout près de la position où on détectait avant 2015 la structure en jet lumineuse!

Summary (2019 to 2023)

Since 2019, we have been monitoring the NGC 2261 nebula more closely. Our work has determined that a section south of the main nebula, associated with the young star R Monoceros (Unicorn R), has disappeared since ~2015. Our follow-up of this nebula aims to try to redetect this source and document its apparent evolution if possible. This dossier also focuses on our work which tries to determine if it is possible to detect remnants of this structure on the sky where, before 2015, we observed this elongated structure (in the form of a jet) of variable luminous intensity, which is in the southern component of nebula NGC 2261.

Three documents summarize our previous work, produced in 2020, 2021, and 2022, are available at:

2020

[Astrourf.com/cdadfs/CDADFS2/recherches/N2261_2020_V243.pdf](https://astrourf.com/cdadfs/CDADFS2/recherches/N2261_2020_V243.pdf)

2021

[Astrourf.com/cdadfs/CDADFS2/recherches/NGC2261_2021.pdf](https://astrourf.com/cdadfs/CDADFS2/recherches/NGC2261_2021.pdf)

2022

G ST-Onge et al, “In Hubble's Variable Nebula (NGC 2261), a jet structure to the south has disappeared from our images since 2015,” *Journal of The Royal Astronomical Society of Canada, August 2022, Vol. 116, No. 4, Whole Number 815*

Introduction

Summary of the detection of this jet-like structure south of NGC 2261:

Before modern sensors, it took very careful observing to detect this jet-like structure in the southern section

of the NGC 2261 nebula. One of the old silver images, which shows very well this jet-like structure of the counterpart, was made at the Australian Astronomical Observatory. This image is available on taoastronomer.com/postprocessgreinerRosetteandConenebulaeinfo.htm at the bottom of the page.

The oldest CCD images by our group that highlight this structure are images from the years 2000, 2009, 2011, and 2012.

Figure 2023-1 – summary:

A montage of images by J. G. Moreau presenting, NGC 2261 of 2009 and 2019. In the one on the left (2009), an arrow shows the position of the jet-like structure south of the star R Monoceros. It is obvious that this structure is missing in the 2019 image (right).

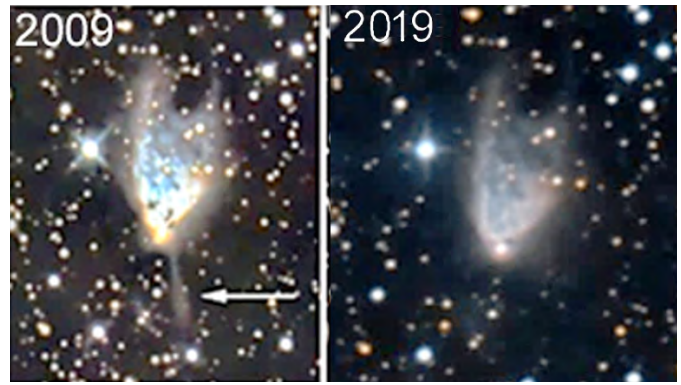


Figure 1 – NGC 2261 de 2009 / 2019 (J. G. Moreau)

It is these images that justified this close follow-up, to try to determine when this filiform (jet-like) structure disappeared from the images (see Table 2023-1), then we also hope to observe its reappearance.

Periods	Authors	Instruments	Status of the Jet-like structure / south
2021 10 06	Réal Gauvin	10" RC at 2032mm	No trace (negative)
2021 11 (10 & 11)	Réal Gauvin	10" RC at $f/8$	No trace (negative)
2021 12 05	Réal Gauvin	10" RC at $f/8$	No trace (negative)
2021 12 09	Robert Cazilhac	Meade12" $f/D10$	No trace (negative)
2022 01 27	J. Guy Moreau	14" $f/3.3$ with Kellner corrector/reducer	No trace (negative)
2022 02 16	Denis Bergeron	Telescope Planewave CDK 30cm $f/8$ FL: 2555mm	No trace (negative)
2022 03 08	J. Guy Moreau	Redcat	No trace (negative)
2022 03 22	Réal Gauvin	RC10" telescope at $f/8$ and a QHY268M	No trace (negative)
2022 04 04	J. Bruno Desrosiers	C14- STF-8300M at Bin2, no filter,	No trace (negative)
2022 09 30	Réal Gauvin	10" Ritchey Chrétien at $f/8$ / QHY268M bin2	No trace (negative)
2022 09 30	Denis Goyette	RC 10" at 1524 mm $f/6$ / ZWO 2600MC Pro / at Bin 3, for 45 min., 9×300 sec.	No trace (negative)
2022 10 27	G. St-Onge	C 8" @ $f/10$, SBIG ST7 unbinned.	No trace (negative)
2022 11 05	J. Bruno Desrosiers	A spectrogram and photometry of the star R	No trace (negative)
2022 11 26	G. St-Onge	C 8" @ $f/10$, SBIG ST10 at bin 2	No trace (negative)
2022 11 27	J. Guy Moreau	Newtonian 14" at $f/3.4$ and 1210mm	No trace (negative)
2023 02 21	Jérôme Astreoud	T520 mm and F2444mm,	No trace (negative)
2023 02 28	Russell Fralich	ED80 (37×60s) / C6 (17×30s)	No trace (negative)
2023 03 15	Réal Gauvin	10"Ritchey Chrétien à $f/8$ / QHY268M bin2	No trace (negative)
2023 04 11	J. Bruno Desrosiers	C14 CCD images of NGC 2261	No trace (negative)

Table 1 – Observations and Status of the Jet-like structure of 2021 / 2022 / 2023. Our observations for this period come from a dozen astrophotographers, some from Canada, others from Europe and the USA. Instruments of different optical configurations were used: Newtonian, Ritchey Chrétien, Schmidt Cassegrain, and a refractor.

Table 2

Presents the following period of the jet structure over ~39 years (1984 to 2023). Its morphology and intensity are discussed. Its luminous intensity is compared to the small curved nebula to SE which is our reference.

Detection period of the jet structure south of the star R Monoceros. (Refer to Graph 2023-1)

Period	Detectable	Undetectable	Comments
	Y (Yes)	N (No)	
1984 – 1992	Y++++		Thin and intense near the star and very wide and lighter away from the star. Anglo-Australian Observatory (Detection of small curved nebula at SE = YES)
1995	Y+++		Thin and intense near the star and very wide and lighter away from the star. Kitt Peak- 0.9 m (Detection of small curved nebula at SE = YES)
2000	Y+++		More intense than small nebula at SE (Detection of small curved nebula at SE = YES)
2001			
2002			
2003			
2004	Y-		Very precise and thin near the star, further it is diffused on the sky, rather well detectable. (Detection of small curved nebula at SE = YES)
2005			
2006	Y-		Diffused over the sky fairly well detectable (Detection of small curved nebula at SE = YES)
2007			
2008			
2009	Y+++		Intense, much more than the small SE nebula (Detection of small curved nebula at SE = YES)
2010	Y++		A little less intense than in 2009 but still more intense than the small nebula at SE (Detection of small curved nebula at SE = YES)
2011	Y++		A little more intense than 2010, not much more intense than the small nebula SE (Detection of small curved nebula at SE = YES)
2012	Y		Diffused close to the star, difficult to detect, but it is more intense further on the sky. (Detection of small curved nebula at SE = YES)
2013			
2014	Y-		Diffuse over the sky, less intense than the SE curved nebula, difficult to detect (Detection of small curved nebula at SE = YES)
2015 – 2023		N	Undetected (Detection of small curved nebula at SE = YES)

Table 2 – It can be assumed that the jet-like structure is a reflection nebula probably illuminated by the star R Monoceros. And, its rapid changes in appearance are caused by circumstellar (fairly dense) materials that circulate near the star R Monoceros, which cause shadows projected into the nebula. They can be detected on the observable walls of the nebula and its environment.

Table 2

This table is a compilation of the assessment of the intensity of the jet-like structure south of the star R Monoceros. Here we present the largest period of observations whose objective is to detect the morphology of the jet-like structure, covering from 1984 to 2023.

We also looked at some pictures on the internet to complete table 2023-2 that follows, these images were not made by our group. These allowed us to draw a better

profile of the events contributing to highlighting that the jet-like structure to the south disappeared around 2015. Some of these images also cover the period from 2015 to 2021, there is no significant trace of the jet-like structure during this period. These images are not reproduced in paper but they were viewed on the web and briefly commented on in Table 2023-2 above.

Here is a list of these additional images retained and examined, they were available on the internet at the time of producing the summary of 2020 observations.

Anglo-Australian Observatory / 1984 to 1992 Steve Lee #2293 (1984 February 2), #2723 (1990 December 16) et #2810 (1992 October 27) taosastronomer.com/postprocessgreinerRosetteandConenebulaeinfo.htm

Kitt Peak National Observatory's 0.9-metre telescope in March 1995 noirlab.edu/public/es/images/noao-n2261a/?nocache=true

NGC 2261 in 2004, San Esteban (Chile) - 2004 January 24 - 04:00 UTC www.astrosurf.com/antilhue/NGC2261.htm

NGC 2261 on 2006 November 15, by Rick Johnson (Posted 2016 February 19 - 02:47 p.m.) www.cloudynights.com/topic/528106-ngc-2261-hubbles-variable-nebula-ver2016/

NGC 2261 on 2015 November 7 astro.perroud-net.fr/NGC2261.htm

NGC 2261 on 2016 February 4 and 6 in Khlepcha observatory, Ukraine www.cloudynights.com/topic/528106-ngc-2261-hubbles-variable-nebula-ver2016/

NGC 2261 on 2017 December 25 viewfrom.earth/past-articles/item/62-hubble-s-variable-nebula

NGC 2261 on 2018 March 13 by Mark Hanson, from Animas, New Mexico, www.hansonastronomy.com/hubble-veri-able-nebula

NGC 2261 on 2019 March 9, (LCO facilities) Las Cumbres Observatory, 2-metre Haleakala observatory lco.global/images/space/

NGC 2261 on 2019 December 7, RC 10 (focale 2000 mm) on Losmandy G11. Caméra G2-4000. astro.perroud-net.fr/NGC2261.htm

NGC 2261 on 2020 January 2, from Bergisches Land, APO Esprit 120ED *f*/7, Alccd-QHY163m + QHY-FW, astro-kooperation.com/?attachment_id=2052

NGC 2261 on 2020 February 13, 14, 15, New Mexico at Rancho Hidalgo (Animas, New Mexico), Astro-Tech AT12RCT at *f*/8 2432mm. www.cloudynights.com/topic/694604-ngc-2261/

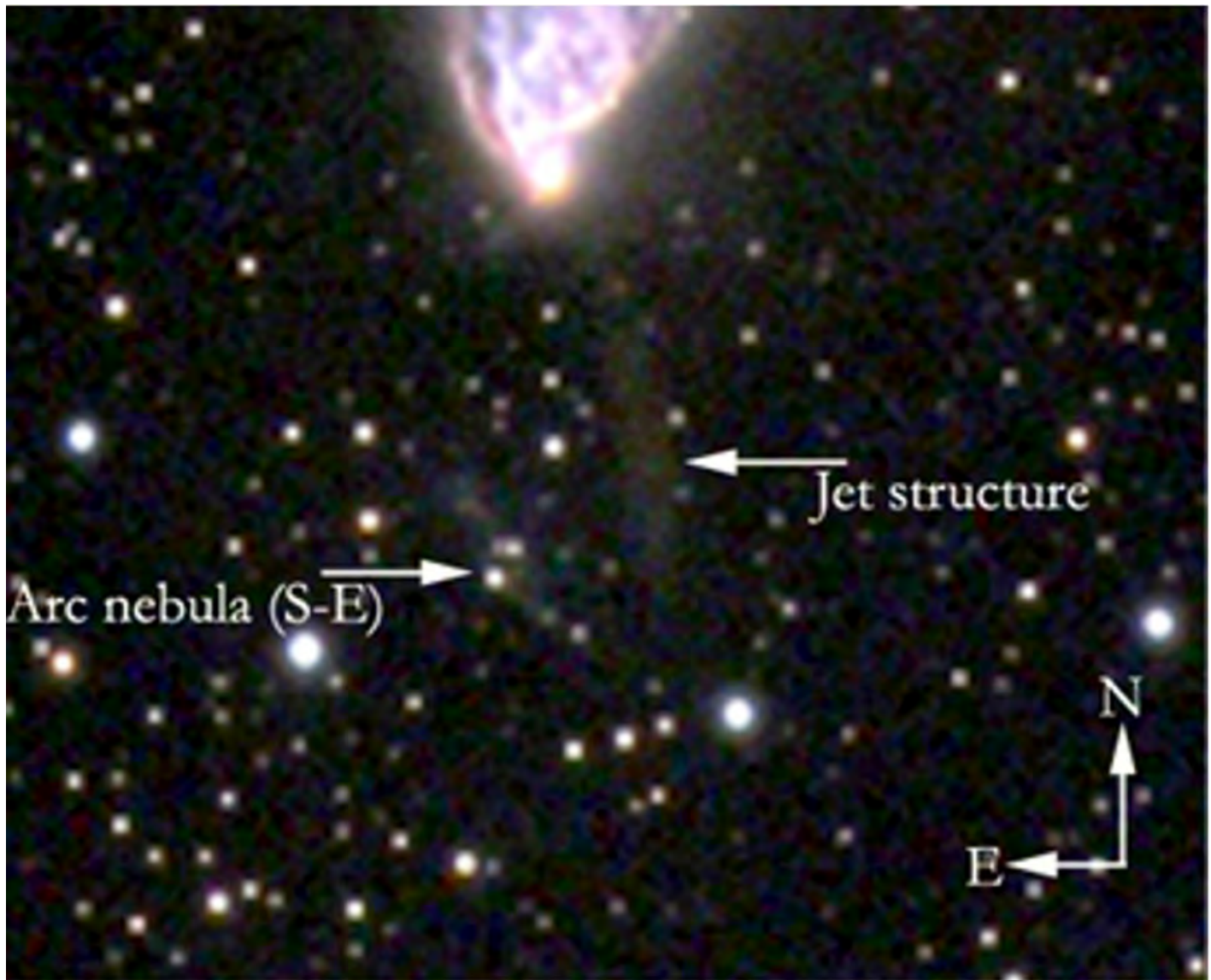
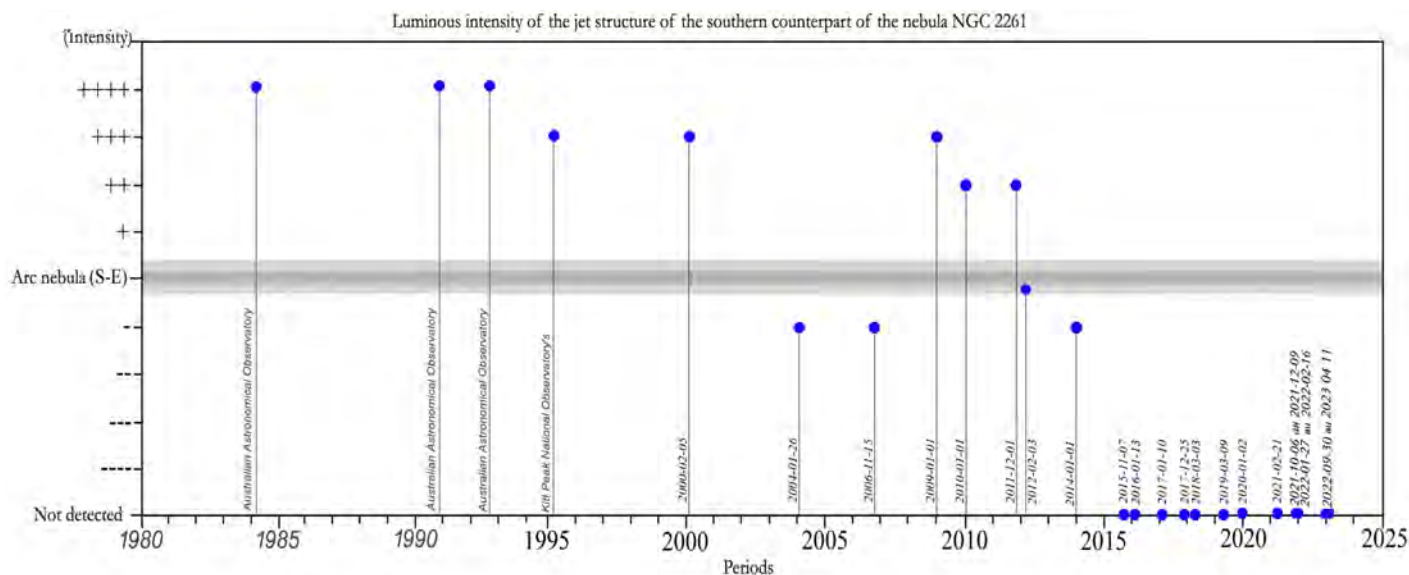


Figure 2a – NGC 2261, from Christian Dupriez 2014. The right arrow points to the jet-like structure that is studied in this paper. The left arrow points to the small arc nebula to the southeast of the jet-like structure. This serves as a reference for the intensity estimates of the jet structure. (See the following Graph 2023-1).



Graph 1

Description of Graph 1.

Referring to Table – 2, we produced the “Graph – 1,” which contains all the detection periods accessible to us of the jet-like structure over the past 40 years. Each measuring point indicates the intensity attributed to this jet-like structure in relation to the reference intensity of the small nebula of a curved shape just to the SE of its position on the images at the corresponding date.

The horizontal and central (darker) line corresponds to the reference point of the intensity. This is the intensity of the small, curved nebula to the SE. It is detected over all observation periods and can therefore be used as a reference to estimate the approximate intensity of the jet-like structure we are searching for. The points above this line are periods where the jet-like structure is more intense than the curved nebula to the SE; The measurement points below this central horizontal line indicate that the jet-like structure is less intense than the curved nebula to the SE; The dots on the axis line, labelled “Not detected,” are the periods when this structure is absent from the images, i.e. since November 2015.

Discussion regarding data from of Graph 1:

Around 1985 and for the early 1990s, the jet-like structure was at its greatest intensity, and very contrasting.

Around 1995, its intensity dropped one notch, to a level approaching that observed in the early 2000s.

At the beginning of 2000, we can see that this jet-like structure had a greater luminous intensity than the small SE curved nebula.

Around 2005, there were two periods when it became just a little less intense than this small SE nebula.

For the 2010 period, it was at a high intensity for 3 consecutive years (2009 to 2011).

In 2012, it tended to decrease in intensity until 2014 when it was less intense than the curve nebula (SE).

From the end of 2015, it becomes undetectable on the images of November 7, (astro.perroud-net.fr/NGC2261.htm) and (astro.perroud-net.fr), yet we have 10 observation periods from 2015 that end in spring 2023. See Figure 2023-2b, below.

Since 2019, very long exposures were made in luminance, RGB, and H α , without detecting any significant trace of the jet-like structure.

Graph 2023-1 confirms that this jet-like structure varies over time independently of the small curved nebula at SE.

It is a nebula of variable appearance, illuminated by the star R Monoceros. An explanatory model of observed variations is proposed in the 2020 paper at:

astrosurf.com/cdadfs/CDADFS2/recherches/N2261_2020_V243.pdf, Model 4.1b / page 9

Here is a CCD image that corresponds to the period of disappearance of the jet-like structure. This 2015 image confirms that, by the end of 2015, the jet-like structure was no longer detectable in standard imaging.

The December 2023 *Journal* deadline for submissions is 2023 October 1.

See the published schedule at rasc.ca/sites/default/files/jrascschedule2023.pdf



Figure 2b – Valère Perroud, of the Duines observatory, located in Marthod in Savoie, France, at 650 m altitude.

NGC 2261 of 2015 November 7.

RC 10" telescope (2000 mm focal length) on Losmandy G11. Camera G2-4000.

Poses ; Luminance (Binning 1x1) : 28 poses de 10 min, Rouge (Binning 2x2) : 10 poses de 5 min, Vert (Binning 2x2): 11 poses de 5 min, Bleu (Binning 2x2) : 12 poses de 5 min

It is available on the website, Astro Site de Valère , in its section "Deep Sky / Nebula," from where the link leads to the platform <http://astro.perroud-net.fr/NGC2261.htm>.



Figure 3 – Denis Goyette (2022 09 30)



Figure 4 – J G Moreau (2022 11 27)



Figure 5 – Jérôme Astreoud (2023 02 21)



Figure 6a/b – Réal Gauvin (2023 03 15)

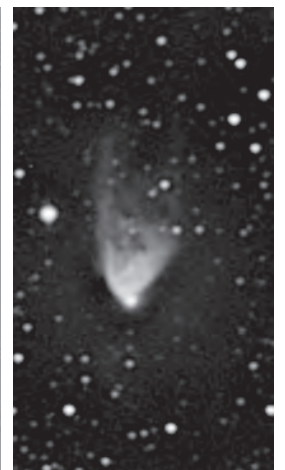


Figure 7 – JB Desrosiers (2023 04 11)

Description of the images of 2022 / 2023

On Figure 3 by Denis Goyette, a yellow oval indicates the section between the star R Monoceros at the top and the region where the jet-like structure should be detected on its right, inside the oval. We can also see the small curved nebula SE, in the lower central region a little to the left, it seems to have widened northward this year, it now has the appearance of a large C, whose opening faces west.

Figure 4 by J G Moreau, shows us very well the curved nebula in SE and the darker region where the jet-like structure should be observed among several nebulous areas of low intensity.

The Figure 5 by Jérôme Astreoud, a superb view of all the nebulousity of this southern region and of the reference nebula SE curve, we can also very easily see the darker elongate

structure where, before 2015, the luminous jet-like structure was observed.

Figure 6 by Réal Gauvin, on which we detect the curved SE reference nebula, but no trace of the jet-like structure. The image on the right has a nice resolution, you can see the irregular morphology of the main nebula in the north side.

Figure 7 by JB Desrosiers, it detects the curved SE reference nebula, but no trace of the jet-like structure. It also has the irregular morphology of the northern main nebula.

Conclusion

Historically, there does not appear to be much literature or documentation about this jet-like structure in the nebula south of NGC 2261. Our research made it possible to draw a slightly

more precise timeline regarding this jet-like structure. We now have several epochs that describe this region. So we can also describe a little better the disappearance of this structure on the timeline.

So, for the first time, we have a brief description of the 2015 event.

Table 2023-2 summarizes the chronology of the disappearance of the jet-like structure, it allows us to describe a little more the observable morphology of the jet-like structure for the period 2011 to 2015. Referring to the section (Comments), on the Table 2023-2, there is a small description of the morphology of the jet-like structure for each of the periods mentioned in this table.

It should be noted that, between 1984 and 2012, nothing seems to predict a disappearance of the jet-like structure. Our work allows us to highlight the subtle changes in morphologies (apparent) of the jet-like structure between 2011 and 2015, one can associate it with the mechanism responsible for the disappearance of this structure in 2015.

Timeline

For the 2011 period, nothing seems to predict a disappearance of this region, “2011 A little more intense than 2010, not much more intense than the small nebula SE.”

For the 2012 period, there is a change in morphology of the jet structure closer to the star. “2012 Diffuses near the star that is hard to detect, but it is more intense further north in the sky.”

For the period ending 2014, the jet-like structure became more diffuse over its entire surface, it even became less intense than the curved nebula at SE. “2014 Diffuse over the sky, less intense than the SE curved nebula, difficult to detect.”

For the period 2015 (November), this jet-like structure is no longer detected? “2015 Undetected”

For the period covered by this paper, 2022/2023 (beginning), we can conclude that this jet-like structure since 2015 has disappeared from our images.

But this year there have been few noticeable changes in the intensity and morphology of the SE curved nebula that has evolved northward, and it is now more like a large “C” with a western-facing opening.

Some of our images from 2023 (figures 2023-3, 4, and 5) confirm this new appearance of the curved nebula. In Figure 8, the curved nebula at SE was identified as well as the darker elongated region that is perhaps caused by the jet-like structure opacity in the background.

The Figures 2023-3, 4, and 5 also show us that the filiform (jet-like) structure still seems to leave detectable traces on the



Figure 8 – Image by Jérôme Astreoud (2023 02 21)

sky. We can see a darker structure than its surroundings where the illuminated jet-like structure was previously observed. It can be assumed that at this location, the new dark nebula can obstruct the nebulosity of the region and background stars by extinguishing and absorbing their light and darkening this area.

We know that this nebula is mainly a reflection nebula, so the light of the star R Monoceros reflects on both sides of the axis. And, that the main apparent variations in the morphology of the nebula are due to materials (circumstellar) that would be parent cloud material that served to form the star and its environment. These materials move very close to the star at angles that are conducive to causing shadows in the star’s light, these shadows move on the nebula NGC 2261, north and south. This jet-like structure would probably be temporarily hidden by materials at the star level that shade it. At this distance, the disappearance of this structure occurred much too quickly, so we must exclude the possibility that it is a jet of ionized matter at supersonic speed of type Herbig-Haro (HH).

We’ve detected some noticeable changes in the intensity and morphology of the SE curved nebula. So it may be possible that this jet structure will be re-detectable in the coming years. We hope to be able to document the chronology of this reappearance, and thus perhaps better understand the mechanisms that are at the origin of the apparent significant detectable changes in this jet-like nebula, that is associated with the nebula NGC 2261 south of the star R Monoceros. ★

Thank you Reviewer and translation—Gerald MacKenzie and Dominique, as well as Karim Jaffer (RASC Montréal Centre)

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https://simbad.u-strasbg.fr/simbad/sim-id?Ident=%40907222&&Name=V*%20R%20Mon&submit=submit

Sloan Digital Sky Survey (SDSS)
https://simbad.u-strasbg.fr/simbad/sim-id?Ident=%40907222&&Name=V*%20R%20Mon&submit=submitEt
Credit: SDSS/Giuseppe Donatiello, 2014 October 07.

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- 11 Denis Goyette, Observatoire POLARIS / 73° 23' 07" Ouest
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A Personal Reflection on Totality

by Clark Muir (Kitchener-Waterloo Centre)
cmuir10@rogers.com

Australian Eclipse Cruise April 2023

The ship P&O Cruise Australia “Explorer” left Fremantle, Western Australia, near the city of Perth, on the evening of 2023 April 17, for a five-night return departure to reach the path of totality for the April 20 hybrid solar eclipse.

My wife and I booked a stateroom directly through the Cruise line. However, tour operators including Sky & Telescope Tours were also on board. As a result, there were several speakers throughout the trip presenting various astronomical topics targeted to engage all passengers on board.

The ship was at full capacity with about 2,000 passengers. It is worth describing the composition of passengers to get a feel for the experience while on board the ship. One speaker shared with the attendees at his presentation that about 75 percent of passengers were Australian. The rest were international travelers. This seemed consistent with my experience when joining in casual conversations with other guests during the cruise. Included in this group were 12 Canadians who had arranged a post-eclipse dinner, meet-and-greet on the ship.

The eclipse also happened to coincide with a two-week autumn school break in Australia. This explained the considerable number of families with children, toddlers, and even babies onboard the ship. While interacting with numerous passengers during the cruise, I concluded that most of the foreign travellers were dedicated eclipse chasers, as were some Australians. Many other Australians were taking an opportunity to see their first eclipse with relative ease and comfort.

Observing Session on the Indian Ocean

The evening of April 18 on the Indian Ocean was clear with a fair bit of haze on the horizon. The *Sky & Telescope* tour operators had prearranged that certain areas of high decks would have their lights turned off to aid casual stargazing. There was even a small telescope set up to allow anyone on board to have a quick look at selected deep-sky objects. I took this opportunity to use my 10×42 binoculars and continue my southern sky observing from last week in the Australian Outback.

Once again, with binoculars in hand, I viewed the Milky Way area through the rich southern constellations of Crux, Centaurus, Carina, and Vela. I revisited several gems in the deep southern sky that I had described in an earlier report. This was in part an exercise to try to remember the orientation of a portion of the sky that I cannot view from home.

I turned my attention to the Large Magellanic Cloud (LMC). Even though the sky at the horizon was quite hazy it became

obvious that the outline of the LMC was visible, especially using averted vision. It was fascinating to see this star cloud through the thin haze. I could confirm this was the LMC with binoculars by observing the Tarantula Nebula within the large cloud. I do not know of any object in the northern sky that can reproduce this unusual effect. I recall that from a very dark, southern, and exceptionally clear sky, the LMC is a spectacular and bright object with the unaided eye.

Ending my short session, I had a brief look at the Southern Pleiades through the modest telescope placed on an aft deck of the ship. This cluster is not as conspicuous as its northern namesake but is attractive in any small instrument.

The Eclipse

The night before the eclipse there was strong confidence from experts on board the ship that the weather conditions would be near perfect. It was a huge relief not to have to second guess any travel plans. For my first and only other total solar eclipse experience in Nebraska in 2017, there was some anxiety about the weather prospects before the event. All ended well but it was a nerve-wracking concern.

The ship’s captain and eclipse planners had followed their “A” plan to position the ship in a bay off the coast of Exmouth, Western Australia. Exmouth is a remote town about 1,200 km north of Perth and is difficult to reach by land transportation. This location had the advantage of enjoying a full 60 seconds of totality, just 16 seconds less than the maximum for this hybrid eclipse, while also promising excellent eclipse observing conditions. On reaching the observing location, the ship was anchored, and the engines turned off. As a result, the decks proved very stable for anyone using tripods for either a small telescope or photography equipment. As we scouted for a location to observe the eclipse on the various decks, I was surprised by the number of telescopes, and cameras on tripods set throughout.

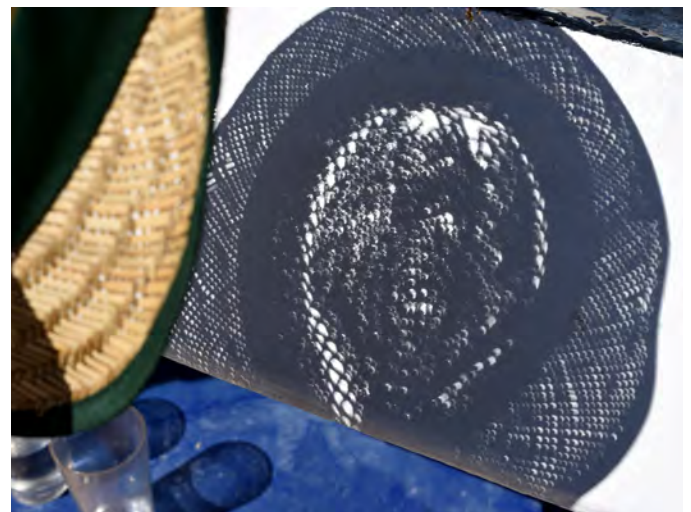


Figure 1 — A weathered straw hat displays beautifully the crescent-shaped Sun during the partial phase before totality. Photo Clark Muir.

We stationed ourselves on a high deck at the bow of the ship that was made accessible to passengers for the eclipse. The location offered a beautiful unobstructed view of the Sun and a vista of both ocean and land. It was very windy when we got there, and I believe this may have deterred people from staying there. As a result, there was a comfortable amount of room for all the groups of people that decided to view from that deck. My earlier concern for finding enough room to view the eclipse comfortably on board the ship was unfounded.

Though it was still only mid-morning, the air was hot and the Sun strong. I wore a jacket and hat that protected me from both the Sun and the wind. Fortunately, the winds diminished.

As the eclipse progressed, the sunlight started to take on the strange quality that eclipses are known for. It is a delight to both observe and feel all the changes to the light and atmosphere as totality approaches. These changes are slow and subtle at first, then it hits like a freight train.

The earlier noticeable changes allow for amusement, for both veteran eclipse chasers and first timers alike, regardless of age. The crescent shaped shadows projected through any objects with small holes is a favourite. Someone, not seen but heard from my location, had brought a cheese grater to amuse people with the novelty of seeing a series of organized, well-placed crescent Suns neatly aligned in tidy rows. I had suggested to a man who happened to be observing near us with his family that he use his worn straw hat for this purpose. The result was quite spectacular.

It was so successful that I will consider packing or buying a straw hat on site for any future total or partial eclipse I am fortunate enough to witness.

Later, for a moment, I observed away in the distance the Sun reflecting off a small area of distant ocean water. Nowhere else was the water showing any noticeable reflection. I assumed this effect was caused by the low percentage of the Sun still unmasked by the disk of the Moon near the ship's location.

Now, more riveting changes are observed as the Sun slips further behind the Moon. For example, shadows become noticeably peculiar. People examine their own crisp shadows of their strands of hair.



Figure 2 — Totality from the P&O Cruises Australia "Explorer" 2023 April 20. Courtesy Stephen Bedingfield. Tech: Canon 5D Mark3 + 24–70mm @ 70mm, ISO 400, f/4.0, 1/250s, hand-held single shot, cropped, tone curve, contrast, noise reduction adjustments.

In this specific scenario, we are surrounded by water with land seen in the distance. Even though there are no clouds, the light has lost all its harshness. No sunglasses are desired or needed. The colors are beautiful and natural. The sky is a darker shade of blue and the intense glare normally seen in open water is gone. It creates a serene, curiously pleasant environment. This is short lived. The atmosphere continues to grow darker.

In the moments before totality, the light takes on an eerie quality. The effect has been described in past eclipses as a steely slate hue being applied to the environment. Colors lose their vibrancy; however, greens and blues are less affected by this. This observation is caused by the Purkinje Effect, a complex phenomenon that affects the human eye in low illumination levels while dark adaptation takes place. In my earlier experience of totality in Nebraska, this effect was profound. In any case, there is no time for conjecture. It is time for Bailey's Beads.

A quick look at the Sun using safely filtered binoculars showed a noticeable but brief display of Bailey's Beads. This is the bubbling appearance of the Sun's disk still shining between the peaks and valleys of the black lunar surface. The Beads are

a warning that totality is imminent. During one last sudden darkening, a cooling and stillness is experienced. My jacket, long since removed, allowed my arms to feel a distinct chill and the sudden stillness in the air. Then, for an instant, the diamond ring! Regardless of age or experience, everyone knew this was the moment totality would start. Darkness and a black hole appear where the Sun once was. The brightest part of the sky is transformed to the darkest in an instant. There are no words from the crowd (except mild profanity), only involuntary gasps and howls.

The corona would emerge intensely bright and created a striking contrast to the darkness within it. The corona was much brighter than during my previous eclipse. Veteran eclipse chasers would confirm this eclipse had a comparably very bright corona. Totality would last exactly sixty seconds.

During that minute, I had used my binoculars, now stripped of their solar filters, to view the eclipsed Sun, the corona, and prominences. My observation was so brief I had forgotten for the most part what I saw. The unaided-eye view, frankly, is incomprehensibly beautiful. Dramatic photographs, videos, and dare I say oral or written accounts cannot convey the experience.

With that in mind, too tempting to resist was my venture into photographing totality. My results were unusable images either grossly over-exposed or blurred. There are several reasons for this, including that I was unable to compensate properly for my failing to use a tripod. Suffice it to say, I was disappointed. My results from Nebraska six years earlier were at least sufficient.

Between these brief attempts at photography and using binoculars was a more successful but still rushed attempt to absorb the experience with just the eyes. It is difficult to look away from the corona. When one does, though, they are rewarded with an otherworldly landscape of colour and contrast. The sky was not exceptionally dark. Twilight does not describe it either. The unfamiliar colour and lighting of the landscape varies from one eclipse to the next but the effect is unique at totality. It cannot be replicated.

Even during this short totality, the crowd quieted down. People, I believe, realize what they are witnessing is so splendid that everyone seeks quiet contemplation either personally or with loved ones. It is not long enough. Despite the precise calculations, the event seems to end without warning. The second diamond ring signals the end of totality. It is accompanied by a dramatic brightening, the reappearance of a sliver of the Sun. The crowd comes alive knowing that it is over with the familiar cheers and hoots. There is no encore.

Despite my desire to see the Moon's shadow race away from my location, I missed it again, even with the reminders over the loudspeaker from the bridge! I also missed the more complex shadow-bands phenomenon. Maybe next time.

After totality, the sky still deserves close inspection, but this is undeniably a mere distraction from the exhilarating experience. Nearby planets are still conspicuous during this time and the sky remains fascinating and changing. The after-totality experience is less spectacular than what preceded it. Perhaps the glaring light of the Sun reemerging destroys any sensitivity within the eye that took it so long to process.

Aftermath

“When is the next one?!” was half-jokingly exclaimed by someone shortly after the end of totality in both of my eclipse experiences.

Later, after the event is long over, there is time for a deeper personal reflection by everyone who has witnessed it. The experience is unforgettable. Most people will feel a sense of enlightenment, and for a few, the event is life changing. For them, the desire to see another one or the next one will lead to the self-declaration that they are now an eclipse chaser. ★

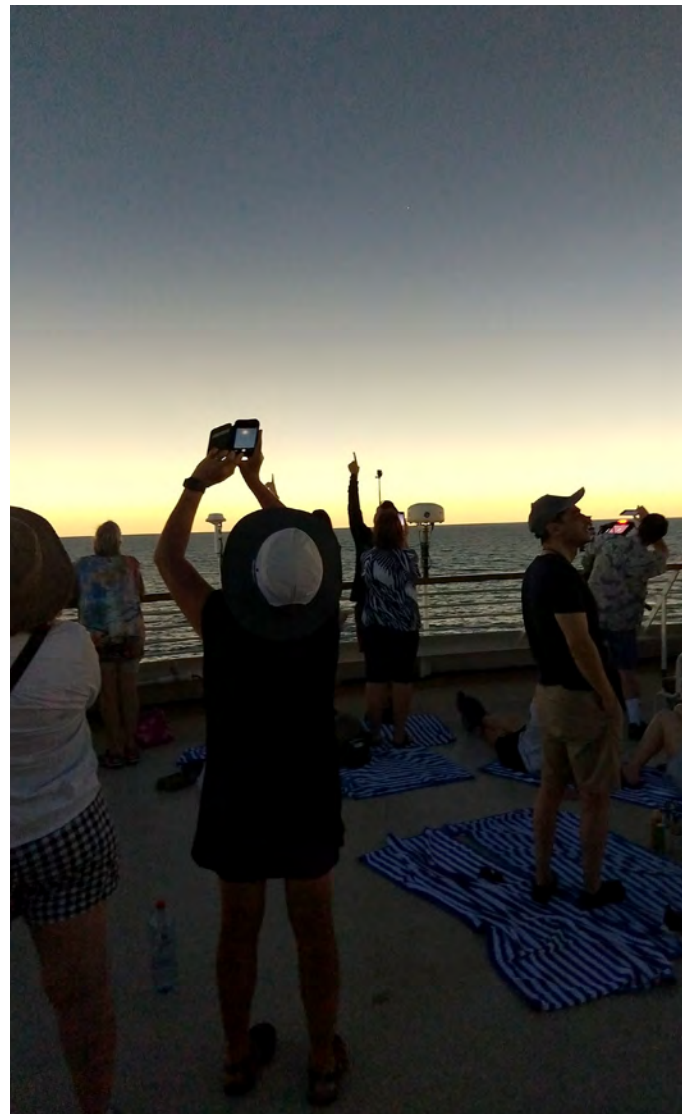


Figure 3 — A smart phone captures the activity from a forward deck mid-totality. Venus is seen in the upper centre. Courtesy Liz Muir.

The ALIVE Model

by Josh Havelka

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Abstract

The local Universe model supposes that the Big Bang occurred physically *within* spacetime. Modern cosmology interprets the Big Bang as an expansion *of* spacetime. The two ideas are at odds with each other, and the former is entirely ignored for that reason. If we adjust some of the common assumptions which justify the disregard of the local Universe model, however, it appears to have more legitimacy. Those adjustments are: a Big Bang velocity vector field $\mathbf{U}=\mathbf{U}(r, 0, 0, t)$, and a reinterpretation of Hubble's law, dark energy, as well as the CMB's dipole.

Unified Astronomy Thesaurus concepts: Cosmic microwave background radiation (322); Observational cosmology (1146); Cosmology (343)

Part 1

There is zero tolerance for the local Big Bang model in modern cosmology but when we ask why that is, there's a tendency to dismiss what is only a narrow definition of such a model. By adjusting some of those assumptions, this local Universe theory could be more plausible than many realize.

The most common rebuttal is related to the recession velocities of galaxies and Hubble flow. Surely if we are in a local Big Bang we would have to be at the centre of where it had occurred to corroborate the observation of nearly all galaxies moving away from us proportionally to distance. And if that were the case, this would be exceptionally unlikely and break the spirit of the Copernican principle since each observer should observe Hubble flow no matter their place in the Universe.

And yet, using only a basic velocity vector field space \mathbf{U} :

$$\mathbf{U}=\mathbf{U}(r, 0, 0, t), \quad (1)$$

where \mathbf{U} is in spherical coordinates and constrained by some inner and outer radius to create a spherical annulus,

$$r^{\min} < \mathbf{U} < r^{\max}, \quad (2)$$

we can demonstrate that cosmological redshift could instead be a literal velocity (and therefore Doppler) measurement rather than an effect of spacetime expansion and without needing to be at the centre of where the Big Bang occurred.

This can be done manually with a dot model by calculating reference frame changes of dots A, B, and C as shown in Figure 1. But it's more visually appealing to show this Absolute Linearly Increasing Velocity Expansion (ALIVE) model in the form of a particle simulation, such as in Figure 2 (a video of this simulation is linked here).

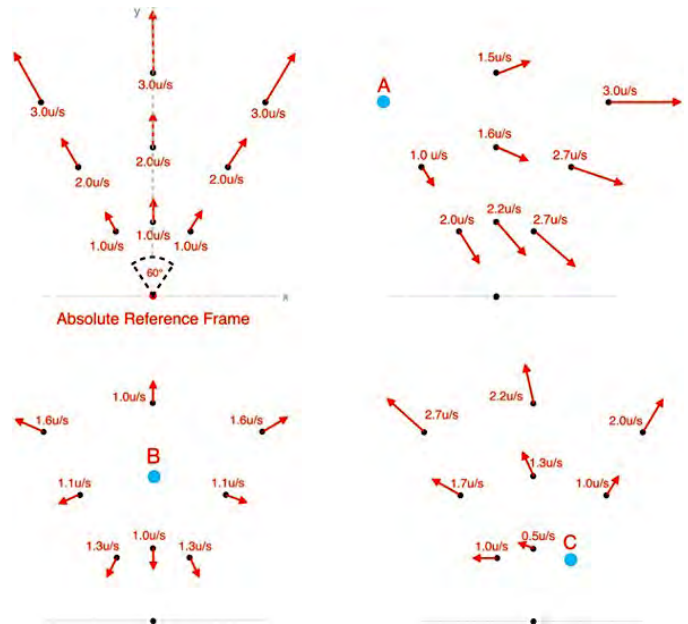


Figure 1 — A 2-D 60° slice of the vector field \mathbf{U} illustrated in the absolute and relative reference frames of three particles A, B and C, one second after the “explosion.” Hubble's law is only a matter of subtracting the velocity components of the reference frame from the velocity components of the object being observed.

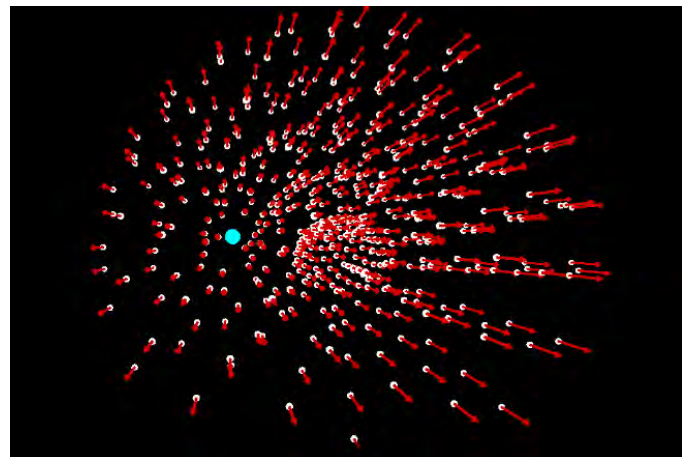


Figure 2 — Simulation of the \mathbf{U} velocity vector field, with the reference frame shown as the blue particle, and the relative velocities of the other particles visualized with red arrows (whose lengths are proportional to their particle's speed). Half the sphere is omitted for clarity. The python coding for this simulation can be found here.

Upon downloading the particle data of this simulation and computing Hubble flow, it reveals the velocity-to-distance ratio is a function, $H(t)$, proportional to the inverse of time since the Big Bang:

$$H(t) \propto t^{-1}. \quad (3)$$

In other words, the farther back in time that we look, the greater we'd expect the Hubble value to be. Exponentially so. Figure 3 shows this effect in the particle data's Hubble values

as they asymptote toward infinity when looking backward in time.

This has a fascinating implication since, interpreted differently, one might believe that the velocity recession rate is accelerating, which could invoke a mysterious force in the vacuum energy of spacetime to explain it. An interpretation like this would also create overestimated distances for galaxies that are high redshift, much like the surprisingly “over-developed” galaxies being discovered by the *James Webb Space Telescope* (e.g. Labbé et al. 2023).

Hubble flow in the ALIVE model

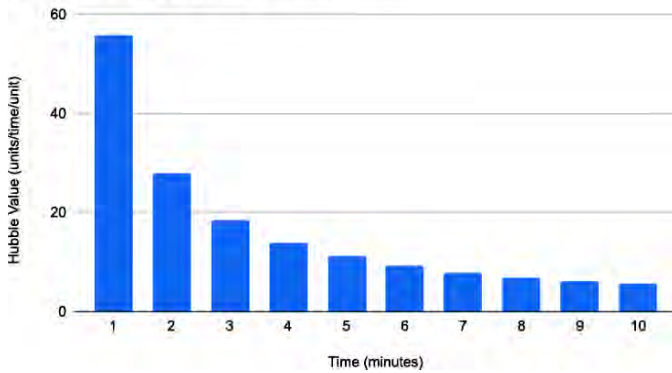


Figure 3 — Hubble values of a 2,500 particle simulation of the ALIVE model that were captured at one-minute intervals. [The complete data can be found at this link here.](#) Units of distance are arbitrary and there was no simulated gravity for simplicity (without gravity, all Hubble values are identical for each particle and each reference frame).

And to be clear, the notion that we would need to be at the centre of the Big Bang to explain Hubble’s law in a local model is not some cherry-picked argument from the internet. It’s come from many mainstream cosmologists: Ethan Siegel, a leading journalist of cosmology wrote this in an article for Forbes (2016); Don Lincoln of Fermilab said the same in a YouTube video (2021); it’s even declared on the Big Bang’s *Wikipedia* page, and by many other experts across popular science channels.

This rather simple idea is not trivial and deserves far more attention than it’s getting. But it requires another adjustment to our current understanding of the Big Bang to become convincing.

Part 2

Since spacetime was not created in this model’s Big Bang, the energy that existed at the moment we currently recognize as the Big Bang was itself positioned physically in spacetime and could be described classically as static or in motion. If we consider this singularity event instead as a phase shift from one energy density not yet understood, into the ones described by general relativity thereafter, then the moment we currently call the Big Bang would be better described as a false Big

Bang, the actual event having occurred perhaps many years before the phase shift we now label as $t = 0$.

A cross section of such a Universe has been illustrated in Figure 4. It demonstrates the essence of this model and the crux of its believability: where the extremely dense energy of the Universe before the false Big Bang *already had an absolute motion* as it transitioned into the energy described by general relativity. To say what caused this motion is beyond the scope of this article, though one could imagine a primordial black hole having the equivalent of a Chandrasekhar limit, which created an omeganova.

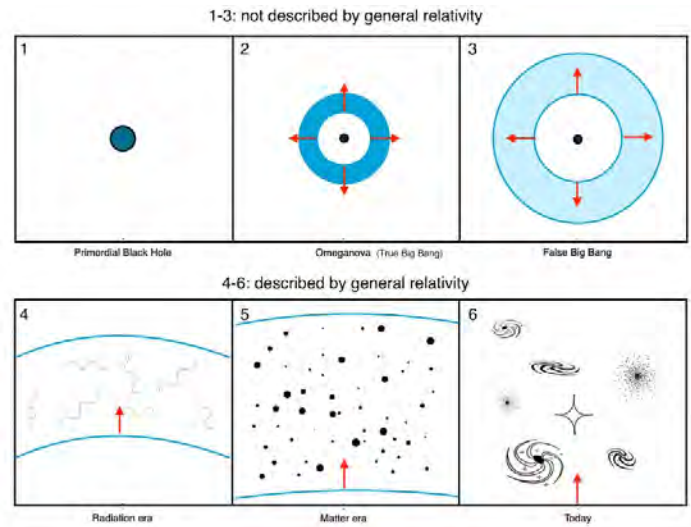


Figure 4 — Cross section illustrating the ALIVE model’s cosmic evolution. The moment we currently label as $t = 0$ may actually be many years after the true moment of the Big Bang.

Part 3

So what would this mean observationally? If the inverse square law diffuses energy as it would in the ALIVE Universe, we should expect three qualities in the Cosmic Microwave Background (CMB):

1. A hotspot in one hemisphere of the CMB as well as an over-density of galaxies in that same direction.
2. From that over-density, a universal gravity-well moving all matter in the Universe back towards the omeganova from whence we came.
3. Seeing as it’s unlikely the Big Bang is a perfect sphere, we would also expect density anisotropies perpendicular to the axis of our absolute motion which correspond to our being in an expanding spheroid.

Conveniently the kinematic interpretation of the CMB’s temperature dipole has recently been called into question because its amplitude doesn’t match the dipole amplitude of cosmologically distant quasars and radio galaxies (Secrest et al. 2021; Siewert et al. 2021; Rubart & Schwarz 2013). So not only is the CMB’s dipole likely to be at least partially due to a

real difference in temperature, this finding “may be interpreted as an intrinsic over-density of galaxies and quasars on very large scales” as well (Secrest et al. 2022).

What’s more, it is now generally accepted we’re in a massive, unexplained, galactic bulk flow that extends out to at least 500 million parsecs. Which is to say, the cosmological principle may no longer be valid because there seems to be some extremely large gravity source pulling all nearby matter *in about the same direction as the CMB hotspot and the galaxy over-density*, a mysterious phenomenon that is far less mysterious in the context of the inverse square law and a local Universe model.

The third CMB quality we would expect in this model is present, too, if we recall how the quadrupole (and octupole) of the CMB is aligned perpendicularly to its dipole.

Assuming the shorter axes of an oblate spheroid are slightly higher density and therefore demarcated by two hotspots, then the energy along the longer axis would be more diffuse and reveal its presence as the cold spots. The peaks and troughs of the dipole and quadrupole could determine what is effectively a Big Bang coordinate system. An illustration of this is shown in Figure 5.

From these CMB qualities comes a satisfying answer to a very common question: the centre of the Universe is at the peak of the CMB hotspot, **(l) 264.0° (b) 48.3°** (galactic coordinates), which is in the direction of the Hydra constellation.

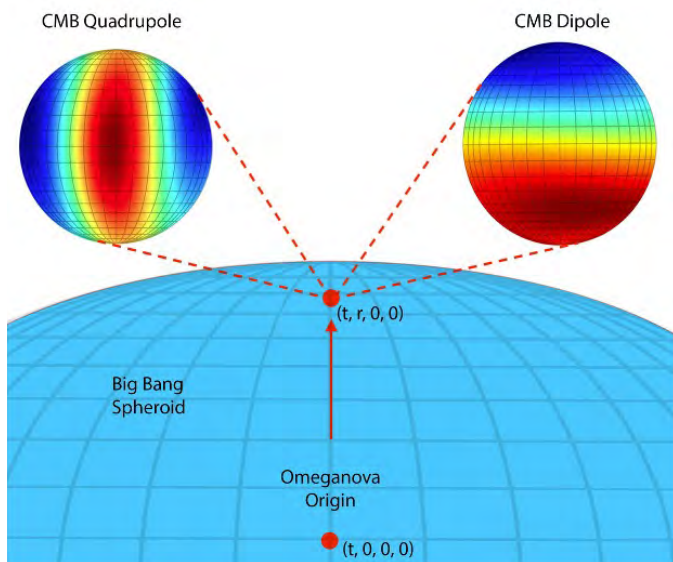


Figure 5 — A rough schematic demonstrating how the CMB’s dipole and quadrupole mark the axes of a local Big Bang’s spheroid. The centre of the Universe is therefor located at the peak of the dipole hotspot.

Part 4

The ALIVE model is appealing first and foremost because it is simple and spherical, two qualities that often come up

when talking about nature’s fundamental properties. Of course there are some deficiencies such as the return of the horizon problem, though it’s possible energy was indeed causally connected within the primordial black hole.

It might also be tempting to equate cosmological expansion with the immense success of general relativity since that would quickly disqualify this article. But these two theories are not mutually exclusive of one another. Albert Einstein himself called the spacetime expansion models “absolutely abominable” according to Georges Lemaitre in an excerpt from *Revue Des Questions Scientifiques* (1958), and he held this belief even after Edwin Hubble discovered Hubble’s law. It wasn’t until Einstein’s static Universe solutions were proven to be unstable by Arthur Eddington in 1930 (even with the cosmological constant) that he eventually accepted it.

Spacetime expansion just seems unnatural, not to mention the *acceleration* of spacetime expansion. Perhaps that was why Einstein was slow to adopt it. Now if we add the dissolution of the cosmological principle, the continuing Hubble tension, the vacuum energy tension, and other problems that have arisen with spacetime expansion models since then (summarised recently by Aluri et al. 2023), surely suggesting that galactic redshift is exactly what it appears to be — the Doppler shift effect — is not such a radical thought?

In closing: it should be noted that, despite what is a rather dramatic deviation from the current model of the Universe, this author has the utmost respect for the professional cosmological community and has written this article only with the spirit of inquiry in mind, not contempt. Because sometimes a brief escape into ideas which seem obviously wrong is not always a futile affair. ★

Author’s Note

Another interesting implication of this model is a possible solution to dark matter, too: the hidden gravitational potential energy may be caused by the “wake” from matter that travels in the forward trajectory of a galaxy that appears to have too little mass to explain its gravity effects.

Statement of Funding

There were no sources of funding for this article.

Data Availability

All data and coding referenced in this article are publicly available and linked where appropriate.

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Blast From the Past

Compiled by James Edgar james@jamesedgar.ca

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.

Audibility of the Aurora

By W.F. King

Originally published in the very first Journal, 1907 Vol. 1

At the meeting of the Ottawa Section, R.A.S.C., on May 9th, during the discussion which followed the reading of Mr. McDiarmid's paper on the Aurora reference was made to the sounds, which, it is affirmed, have been occasionally heard, 'proceeding from brilliant aurora.

Doubt has been cast upon the reality of this phenomenon from the fact that apparently the sound has never been heard by any of the scientific Arctic explorers, though they have listened for it. The evidence of those who claim to have heard it is commonly, in scientific writings, turned by the supposition that the sounds are due, not to the auroral movement, but to the cracking of ice, the driving of snow before the wind, etc.

In this connection may be cited a piece of evidence which, though in print for nearly twenty years, has not yet found its way into the literature of the subject.

Mr. Wm. Ogilvie, the well-known surveyor and explorer of Yukon Territory, in a report forming part 8 of the Report of the Department of the Interior for the year 1889, says:-

As to the aurora making an audible sound, although I often listened when there was a very brilliant display, and despite the profound stillness which is favorable to hearing the sound, if any sound occurs. I cannot say that I ever even fancied I heard anything. I have often met people who said they could hear a slight rustling sound whenever the aurora made a sudden rush. One man, a member of my party in 1882, was so positive of this that, on the 18th November, when there was an unusually brilliant and extensive display, I took him beyond all noise of the camp, blindfolded him, and told him to let me know when he heard anything, while I watched the play of the streamers. At nearly every brilliant rush of the auroral light he exclaimed: 'Don't you hear it?' All the time I was unconscious of any sensation of sound.

The simple test applied disposes of two explanations which may suggest themselves in ordinary cases—conscious imposture, and self-deceit from the impression on the mind produced by the seemingly violent movements of the streamers. That the sensation of sound coincided with the rush of the streamers shows that what was heard was not the wind, unless this wind was a phenomenon of the aurora. There remains the curious fact that the sound was not heard by both. Whether this was due to difference as to keenness of hearing, or to some physiological effect to which different persons are not equally sensitive does not appear.

It is interesting to note that at the reading of Mr. McDiarmid's paper there were present four persons, members of a prominent Ottawa family, who have heard the sound of the aurora.

It was in Gaspé some years ago, in the month of August. The aurora was a very brilliant one, forming a corona overhead with diverging streamers covering almost the entire sky. The movements of the streamers were very rapid, and accompanied by a sound, described as of a hissing or whizzing sound, and very distinct. The sound recurred at every brilliant flash for more than an hour, and was heard by all the members of the family (six). The night was perfectly calm, and the place far enough from the sea to preclude the supposition that the sound could be confounded with that of the waves, to which indeed it had little resemblance.*



Figure 1 – This close-up view of the Cygnus Wall within NGC 7000—also known as the North America Nebula—was taken by Rob Lyons from his rooftop in Vancouver over five nights in July. Rob used a Celestron Edge HD 8", with a 0.7× reducer, an ASI533MM Pro Camera, Antlia 3-nm pro filters, Antlia LRGB V5 Pro filters, and a ZWO AM5 mount.

Figure 2 – Molecular cloud LBN 552 is seen here in this stunning image taken by Tammy Foley in Norfolk County, Ontario. Tammy imaged this cloud located in Cepheus using a Redcat 51, with an ASI 183MC Pro, on an EQ6-Pro/CEM70 mount. She guided using a 30-mm f/4 scope with an ASI 120-mm mini and an L-Pro with a ZWO 5-position filter wheel. She imaged the cloud over nine nights in May and June. As she says, "Long integrations are a passion of mine. Capturing these types of dusty targets is just the thing for me in that regard." Processing was done in PixInsight.



Continues on page 201

What's Up in the Sky?

October/November

Compiled by Scott Young, Winnipeg Centre

October 2023 Planetary Highlights

October skies this year feature all four of the gas giant planets in our solar system. **Saturn** is already up in the southeast as darkness falls, reaching its highest elevation (and thus best telescopic viewing) by 11 p.m. at the beginning of the month and before 9 p.m. by Hallowe'en. **Jupiter** rises about 8:30 p.m. at the beginning of the month and is likely to be the planetary highlight of the fall, rising high enough even from western provinces to climb out of the murky horizon air.



Figure 1— Finder chart for Uranus, retrograding near the stars of Taurus, The Bull.

Meanwhile, **Neptune** hovers below the circlet of Pisces the Fish, requiring at least binoculars or a small telescope to track it down. **Uranus** is between Jupiter and the Pleiades star cluster. It's technically visible to the unaided eye under a dark sky as a faint star-like point, but most observers will use binoculars or a telescope to identify it. Charts to track down the outer gas giants are found on page 224 and 225.

Of the other planets, **Mercury** begins the month very low in the east before sunrise, but quickly dives out of sight. It reaches

superior conjunction on October 20, passing behind the sun from our point of view. **Venus** is also in the morning sky but much higher, about 30 degrees above the east-southeast horizon by sunrise. **Mars** is lost in the evening twilight. For those with large telescopes and imaging systems, the dwarf planet **136199 Eris** reaches opposition this month, visible above the back of Cetus the Whale at magnitude 18.8—a challenging observation to be sure!

There is a **solar eclipse** on October 14, as the Moon passes in front of the Sun as seen from Earth. The eclipse is a partial one as seen from all of Canada, with more of the Sun being eclipsed the farther south and west you go. For a narrow path from Oregon through Texas, the eclipse will be annular, with a thin ring of Sun still visible around the Moon.

For local details for this event, see (page 131 of the 2023 *Observer's Handbook*.)

Two weeks later, a **partial lunar eclipse** occurs on October 28-29, but it is not well-placed for Canadian observers. Most of Canada will miss the entire event, while Québec and Ontario will see only the final penumbral phases and only Newfoundland and parts of northern Québec and Nunavut glimpsing any of the partial phases after moonrise. For details, see page 137 of the 2023 *Observer's Handbook*.

The **Moon** passes near the planets as it orbits our world, sometimes appearing close enough to provide a nice photo opportunity.

- October 1-2: Jupiter is 3 degrees to the bottom right of the waning gibbous Moon
- October 10 (morning sky): the waning crescent Moon is above and to the left of Venus
- October 23 & 24: Saturn is close to the waxing gibbous Moon on both of these nights
- October 28: the nearly full Moon is near Jupiter this evening
- October 29: Uranus is in the same binocular field of view as the Moon

The Sky October/November

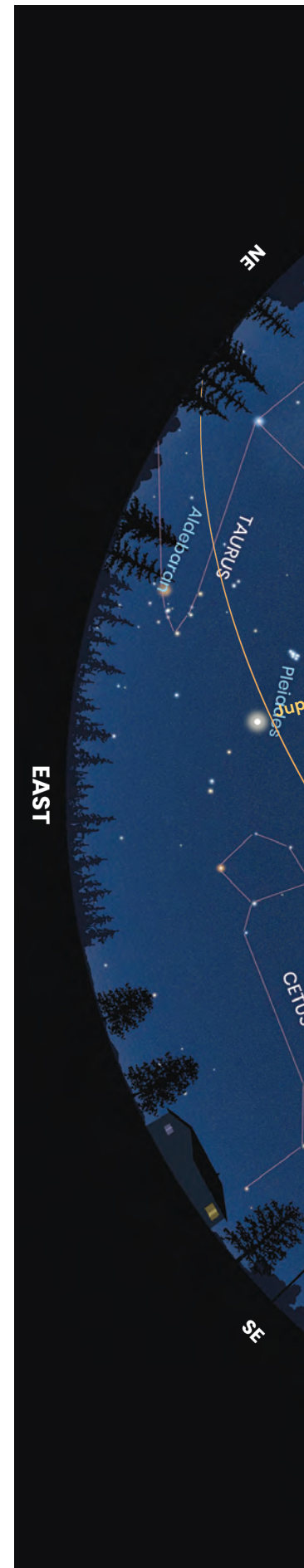
Compiled by James Edgar with cartography by Glenn LeDrew

Celestial Calendar *(bold=impressive or rare)*

Oct. 1 Jupiter 3° south of Moon	Nov. 2 Jupiter at opposition
Oct. 3 Moon 1.1° south of Pleiades (M45)	Nov. 3 Pollux 1.4° north of Moon
Oct. 6 Moon at last quarter	Nov. 5 Daylight Saving Time Ends
Oct. 7 Pollux 1.4° north of Moon	Nov. 5 Moon at last quarter
Oct. 9 Moon at apogee (405,425 km)	Nov. 5 South Taurid meteors peak at 8:00 p.m. EST
Oct. 10 Venus 2° south of Regulus	Nov. 6 Moon at apogee (404,569 km)
Oct. 10 Venus 6° south of Moon	Nov. 9 Venus 1.0° south of Moon
Oct. 14 New Moon (lunation 1247)	Nov. 11 North Taurid meteors peak at 7:00 p.m. EST
Oct. 14 Annular Solar Eclipse	Nov. 13 New Moon (lunation 1248)
Oct. 20 Double Shadows on Jupiter	Nov. 14 Mercury 1.7° north of Moon
Oct. 21 Orionid meteors peak at 8:00 p.m. EDT	Nov. 14 Antares occulted by Moon
Oct. 21 Moon at first quarter	Nov. 18 Leonid meteors peak at 11:00 p.m. EST
Oct. 24 Saturn 3° north of Moon	Nov. 20 Moon at first quarter
Oct. 25 Moon at perigee (364,872 km)	Nov. 21 Moon at perigee (369,818 km)
Oct. 28 Full Moon	Nov. 25 Jupiter 3° south of Moon
Oct. 29 Jupiter 3° south of Moon	Nov. 26 Uranus 3° south of Moon
Oct. 29 Uranus 3° south of Moon	Nov. 27 Moon 1.1° south of Pleiades (M45)
Oct. 30 Moon 1.1° south of Pleiades (M45)	Nov. 27 Full Moon

Planets at a Glance

	DATE	MAGNITUDE	DIAMETER (")	CONSTELLATION	VISIBILITY
Mercury	Oct. 1	—	5.8	Virgo	—
	Nov. 1	—	4.7	Libra	—
Venus	Oct. 1	—	5.8	Virgo	—
	Nov. 1	-4.4	22.1	Leo	Dawn
Mars	Oct. 1	—	5.8	Virgo	—
	Nov. 1	—	15.0	Taurus	—
Jupiter	Oct. 1	-2.9	47.7	Aries	Evening
	Nov. 1	-2.9	49.5	Aries	Evening
Saturn	Oct. 1	0.5	18.6	Aquarius	Evening
	Nov. 1	0.7	17.8	Aquarius	Evening
Uranus	Oct. 1	5.7	3.7	Aries	Evening
	Nov. 1	5.6	3.8	Aries	Evening
Neptune	Oct. 1	7.8	2.3	Pisces	Evening
	Nov. 1	7.8	2.3	Pisces	Evening





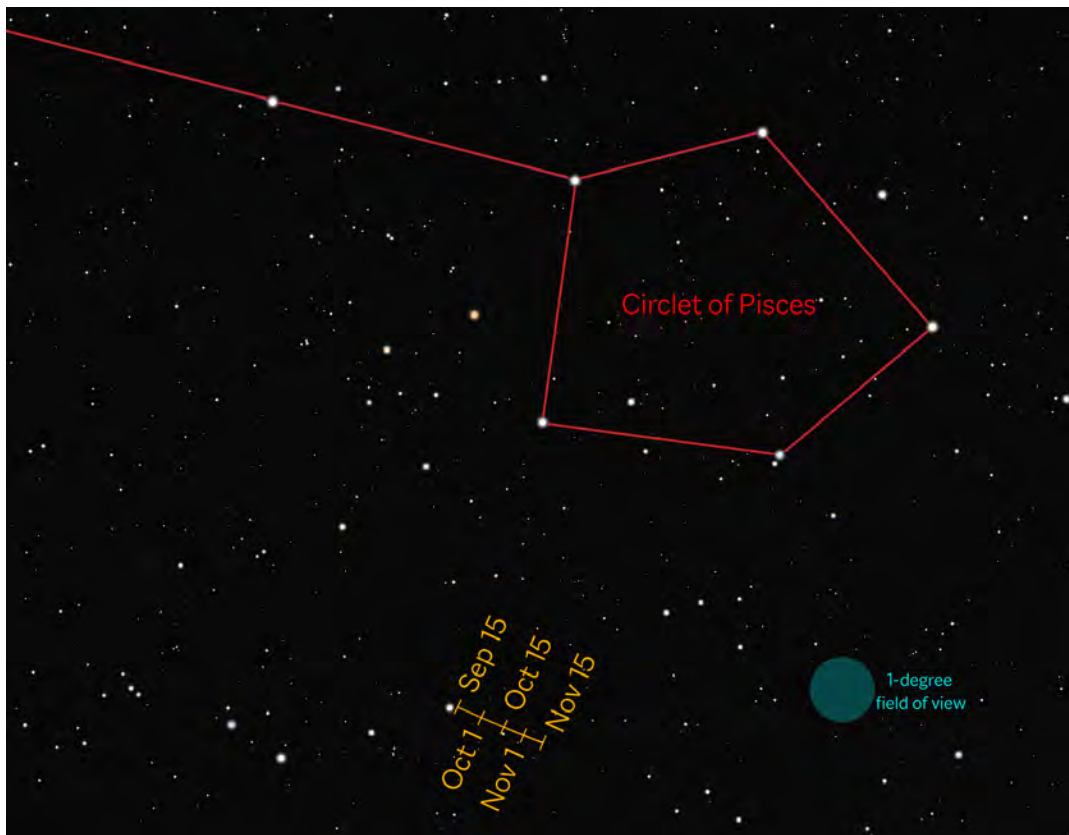


Figure 2 — Finder chart for Neptune, retrograding near the stars of Pisces.

Other events: Besides the pair of eclipses, two annual meteor showers peak this month. The Draconids are often weak but occasionally have unexpected outbursts; they peak on the morning of October 9, with the Moon largely out of the sky. The Orionids meteor shower originates with Comet Halley, but peaks on the night of October 21-22 with a waxing gibbous Moon in the sky. Probably the best views will come before dawn on the 22nd after moonset.

November 2023 Planetary Highlights

November sees **Jupiter** at opposition, providing its largest face this year at nearly 50" across, close to the limit of the human eye's resolution. It rises at sunset and is visible all night, finally setting in the west as the sun rises. **Saturn** is at its highest shortly after sunset, but still low in the sky for much of the country. Although visible until after midnight, you'll want to catch Saturn and its rings as early in the evening as possible to minimize the poor seeing nearer the horizon. **Uranus** reaches opposition on November 13, its best and brightest for the year but still requiring at least binoculars for most observers to spot it as a faint 'star'.

In the morning sky, **Venus** rises about 3 hours before the sun and stands high in the east in the pre-dawn sky. **Mercury** has moved into the evening sky but the angle of the ecliptic at this

time of year keeps it too low to be easily spotted. **Mars** passes around the far side of the Sun on November 17 and so is invisible from Earth.

The **Moon** passes several planets this month:

- November 9 (morning sky): the waning crescent Moon is about 1 degree away from Venus in the morning sky (closer in the eastern part of the country), a spectacular alignment worth getting up for.
- November 14 (evening sky): the thin crescent Moon is near Mercury, but the pair will be too low to observe from Canada.
- November 24-25: The waxing gibbous Moon is near Jupiter tonight.

Other Events: The annual Leonid meteor shower

peaks on the night of November 17-18, with a predicted rate of about 10-15 meteors per hour (under a dark sky) in the pre-dawn hours of the 18th. The Moon is a thin crescent in the evening and so won't interfere with observation, making this a decent year for this famous shower. No major outbursts are predicted for this year, which can cause rates of several thousand per hour. A potential minor outburst may occur near 12h Universal Time on November 21, consisting of 10-15 bright meteors per hour. This timing is well placed for North American observers and is worth monitoring. For details on how to turn your meteor watching into scientifically useful data, visit the International Meteor Organization's page at www.imo.net/observations/methods/visual-observation/. ✨

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Figure 3 – “Most of us have observed a partial eclipse of our Moon. However, what about two moons undergoing a partial lunar eclipse, at the same time, on another planet?!” asks Shakeel Anwar.

Shakeel imaged Jupiter in the early hours of 2022 September 30, from Mississauga, Ontario, along with the volcanic moon Io as it is eclipsed by Jupiter on the right. At the same time, the ice-moon Europa can be seen emerging from Jupiter’s shadow on the left. But wait, there’s more! “Above and to the left of Europa is Callisto, Jupiter’s second-largest moon and the third-largest moon in our Solar System. The Great Red Spot is emerging from the left and many storms and festoons are visible across Jupiter.” A short timelapse and video can be found here: www.youtube.com/shorts/WfRrJlu4M80. Shakeel used a Celestron C11, Televue 2.5× Powermate, and a ZWO ASI224MC camera.

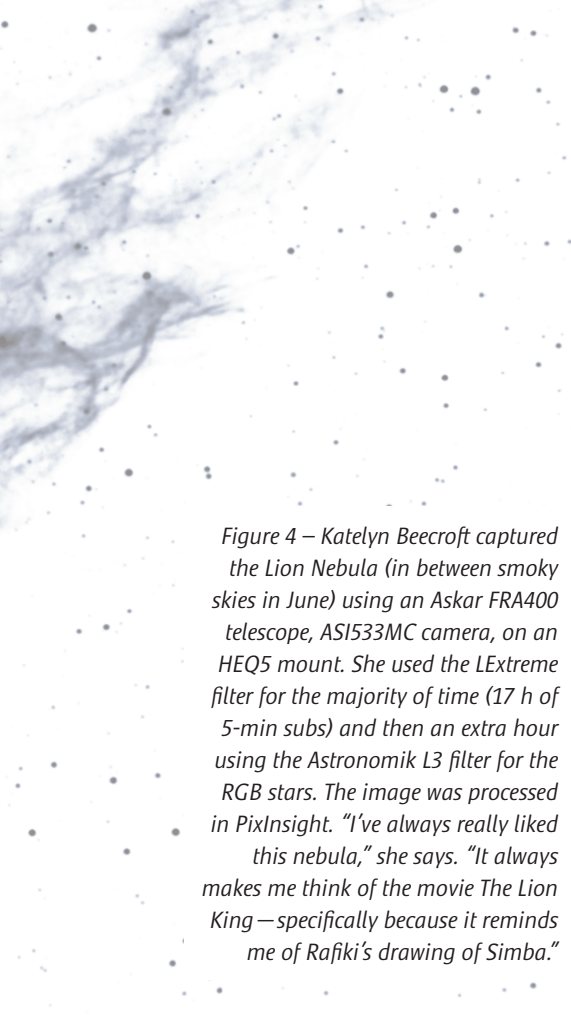
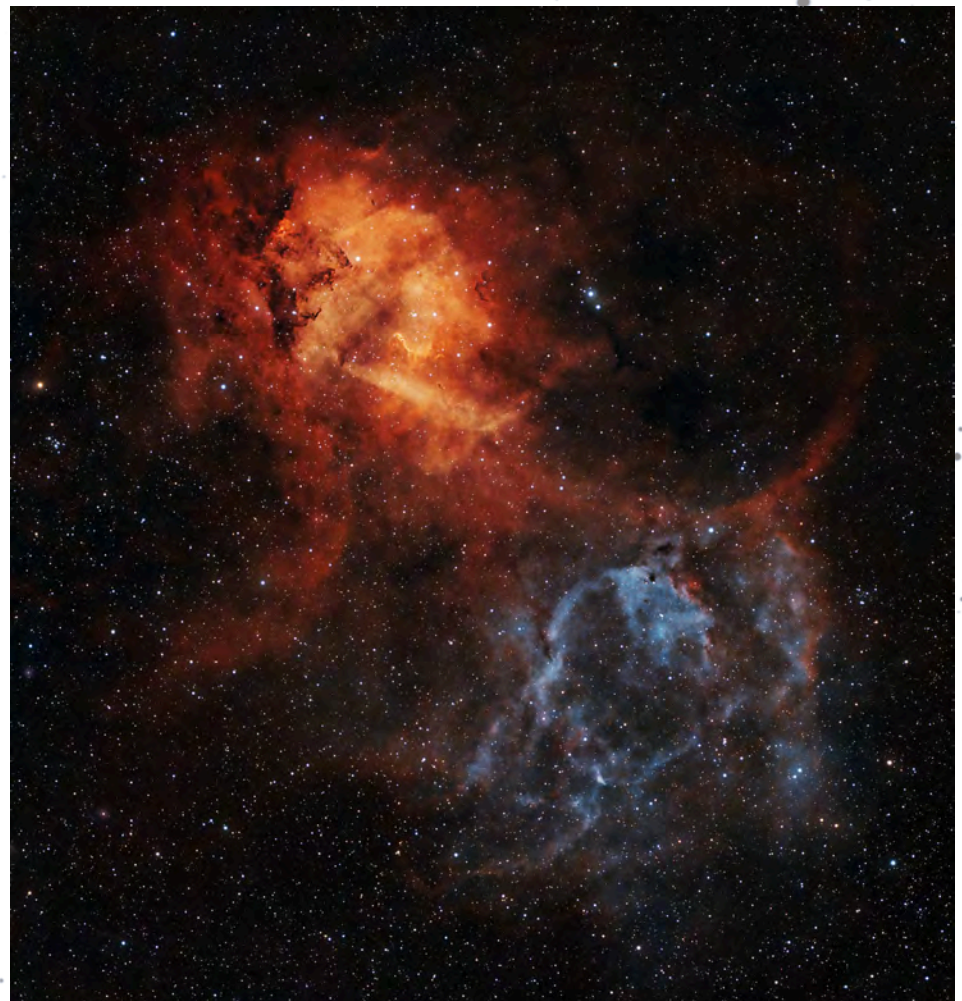


Figure 4 – Katelyn Beecroft captured the Lion Nebula (in between smoky skies in June) using an Askar FRA400 telescope, ASI533MC camera, on an HEQ5 mount. She used the LExtreme filter for the majority of time (17 h of 5-min subs) and then an extra hour using the Astronomik L3 filter for the RGB stars. The image was processed in PixInsight. “I’ve always really liked this nebula,” she says. “It always makes me think of the movie *The Lion King*—specifically because it reminds me of Rafiki’s drawing of Simba.”



CFHT Chronicles: Mapping the Universe, Now in Colour



by Mary Beth Laychak, Director of Strategic Communications, Canada-France-Hawaii Telescope (mary@cfht.hawaii.edu)

The *Euclid* satellite's launch on July 1 was the culmination of countless hours and more than a decade of work to take the mission from concept to fully functioning, orbiting telescope. The collection of *Euclid* data from space may be a few months away, but members of the Ultraviolet Near Infrared Optical Northern Survey (UNIONS) team have been using telescopes in Hawai'i for years to create a complementary data set. My *Euclid* column will focus on work done using CFHT, the Subaru Telescope, and Pan-STARRS, and by no means is a complete overview of the *Euclid* project or Canadian contributions to the project. I had the pleasure of working with a



Figure 1 — CFHT's director Jean-Gabriel Cuby attending the *Euclid* launch. Cuby is a member of the *Euclid* board.

very robust Canadian communications team in June that was tasked with telling the story of Canada's *Euclid* contributions. The team did a phenomenal job, and I'd like to take the space to acknowledge them here: Rebecca Elming from the University of Waterloo, Cara Chartrand from NRC/CNRC, Alex Walls from the University of British Columbia, Isabel Charron from the ASC/CSA, and everyone from the press and communications offices of those institutions. For the Hawai'i story of *Euclid*, I worked with teams from the University of Hawai'i, Sarah Hendrix, Roy Gal, and Ken Chambers along with Kumiko Usada-Sato from the Subaru Telescope. It was a team effort, and the remainder of the column pulls from a joint news release.

The *Euclid* mission aims to answer the big astronomy questions of our time: What is the Universe made of? What is the mysterious dark matter? How has the structure of the Universe evolved over billions of years? After 12 years of planning, the European Space Agency launched its *Euclid* satellite from Cape Canaveral, Florida on July 1. *Euclid*'s incredible dataset will receive a big helping hand from observations taken at three observatories in Hawai'i.

The *Euclid* mission plans to observe billions of galaxies across more than a third of the sky, building a 3-D map of the Universe. Unlike the *James Webb Space Telescope*, which observes a tiny portion of the Universe in great detail, *Euclid* will survey a large portion of the sky, seeing the entire image. Prior to *Euclid*'s launch, the work of creating the map began in Hawai'i through the UNIONS project, an ambitious imaging survey of the northern sky in the optical and near-infrared, conducted by three Hawai'i based telescopes since 2017: the Canada-France-Hawaii Telescope (CFHT), Japan's Subaru Telescope on Maunakea, and the University of Hawai'i Institute for Astronomy (IfA) Pan-STARRS telescope on Haleakalā, Maui. UNIONS is co-led by Jean-Charles Cuillandre CEA Saclay/Université Paris-Saclay, along with Ken Chambers at the University of Hawai'i Institute for Astronomy (IfA), Alan McConnachie at the Dominion Astrophysical Observatory (DAO) in Canada, Oguri Masamune at Chiba University in Japan, and Mike Hudson at the University of Waterloo in Canada.

"The superb observing conditions in Hawai'i led to the unprecedented collection of galaxies over a very large area of the sky with each telescope playing a critical role by adding different filters or colours to the *Euclid* data," said Cuillandre, a former CFHT staff astronomer. "While a critical part of the original motivation to obtain the UNIONS data was the *Euclid* mission, the data will have an impact extending far beyond the space mission." By observing more than one-third of the observable sky outside the Milky Way, *Euclid* will image billions of targets out to a distance of ten billion light-years. Astronomers estimate the distances to these galaxies—and thus convert two-dimensional images to a 3-D map of the



Figure 2 — Full-colour image of a UNIONS field with data from CFHT, Subaru, and Pan-STARRS. Credit: UNIONS team

Universe—using their observed brightness in different colour filters. The more filters are used, the better the distance estimate. *Euclid* has only four filters: one that spans most of what we see as visible light at 550–900 nm, and three that cover infrared wavelengths, 900–2000 nm, beyond what our eyes can see. The Hawai’i telescopes will add observations in five visible–light filters, spanning the rainbow from the violet to far-red. In other words, the three Hawai’i telescopes turn the black-and-white 2-D images from *Euclid* into a full-colour, 3-D map of the Universe. Because *Euclid* is mapping such a huge swath of sky, and ground-based telescopes have different capabilities, multiple observatories must contribute to provide all the data.

“The idea for one filter from space and additional filters from ground-based telescopes was the *Euclid* plan from the beginning. Subaru observations add far-red and green, Pan-STARRS adds red and CFHT adds blue, enhancing the one filter images that *Euclid* will produce. UNIONS is a consortium of telescopes in Hawai’i,” said Professor Satoshi Miyazaki, director of Subaru Telescope. “Not only with *Euclid*, UNIONS scientists are also sharing data to conduct research collaborations based on Hawai’i.”

But how does one calibrate data from space to data taken on the ground? We can use the observations taken at CFHT as an example. The UNIONS team uses our wide-field optical imager, MegaCam, to observe in the u-band (311–397 nm) and r-band (566–714 nm). Our r-band observations overlap with *Euclid*’s lone visible filter at 550–900 nm. The team uses the CFHT r-band data from each field as a reference point for the u-band data. Similarly, Subaru’s “green” g-band observations bridge the gap between CFHT’s u-band and the start of the *Euclid* visible filter.

Regardless of where it’s been taken, the goal of all this data is to try to unravel the mysteries of dark matter. Dark matter does not emit light like the more familiar planets, stars, and galaxies, rather its gravity is detected by observing large clusters of galaxies. In some cases, the immense gravity of a galaxy or cluster of galaxies can bend light from an object behind it, known as gravitational lensing. Ground-based observations will assist astronomers working on the *Euclid* gravitational lensing project.

“I have worked on the *Euclid* mission for 12 years, and it is very satisfying to see the mission launch,” said Jean-Gabriel Cuby, CFHT executive director and *Euclid* board member.

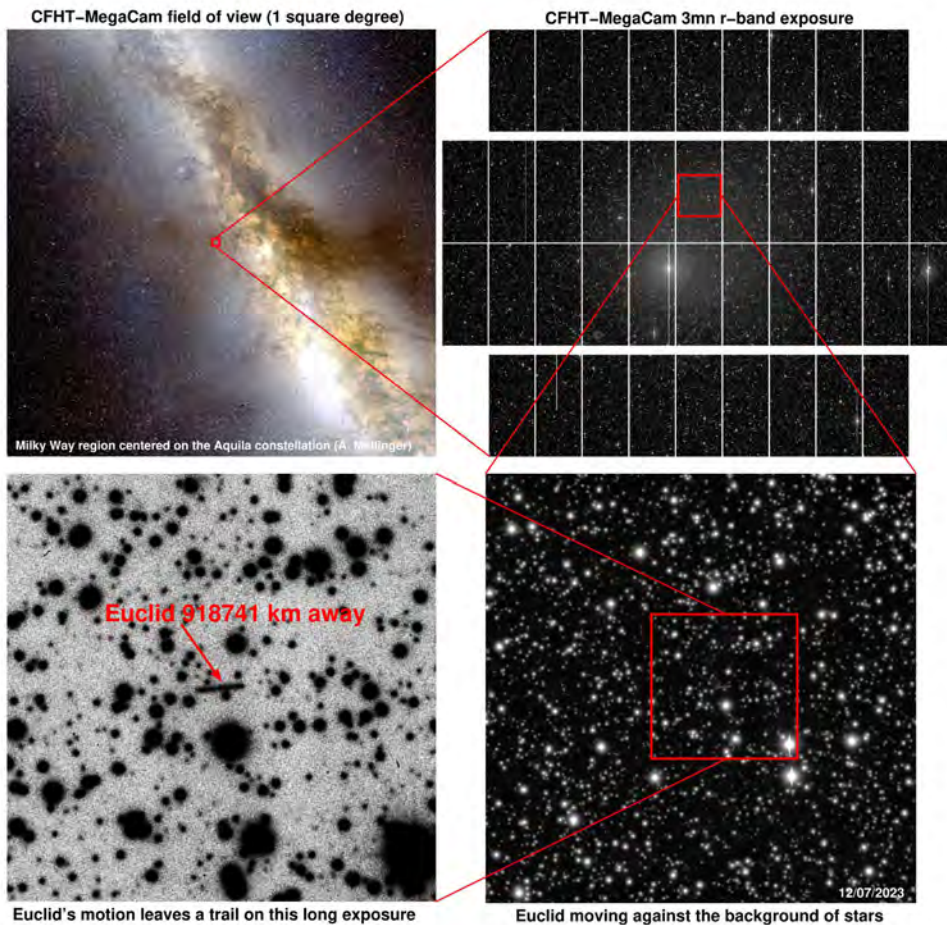


Figure 3 — Jean-Charles Cuillandre (CEA) created a visual to give the context in the sky and the observation. Mahalo to Klaus Merz (ESA), Stephen Gwyn (CADC), Jean-Charles Cuillandre (CEA), and the CFHT observing team for their key contribution to this effort. Image credit: Cuillandre (CEA)

“Much like with the *James Webb Space Telescope*, *Euclid* will surprise us and lead to insights we do not fully anticipate. Insights enabled by the efforts of the teams at CFHT, Subaru, and Pan-STARRS.”

The *Euclid* mission will spend more than 6 years in space to accomplish the mission and involve more than 2000 scientists, including astronomers in Hawai’i. The University of Hawai’i team is especially interested in using this data to measure the parameters that characterize the properties of the Universe.

“The *Euclid* mission will provide a next generation measurement of these characteristics and we may discover we have made a mistake or series of small mistakes along the way, or we may find that dark energy is more complicated than in Einstein’s formulation. Or there might be something else, some new aspect of the Universe that we are presently unaware of,” explained Chambers.

The first images from the *Euclid* mission are expected in around two months. *Euclid* will build up a large archive of unique data, unprecedented by volume for a space-based

mission, enabling research over all disciplines in astronomy. The data will be archived at the Canadian Astronomy Data Center (CADC) and accessible to astronomers around the world. The CADC will also provide colour information based on the observations from the Hawai’i based telescopes.

“The *Euclid* images will be beautiful to look at, above and beyond the considerable scientific value of the data. I’m looking forward to seeing them,” said Stephen Gwyn, Science Data Specialist at the Canadian Astronomy Data Centre. “Ultimately, data from the Hawai’i telescopes—CFHT, Subaru, and Pan-STARRS—will turn the images into a three-dimensional map of our Universe.”

CFHT is not done with the UNIONS survey; it is scheduled to be observed through the 2024A semester. Nor were we done with *Euclid*, rather using MegaCam, *Euclid* was observed for 1.5 h on July 11 with a sequence of 26 images (3mn integration each). *Euclid* is travelling to Lagrange 2, a million miles away from the Earth and one of the Earth’s Lagrange points. Lagrange points are

spots where the forces of gravity of the Sun and Earth form essentially a parking spot for satellites where they sit with minimal orbit corrections. The *James Webb Space Telescope* is also at L2. In the July 11 images *Euclid* is the oblong shape moving through the stars. It’s moving faster than the stars, which is why we see motion in the image. When CFHT takes images of close objects in the Solar System, there are two choices—move the telescope at the same speed as the object across the sky (which makes the object its actual shape and the stars look funny) or move the telescope at the speed of the stars (which makes the stars round and the object oblong). In this case, the telescope couldn’t move fast enough. In the image, *Euclid* is “only” about 920,000 km away, so it’s oblong, and the stars are round. The telescope is too small for us to detect its actual shape. ★

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

John Percy's Universe

Astronomy Education around the World



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

In my last column, I argued that we humans should care about the cosmos and make sure to include astronomy in our formal and informal education curricula. This (in theory) is where everyone should learn about the wonders of the Universe. It is estimated that there are presently almost two billion students, at all levels, worldwide. For many of them, astronomy is in the curriculum. But how well is it being taught—if at all? How can the situation be improved? This is an ongoing concern for astronomers and their professional organizations. From 2023 May 10–12, 180 astronomers from around the world gathered, in person or virtually, at *AstroEdu 2023* (astroeducon.org/2023) in Toronto to address these questions.

AstroEdu 2023 was held at the University of Toronto, hosted by the Dunlap Institute, and sponsored by the International Astronomical Union (IAU: iau.org). The theme was “Bridging Research and Practice.” There were three keynote addresses, a panel discussion on the future of astronomy education, dozens of invited and contributed in-person or virtual talks, 14 workshops, dozens of in-person or virtual poster papers (conveniently projected onto the walls at lunch time). All this was enhanced in the hybrid mode with Zoom and Slack to enable real-time discussion, and superbly managed by Julie Bolduc-Duval, director of Canada’s flagship national, bilingual *Discover the Universe* program for teachers. My poster (Percy 2023) reviewed the highlights of my 60 years in astronomy education.

Given the challenges of travel to the conference—cost, visas, the lingering pandemic, travel disruptions, and carbon footprint—virtual participation was an excellent alternative. Registration fees were scaled to the participant’s country’s Gross National Income, being \$25 (plus GST) for virtual participation from the lowest GNI countries.

The primary themes were, of course, astronomy-education research, best practices in astronomy education, and how to bridge the two. But some other topical themes arose, notably cultural (including Indigenous) astronomy, interdisciplinary connections, the challenges of astronomy education in the developing world, and the use of remote telescopes and other technology to experience the thrill of discovery.

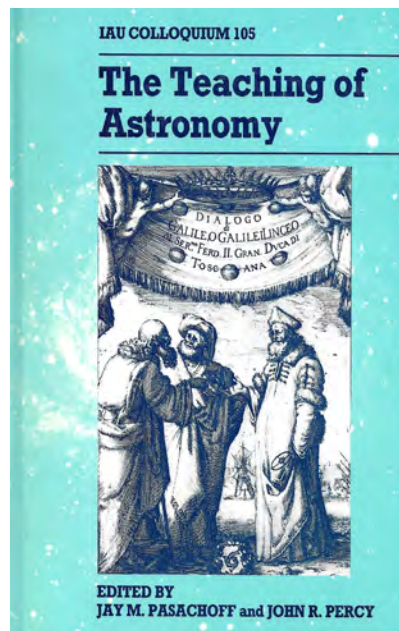


Figure 1 — The proceedings of the first IAU conference on astronomy education, hosted by Williams College, Williamstown MA (Pasachoff and Percy 1990).

Why Bother?

Why be part of an international astronomy education community? To meet “kindred spirits” from elsewhere, including

the leaders in the field; to share knowledge and experience; to learn new/better things about teaching and learning; to see how things are different—or the same—across the world; to broaden our cultural horizons; to potentially have opportunities to help astronomy educators in less-developed countries; to thereby derive the satisfaction of being a good global citizen; and to potentially increase the diversity of astronomy by enabling the training of young astronomers in all countries.

How it Started

The IAU established its Commission (interest group) on the Teaching of Astronomy in 1964. I joined in 1973 and was a Canadian representative for many years. I served in many other roles, including President from 1994 to 1997. The Commission undertook a variety of projects and programs: international schools for young astronomers, exchange of astronomers, loan of books and journals, a travelling telescope, and a newsletter—which I edited from 1985 to 1998. We organized regular conferences (like *AstroEdu*) for which I edited/co-edited the proceedings of five of them, including the first one, held in Williamstown, Massachusetts, (Figure 1, Pasachoff and Percy 1992) in the age before widespread internet access. When the world’s astronomers gathered for a General Assembly every three years, we educators met, presented, discussed, and planned. But all of this was done by volunteers!

How it's Going

The IAU’s education program looks very different now. There is an Office of Astronomy for Education, based in Germany (astroedu.org). It has gradually grown since its conception five years ago, adding programs, projects, and staff, thanks to foundation support. There are centres or nodes in Cyprus,

Egypt, France, India, Italy, Republic of Korea, Nanjing (China), and Nepal, helping to make the IAU's work more relevant and effective, locally. There is a worldwide system of small teams of National Astronomy Education Coordinators (NAECs). Canada's is chaired by Julie Bolduc-Duval; I am a sort of "emeritus member." There are still conferences, with proceedings, as well as Shaw-IAU Workshops, supported by the Shaw Prize Fund.

The AstroEdu Conference Program

The comprehensive program was developed by a Scientific Organizing Committee, chaired by Urban Eriksson (Sweden)—no mean feat. The Local Organizing Committee was chaired by my colleague Michael Reid; I was a member.

There were three outstanding keynote presentations. Julia Plummer (Penn State University) spoke on spatial thinking in astronomy education research, and also led a workshop on practical strategies for astronomy education research. This was important, given most astronomers' lack of experience in this field. See Percy (2015) for a brief review of astronomy education research. Pierre Chastenay (Percy 2022), Canada's leading astronomy education researcher, presented an excellent example—a research project on teaching seasons in school by using data mining, analysis, and modelling. These are the same processes used by astronomers in their research.

Michael Fitzgerald ([Las Cumbres Observatory](#)) spoke on considerations for, and barriers to implementing astronomy innovations into the K-12 school system. It echoed some points that I made at another conference, many years ago (Percy 2003). There is a very big challenge when it comes to teacher training; very few teachers have any background in astronomy, or astronomy teaching.

As well, Carola Knockwood (Nova Scotia Ministry of Education) spoke on *Etuapymunk*—loosely translated as "two-eyed seeing"—as a guiding principle in dealing with Indigenous knowledge in the curriculum. Her specific work is with the Mi'kmaq Nation of Atlantic Canada. Her topic is front and centre in school science curricula in Canada.

Carola's talk was one of several on aspects of Indigenous and cultural astronomy. Professional astronomers tend to see astronomy mainly as a science, but it has so many other connections to culture—its use as a clock, calendar, and compass; its connections with spirituality, and to the arts and humanities. STEM (science, technology, engineering, math) has become STEAM, where A stands for arts. All these will depend, of course, on the culture under discussion—Indigenous culture, for instance.

As one example, astronomers from McMaster University's W.J. McCallion Planetarium described a planetarium show about Indigenous astronomy, co-developed and co-delivered

by a local Indigenous elder (1). This was one of the few papers about planetaria; there were many at the Williamstown conference in 1989. Interesting and somewhat puzzling.

Heidi White (Dunlap Institute) described the use of place-based learning and Indigenous astronomical knowledge in K-12 education, and also introduced *Astrodigenous* (2), an online collection of resources for teaching and learning about Indigenous astronomical knowledge.

Linda Strubbe, an education consultant from B.C., described PASEA—the Pan-African School for Emerging Astronomers—and the use of inquiry-based teaching there. PASEA (3) was co-founded by Canadian astronomers, including Linda, and is co-sponsored by the Dunlap Institute. Two students from Africa are now graduate students in astronomy at the University of Toronto. Linda also led a workshop on equity and inclusion in astronomy education—yet another important and timely topic.

Among the other timely presentations were one by Rupinder Brar (Ontario Tech) on a novel method for teaching large astronomy courses online. Hundreds of Canadian astronomy instructors and teaching assistants have struggled with this challenge during the pandemic. And Martin Connors (Athabaska University) spoke on the implications of artificial intelligence in astronomy teaching. Marie-Eve Naud (UMontreal) described methods and resources for teaching about exoplanets—one of the hottest topics in 21st-century astronomy (and much more exciting to students than seasons and Moon phases).

There were a few papers that appealed to me for personal reasons: "Astronomy Education for Elderly Learners" by Shigeyuki Karino (Japan), partly because I have given many courses and presentations for this group, and partly because I was the most elderly participant at the conference—at least in person!

There were several presentations from the developing world which were particularly inspiring, given the challenges of teaching astronomy there. Shahrzad Mirsoltani gave one—a virtual presentation on using smart-phone digital technology to bring the Universe to children in Iran.

Joseph Wilson spoke about a course that he gives at York University: "The Anthropology of Outer Space," an ultra-interdisciplinary approach to engaging undergraduates in space studies. In 1999, Joe (then an undergraduate) and I co-organized yet another international conference on astronomy education and co-edited the proceedings (Percy and Wilson 2000).

I apologize for not mentioning more of the excellent papers at *AstroEdu 2023*, but you can find summaries of them all at astroeducon.org/2023

Final Reflection

I joined the IAU and its Commission on the Teaching of Astronomy in 1973, exactly 50 years ago. *AstroEdu 2023* was therefore a fitting reminder, for me, as to why I became involved in international astronomy education in the first place. In this sense, my astronomical career has come full circle. ★

Endnotes

- 1 planetarium.physics.mcmaster.ca/available-shows
- 2 AstroDigenous: astrodigenous.ca
- 3 PASEA: paseafrica.org/home

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John Percy FRASC is a very active Professor Emeritus in Astronomy & Astrophysics, and Science Education, at the University of Toronto. He is a former President (1978–80) and Honorary President (2013–17) of the RASC.

Great Images

by David Chapman



Asterism: Muin and the Seven Bird Hunters. The Mi'kmaw story Muin and the Seven Bird Hunters is told using stars from the two official I.A.U. Greco-Roman constellations, Ursa Major and Boötes, so only in this sense can the Indigenous grouping of 11 stars be considered an "asterism."

Location: Keji Dark Sky Preserve, NS Date & Time: 2015 September 7 @ 8:04 p.m. ADT. Camera: Canon EOS REBEL SL1 on tripod ISO: 1600. Lens: EF-S 17–85mm f/4–5.6 IS USM @ 17-mm Aperture and Exposure: f/4.0, 30 s

Meteors Scratch the Sky and NGC 663



by David Levy, Kingston
& Montréal Centre

Meteors Scratch the Sky

Despite what you read online, it is possible to think of meteor watching as one of the most boring things you can do with the night sky. No cosmic connection, no postulating about the origins of the Universe, no understanding of what dark matter might entail. When we look for meteors, we are in our own celestial backyard. We usually do not even use a telescope or binoculars; we just sit on a comfortable lawn chair looking up at the sky. Even if we spot a shooting star as bright as the brightest of stars, it is only a large speck of dust that is probably only a few dozen miles above our lawn chair.

So why bother with watching meteors at all? Actually, it is because they are so close, so local, that makes this activity unique. A meteor may be a large speck of cosmic dust, but it strikes the Earth's upper atmosphere at a velocity of 65 km/s (40 mi/s). And that is precisely what I saw, 44 times, on the beautiful night of 2023 August 12.

That night began with the usual thickness of clouds, typical of the Arizona summer monsoon. But the clouds rapidly dissipated. Instead of clouds, stars began to appear. Well before midnight, I was out with Eureka, my 300-mm (12-in) diameter telescope with which I would complete 2 hours of comet hunting before the night ended. One hour before midnight, another before dawn. In between, I counted my 44 meteors, one of which is in the accompanying picture.

The Perseids of 2023 were a very good meteor shower, but not the best. In November 2001, Wendee and I were in the Australian outback during the peak of that year's Leonid meteor shower. We gathered on the shore of a dry lake bed and watched carefully as Leo the lion reared its handsome head above the eastern horizon. Then, silently and swiftly, a bright shooting star appeared in the east, made its way across the sky, then slowly vanished in the west. One watcher said it all: "This trip was worth it!" A few minutes later, a second meteor did almost the same thing. After that, the meteors came thicker and more often until, at around 3:00 in the morning, they suddenly began pouring out the sky at the rate of about one meteor per second. One observer even saw a meteor after the Sun rose.



Figure 1—Perseid meteor photo from August 12.

What caused this burst of shooting stars? It appears that they originate from a comet. In December 1865 and January 1866, that comet was discovered by the German Wilhelm Tempel and Horace Tuttle of the United States. Because its orbit was identical to the orbits of the meteors, it was subsequently identified as the "parent comet" of the Leonid meteor stream. Moreover, because the comet passes close to Earth every 33 years, it was connected to the great meteor "storms" of 1833 and 1866.

In a similar way, Comet Swift-Tuttle, discovered in 1862 by the Americans Louis Swift and Horace Tuttle, was determined to be the parent comet of the Perseid meteors. As I watched them that unforgettable night, I was struck by the awe these tiny specks can generate as they race through our atmosphere. I was struck also by the wonder they generated in my mind: these always-welcome visitors from space invariably enchant my soul.

A final note: One night in 1833, when Abraham Lincoln was a young lawyer, a deacon friend pounded on his door and woke him. "Arise, Abraham," he yelled. "The day of judgement has come." Lincoln leapt out of bed and strode to a window, and he saw countless shooting stars. Shortly after he became president, when several states left the union, Lincoln told this meteor story to some visitors. As he watched the falling stars in wonder, he also saw that the familiar constellations were still there in the sky. "The world did not come to an end then," he said wisely. "Nor will the Union now."

A fellow citizen who lived at the same time as Lincoln, and who likely admired and respected him, was Carl Schurz, who would be elected to the U.S. Senate a decade later. On 1859 April 18, on the eve of the American Civil War, he gave a lecture in Boston's Faneuil Hall. He said: "Ideals are like stars; you will not succeed in touching them with your hands. But like the seafaring man on the desert of waters, you choose them as your guides, and following them, you will reach your destiny."



Figure 2—NGC 663 by Dominique and Gerald Mackenzie, Montréal Centre

NGC 663

One of the first astronomy books I ever read was John Benson Sidgwick's *Introducing Astronomy*. The book was published in 1959, a year after his death. In it was a large section in which each constellation was introduced, along with interesting things to see in each one. I particularly recall Cassiopeia, in which, between the two fainter stars Delta and Epsilon Cassiopeiae, lies the open cluster NGC 663. I first saw that cluster during the late summer of 1962. All Sidgwick had to say about it was that it can be spotted through binoculars. It didn't look like much, but I did spot it and then promptly forgot about it for more than 60 years. The other night, while conducting my search for comets, I encountered this star cluster again. This time it was one of the loveliest things I have ever seen. It moved me to tears.

I have since learned that NGC 663 is a grouping of about 400 mostly big, bright, bluish suns. On a really dark night it might even be visible with the naked eye. An unusual feature is that the cluster happens to be positioned directly in front of a molecular cloud, which somehow blocks the background

stars and allows the cluster to be even more beautiful. In a field of view already rich with stars in the Milky Way, the cluster stands out like a heavenly flower filled with diamonds.

I do have more to say about Sidgwick. In my youth I considered him a famous astronomer, but he is known mostly for the few books he wrote, especially *Introducing Astronomy*. Sidgwick enjoyed wide interests. He loved to hitchhike across the United States and Canada, and he edited a book of Walter Savage Landor's shorter poems. Landor, Sidgwick's subject, had an unusual life, getting expelled both from Rugby School and from Oxford, where he allegedly shot a gun in his dormitory room. Reading about him led me to his delightful poem "The Evening Star"

Thy star O Venus! often changes

Its radiant seat above,

The chilling pole-star never ranges—

'Tis thus with Hate and Love.

And 'tis thus I return to NGC 663, a cluster of stars that warms my heart. Where have I been for the last 60 years, religiously watching the sky, searching successfully for comets, enjoying many far-off stars and galaxies, but largely ignoring one of Nature's most wondrous splendours? ★

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.

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Binary Universe

Deep-Sky Planner



by Blake Nancarrow (London Centre)
(We are saddened to announce the sudden passing of Blake who succumbed to cancer on Sept. 1. He will be sorely missed.)

This entry belongs to a special category: planning. There are few applications dedicated to observing session planning.

These astronomy planning tools let you:

- plan an observing session days or weeks ahead
- create new lists based on previous ones, manual entry, and automated routines including currently visible comets and novae
- take into account the date, time, location, likely weather, and capabilities of the observer
- present session targets in a logical way for improved views and signal-to-noise ratios
- aid the astronomer using advanced star-hopping techniques
- aim the go-to telescope to the next target, if required
- act like a checklist, showing progress through the evening
- allow corroboration and logging of targets, including actual conditions and updating life lists
- encourages sharing, e.g. your list of bright edge-on galaxies might be of great interest of others

This time around we showcase the planning tool *Deep-Sky Planner* (DSP) written by Phyllis Lang of Knightware software.

The author graciously provided a complimentary copy of the software. Normally, it would be purchased from knightware.biz/dsp at \$107 USD.

Hump Day

It's hump day, and you're thinking about the weekend! You've been watching the weather, and it's looking glorious. Finally, favourable conditions during a new-Moon phase! Hopefully the smoke will abate. You've been closely watching the distracting Clear Sky Chart and it's improving.

You've set your mind to getting some good astronomy done on the weekend. And that means hitting the ground running Friday evening. One must make use of every precious moment during the short summer evenings with just a few hours of significant darkness after astronomical twilight. As long as you can stay awake.

You fire up our planning tool, DSP. You will make a new observing plan for the weekend with new targets not previously seen, with objects to revisit, to get a better look at,

and because they look cool. That comet you heard about, you should give it a go, so we'll look it up and make sure it's on our list.

You're also chipping away at the RASC Finest NGC observing certificate program. For these you want to work carefully and slowly, take your time, examine them as they cross the meridian, maybe do a sketch, get some good notes for the logbook. That list is already in the DSP application, so you just need to copy some good candidates, some well-placed targets.

You can start building this plan now actually, over the next couple of days, so that you're not scrambling on Friday night in darkness while setting up the telescope.

Updating

It's been a while since you used DSP. Via the *Help* menu command, you discover there is an update available. You click the *Get Update* button, and the file is downloaded in short order. You run the update program and relaunch DSP. Sometimes the database needs updating but that's automated. Easy peasy. It is comforting to know that Phyllis actively works on the application, fixes bugs, adds features, vets source data errors, and liaises with her devoted user community on groups.io.

You are up and running with version *Deep-Sky Planner* v 8.3.4.0 as of March 2023.

New Site

Something new. This weekend, base of operations will be your Centre's observatory. Looking forward to seeing the place and meeting up with local members.

This means you should create a new location in the planner. With that data, DSP will be able to calculate accurate rise and set times for the Sun, Moon, planets, and all your celestial targets. This site will also be recorded in your logs. Instead of the menu, you click the globe button in the toolbar to display the *Location Manager* window. You look up the latitude, longitude, and elevation, and create a *new Loc* within your *Area* or group, which is simply called *my sites* (see Figure 1). By browsing or searching, you can always use the built-in locations for cities around the planet.

Your other custom locations are saved and ready for future sessions, including one for the robotic imaging observatory. You've been meaning to create the Horizon Model for that location as it will better inform you of targets too low for the 'scope and dome.

Optical Train

Since you'll be using our own equipment, there's no need to add any telescope gear proper.

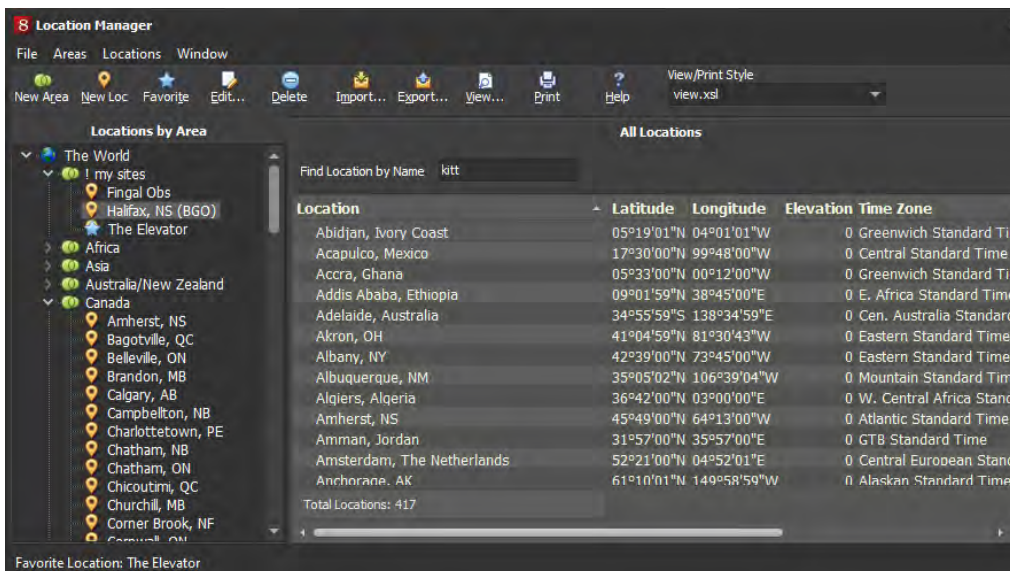


Figure 1 — Location Manager list in Deep-Sky Planner with presets and custom sites.

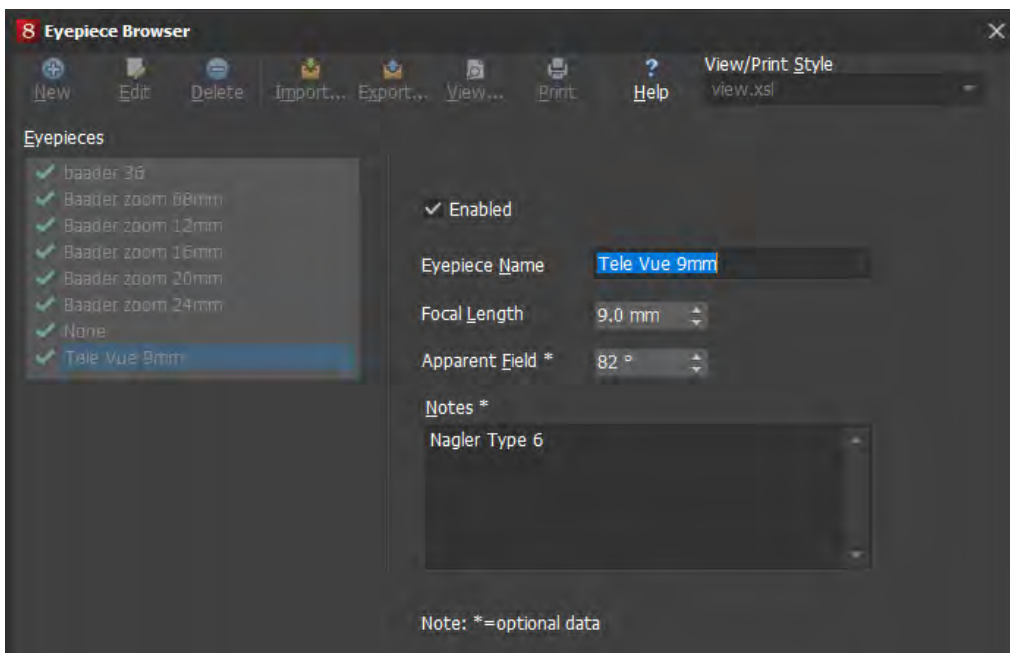


Figure 2 — Eyepiece Browser window showing personal equipment for predictive algorithms and logging.

Previously you had configured the optical tube assembly details, camera information, and particulars of filters and Barlows. But you recall not seeing a particular eyepiece in your profile. You forgot to add a recently purchased item. From the *Equipment/Observer* menu, you choose the *Eyepiece Browser* and add the item (Figure 2).

Make a List

You're ready to make an observing list for the weekend. You choose *File, New, Observing Plan*. The main screen is filled with the "document" with a tab label element at the top. You enter a *Plan Name* alluding to the weekend. The *Category* field is optional, but you select *Various Types* to reflect the general

nature of your weekend goals. Might be handy for searching later.

Then you use the *Edit Plan* button/menu to access the *Add* command. The *Observing Plan Object Editor* dialogue appears (Figure 3) and you use this, repeatedly, to include targets in the plan. Many common names are recognized along with Messier and NGC designations.

Your list is taking shape. You could add hundreds of items here, but you know that—realistically—if you're not rushing, you can expect to observe 30, 40, perhaps 50 objects over a weekend.

"Save early, save often," echoes in your thoughts. DSP crashes once in a while. One time you were working on a new list and had to start all over, from scratch! Given there's no automatic saving routine, you perform a *File, Save As* command and provide an obvious filename. Then, periodically, you issue a *File, Save* command. Unfortunately, there's no keyboard shortcut! However, the asterisk symbol serves as an on-screen reminder to save.

Whenever launching the app, saved files appear at the bottom of the *File* menu.

You need to add some of the certificate targets. From the menu, you choose *Community, Categories, Deep-Sky*. The *Community - Plan Library* window appears. It contains over 600 plans! While there's no search command, it is not difficult scrolling the alphabetic list to find the various RASC lists. A DSP contributor (sure looks like Phyllis) made the *RASC Finest NGC Objects* list in 2016 based on the listing in the *Observer's Handbook*. You use *Get* button to download the Deep-Skyplan file.

You immediately issue a *File, Open* command and from the *Community* subfolder you locate the RASC file. You note previously downloaded files for the *RASC Colourful Double Stars* and the *RASC Deep-Sky Gems*. At last, in a second tab in the main workspace, the RASC list appears.

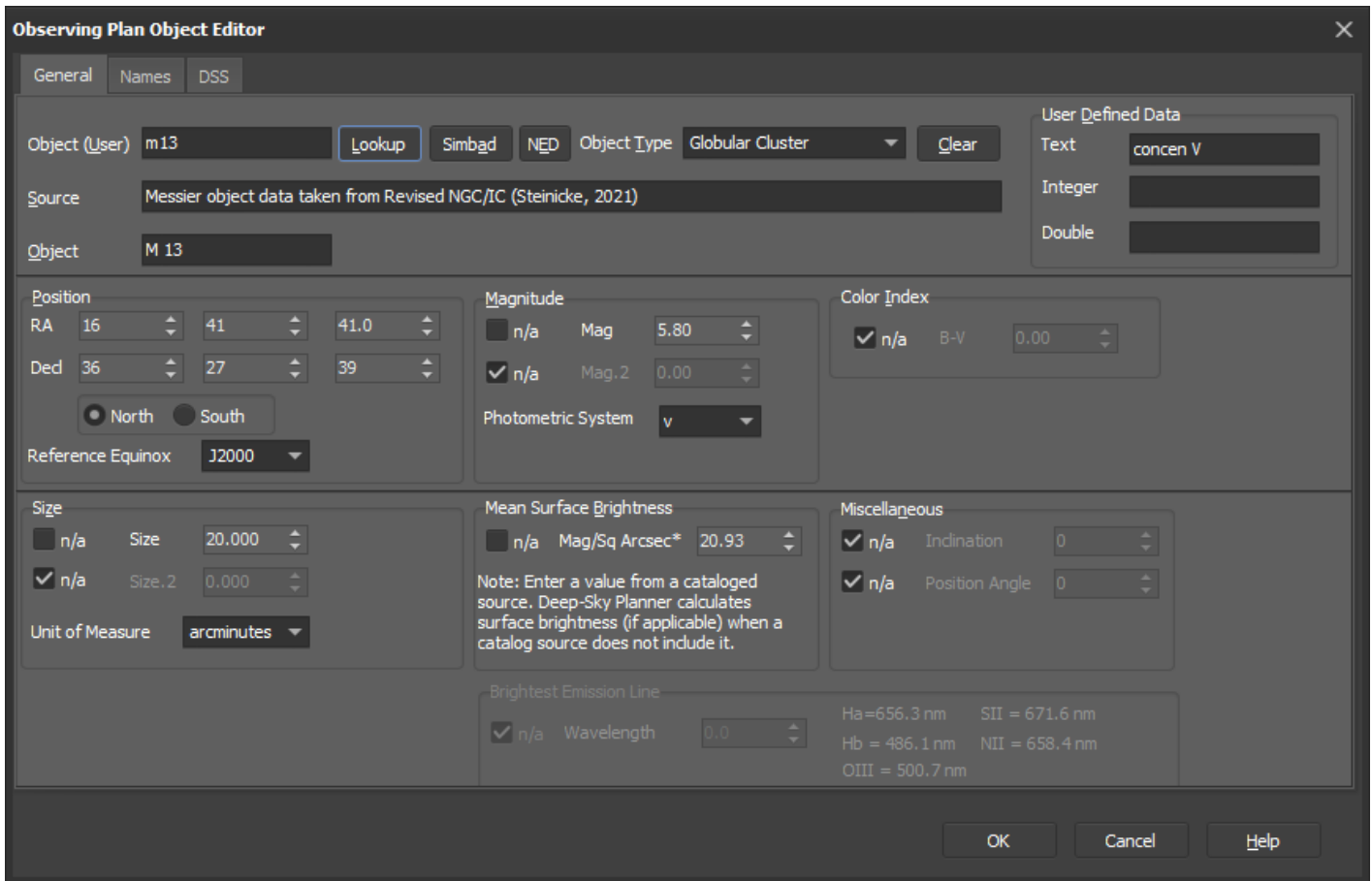


Figure 3 — Observing Plan Object Editor window is very helpful when adding objects to target list.

You use common list selection techniques such as Shift-Click and Ctrl-Click. While there's a shortcut menu deployed by right-clicking, it does not show copy commands! The keyboard shortcuts Ctrl-C and Ctrl-V are required to transfer items from one list to another. You perform the same process for old plans with celestial targets not successfully observed.

According to some astronomy sources, there are interesting phenomena occurring over the weekend at the king of the planets, transits, shadow transits, etc. Always fun to take in. You choose *File, New, Brief Planet Ephemeris*. You select Jupiter and mash the *Calculate* button. Copy and paste. A reminder to look at Jupiter. You'll need to set an alarm somewhere though for time-sensitive events.

You would love to get a glimpse of that comet. There are a number of techniques that may be used in the tool, such as the *Options, Orbital Elements Manager* command or the *File, New, Comet Search*. You used *File, New, Comet Ephemeris*, scrolled through the list of comets until you found the designation, and then you clicked the *Calculate* button. As before, you copy it from the comet tab to your weekend collection.

A very good start. You spot your boss heading toward your cubicle. Get back to work! You'll add more, but lunch break is over.

Friday Night

Tired from an intense work week. Tired from running the highway gauntlet. At least there's time to charge up with a decent meal as the sky slowly darkens. 'Scope set up on the Observing Pad. OTA cooling. Dew heaters at the ready.

The plan is to ... well, take it easy. Just start visually observing targets from the list built up over the week prior. No rush. You'll see what you can accomplish before fatigue sets in.

You're going to use the computer at the telescope, of course. It will be The Checklist. But it will also be the star chart. As you star hop, with your finder scope, you'll identify bright stars near your quarry, at your start point, and markers along the way. Then you'll zoom into the computer display (paper charts haven't figured that out) to do field identification against the ocular, as needed.

Dark Mode

To maintain your dark adaptation as best as possible, you'll run DSP in dark mode. It offers rich control of the interface. From the *Options* menu, you choose *App Style*. The *Charcoal Expressive* is your favourite muted palette, affecting the overall appearance. Next, you choose *Report Styles* to change the look

of the tables. There are three dozen pre-sets and you can roll your own. *DspRed* looks good with the red cell fill background colour with alternating banded rows. The currently selected row goes black.

In addition to using these thematic settings, you activate the *Night Vision* command, which applies a red tint over the entire computer screen! This excellent option covers the bases literally, reddening other Windows rogue programs running in the background. You drop the monitor brightness and let your peepers adjust further. The astronomy neighbours aren't protesting. You're happy.

The right way to view celestial targets is according to a few factors. Broadly, planets and galaxies and double stars setting in the west should have priority; you should tag them before they disappear. The observing list table exposes a number of columns (user selectable) to help you. You could sort by *Right Ascension* but the better field to use is *Best (Alt)*, which takes into account a variety of parameters, including type of object and atmospheric extinction.

You want to record sky conditions. Easily done by clicking the hamburger button in the toolbar area.

It Begins

First up, Messier 13. One of your favourites. That one's easy. You put the finder along the western edge of the keystone—ah-ha! You see the fuzzy ball right away. And there it is, the glorious globular in the ocular, several hundred thousand stars glommed together, hovering outside the galaxy. Didn't need no chart to find that; but you want to mark it observed, kicking off the evening rally.

You look to the right of the table. Useful tabs include *Daily Altitude* and *Yearly Altitude* (helpful during the evening, or long-range planning, for visual and photographic pursuits). You're interested in the *Observations* tab. To record tonight's observation of Messier 13, you click the *Add observation* button, which opens the very detailed *Observation Editor* dialogue.

Logging Those Logs

You note the *Location Method* used to reach your target and you set the *Eyepiece* used. The *Notes* field at the bottom allows you to record your impressions. You click the *Now* button before closing the box. The table shows the object observed to help you know what's completed.

You work through a few more targets before heading to the kitchen for some coffee. Chit chat with some members then back to the trenches.

A fellow observer asks what you're looking at. You offer a view and quote the NGC number. They ask where it is. You're

naming the constellation when you notice they're holding the *Pocket Sky Atlas*. "Hold on," you say. From the table, you locate the *PSA* column and give the page number.

Time to Hop

Next target is new to you and you've no idea where it is. You spot the *Constellation* column, but still... You right-click the object and choose the *Show Chart* command. An electronic chart shows, and you can now start the hopping plan to reach the prize.

All this is possible because of all the particular steps you performed after acquiring the program, when configuring *Deep-Sky Planner*. It is rather unique, arguably very clever, that DSP has no built-in charting capabilities. Clearly Ms Lang thought, "Why reinvent the wheel?" when there are so many excellent planetaria out there. Instead of drawing charts, DSP connects to *Cartes du Ciel*, *Redshift*, *Starry Night*, *Stellarium*, or *TheSky*.

Viewing Charts

You decided to use the free *Stellarium* **inside** DSP and that requires using the *Remote Control* plug-in. It was most convenient to have the server inside *Stellarium* start automatically on future sessions. On the DSP side, you chose *Options*, *Star Chart Programs* ... and designated *Stellarium* the *Favorite*. The tricky bit was ensuring the correct URL was specified for the TCP Connection. While the DSP help notes are quite good, an example and some clarifying notes here could have avoided headaches.

Now, when the *Show Chart* command is used, DSP minimizes and *Stellarium* snaps to attention (Figure 4).

You maintain full control over *Stellarium*. You zoom out, turn on the constellation lines and borders. It's tempting to turn on the *DSS* (Digitized Sky Survey) here but that'll give the photographic view of the field and you don't want any preconceptions. Similarly, you elect to not use the *DSS* tab and the *Refresh/fetch* button, which would load an image into *DSP*. Certainly, handy when you want to know what you're looking for.

Rinse and repeat. You view a few more objects when you realize your eyelids have been closed half the time. One more?

You try for your next target. Don't see anything. You repeat the star hop as you are uncertain of the end location. You're confident you're in the right area so you check the *Vis Pred* column. The visual predictor shows "Too Dim." Complex formulae within DSP are used to assess objects taking into account many parameters, including attributes of the observer. You are inclined to agree with the assessment—the object is getting low in the sky; on top of that, you're very tired.

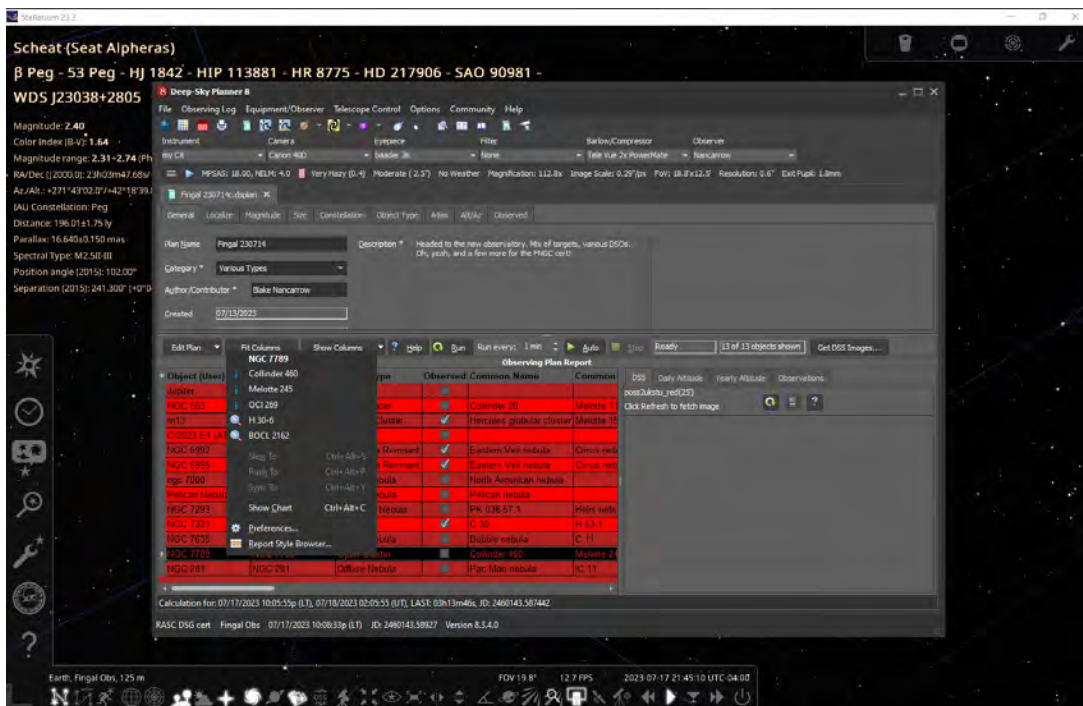


Figure 4 — Stellarium waiting in background while target selected from DSP list to be shown in chart.

You begin to close DSP. It prompts to save the changes to the observing plan file. Very important, yes. And the app reminds you to back up your data. Legacy database handling: it's always a good idea to backup your db file. The *Backup* dialogue shows the many items recorded including your equipment and user preferences. Everything's captured to a zip file, safe and sound. You need a cocoon.

Saturday Afternoon

It is time to turn ahead, for this evening's session, working from the same weekend observing plan. It's Saturday afternoon and you don't have to rush about in darkness. Your end goal tonight: more photons!

You're going to do two things to increase the time with your eyeball to the eyepiece: audio notes and mount control.

Working Faster

You'll use the audio recorder and speak or orate your impressions as you observe. You've learned that to make the Observed checkmark to appear in the list you just need to ensure Notes field is not blank: you'll drop a word or two ("viewed" or "view again").

The other thing, the big thing now, is to ensure you can drive the mount, use this powerful feature in Deep-Sky Planner. At the beginning of the session, you will connect the computer to the mount. Then as you consider your next target from the plan list, you want to tell DSP to make the mount slew to that object. You're not star hopping tonight.

That means you've gotta dig out the various cables and adapters needed.

Sharing a Plan

While chatting with a fellow observer, they ask about the objects you're planning to look at. They are feeling a little lost, not sure what to try. They're new to the hobby, have a handsome shiny new telescope, but are still learning the sky. You show your observing list. They like it, think it'd be fun, they could use a good sampler of interesting celestial objects.

Then they say, "Do you think I could view the list on my phone? I bought

SkySafari." You choose *File, Export Plan to App, SkySafari*, and click the *Save* button. You point out that DSP also supports NINA, Sequence Generator Pro, APT, and other apps. You email the file to your friend and then walk them through the peculiar sequence to access the file inside the SS app. They are tickled to see the list on their mobile device. Another happy camper.

You grab your data cable and attach it to the hand controller. You rummage through the bag of doodads and thingamajigs and spot the USB-serial adapter. You interconnect this to the data cable. When you plug in the USB-serial adapter to your Windows computer, you hear the familiar 3-step tone. You don't recall which USB port you used previously and rightly assume that Windows has assigned a unique communication port number (COM) which you quickly look up using Windows Device Manager. You memorize the COM number.

In DSP, you click the *Telescope Control* menu command and choose *Setup*. The *ASCOM Telescope Chooser* (natch) window appears. You see the correct ASCOM mount driver is active but click the *Properties* button. In the configuration window, you specify the COM port as designated by Windows. OK. Nap time.

Go Time, er ... Go-to Time

It's time to observe! The Earth has turned away from the Sun. The stars reveal themselves. You crave the celestial treats not yet viewed. And you are going to get your tech helping you reach your targets as quickly as possible. You choose the

Sunday Evening

Back home, reflecting on the weekend, you are very pleased. You know that you need a list to work from, it's a personal thing, you did it everywhere, home chores, project management activities at work. And you want challenges, new celestial wonders to take in. And for certificates and life lists, you want to be thorough, not miss or collect data overlooked. It proves helpful for visual astronomy and imaging projects.

Some people need a plan. DSP helps you make a plan, follow it, stick to it.

Deep-Sky Planner lets you do these things making for a joyful experience at the telescope.

Summary

A bit of an oddity, this software. There aren't many in this class, astronomical planning. Rivals include *SkyTools* (see Apr. 2015 *JRASC*) and *AstroPlanner* (Oct. 2016 *JRASC*).

Deep-Sky Planner is not inexpensive software. But for observers or imagers who need a plan, who want excellent logging, anyone who wants more photons, it is a good investment. Like *SkyTools*, it is for the Windows OS. *Deep-Sky Planner* is very accurate and precise and you appreciate knowing you are working with current and vetted data.

Bits and Bytes

Collimation Circles (Aug. 2023 *JRASC*) is undergoing rapid development (as I submitted my article to the editor!). The appearance of control screens is changing but hopefully you'll not be thrown off too much. Also, for convenience, the developer added a focusing tool to support Bahtinov masks!

Check out *Astrospheric* (Aug. 2018 *JRASC*), the very useful weather and sky conditions resource, website, and mobile apps! A new circular chart called *Astronomical Clock* (I love dynamic charts!) appeared on the website and you can add target classes to it. ★

The Journal Production Team sends condolences to all of Blake's family, friends, and colleagues at this difficult time.

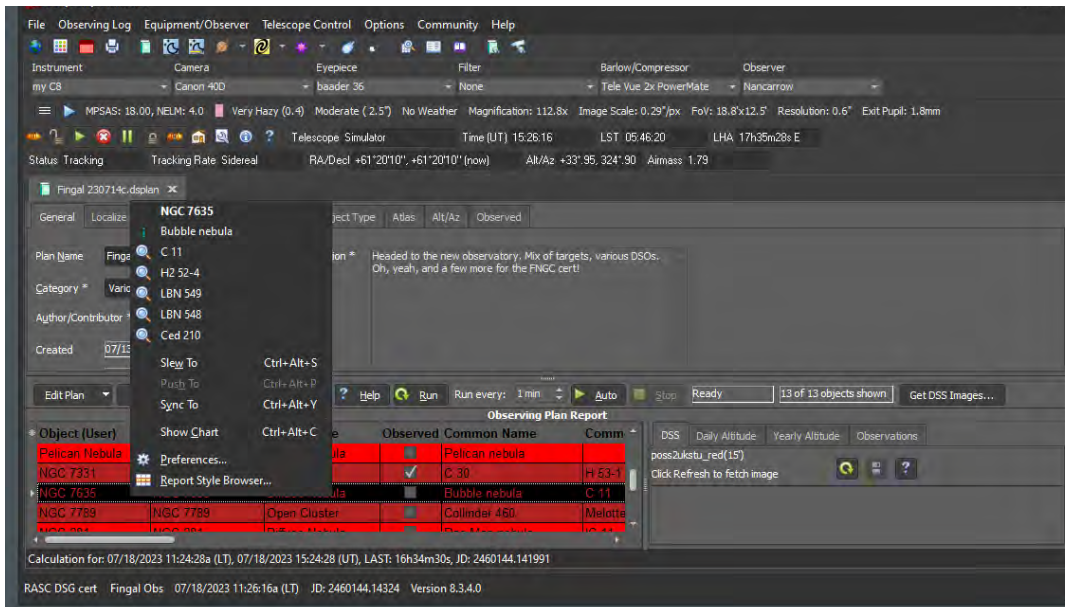


Figure 5 — DSP communicating with mount, Telescope Control toolbar active, target selected, ready to slew.

Telescope Control menu again. This time, you select the *Connect* command. Quietly, the screen jostles. The *Telescope Control* toolbar appears below the equipment and weather toolbars and includes many buttons, such as *Unpark Telescope* and *Stop Tracking*. There are also various status indicators such as Local Sidereal time. Everything looks good.

You scroll the observing plan, find your next object of interest, you right-click and choose *Slew to* (Figure 5). You note the keyboard shortcut, Ctrl Alt S; you'll use that next time.

And we're Off to the Races!

After a few hours of observing and sketching, you decide to call it quits. You've observed almost everything from your original list. And you feel good. Like completing a honey-do job-jar weekend list. Like closing out tasks of a project. You're tired but satisfied.

You use the *Sync to* command a couple of times through the evening to improve acquisition.

Many objects viewed included new sights, a few more doubles for the life list, and some interesting galaxies. The certificate items you'll include in a report for RASC. The wonderful views of the edge-on galaxies we imagine others might enjoy. In the morning we'll look to share a list and have it published.

Telescope teardown? You defer that to Sunday morning. For now, you disconnect the computer and mount. You click the *Park* button then *Disconnect*. All part of the graceful shutdown. As you don't need to keep mount configuration settings for Sunday, you immediately power down the mount.

Astronomical Art & Artifact

The Astronomical Landscape of Canada (ALC)



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Abstract

The Astronomical Landscape of Canada (ALC) is a curated citizen-science project aimed at creating an online descriptive inventory & guide to the sites of astronomical significance in Canada. It includes both manufactured and natural features of the landscape (e.g. observational facilities, and Earth-impact sites). Its growth will be cumulative as additional sites are added and new ones discovered or created; existing entries will be subject to continual revision as research advances. It is specifically designed without an end date. The genesis, models, nature, and goals of the project are described here, as well as ways to participate.



Figure 1 — Logo of the Astronomical Landscape of Canada. The design consists of the acronym of the project superimposed on a representation of the Manicouagan Impact Structure (craterexplorer.ca/manicouagan-impact-structure). Design by R.A. Rosenfeld.

The History of the Project

The green paper “Opportunities for Growth: the RASC in the Wake of IYA 2009” produced by the Society’s former Membership and Promotions Committee contained the genesis of the idea that the RASC could produce a guide to the astronomical sites located in Canada (Rosenfeld 2009, 11, no. 6). This was one among various possible programs that would enable the RASC to build on the momentum generated by the International Astronomical Union and UNESCO’s International Year of Astronomy 2009 (IYA2009),

Key to category site icons

	Impact site (astrolene)		Astronomical expeditions
	Collection(s) (museum)		Institution for higher education in astronomy, or a research institute
	Institution for popular education in astronomy		Site of notable, or unusual observation
	Astronomical monument, or building with astronomically themed decoration, or astronomically themed landscape architecture		Observational facility
	Astronomer's residence		Place associated with the development, production, or distribution of astronomical apparatus
	Historical plaque		Funerary monument (tombstone)
	Mathematical practitioner's premises		

Figure 2 — Key to category site icons. These icons provide a quick means to identify the type of site at a glance. The descriptions in the text of the entries provide more detail on the nature of the sites. Design by R.A. Rosenfeld.

a highly successful worldwide year of programming inclusively celebrating the collective global scientific and cultural achievements in astronomy, which in Canada was the cooperative work of the Canadian Astronomical Society (CASCA), the Fédération des astronomes amateurs du Québec (FAAQ), and the RASC (Hesser 2009)¹. The green paper didn’t go much beyond suggesting the creation of a guide to the astronomical sites in Canada—few of the details necessary for such a program were even mentioned. The few specifications seemed to suggest that this was a program to be realized by individual centres, without the aid of uniform standards and protocols, or the benefits of curation, or coordination at the national level. Print was to be the primary form of presentation, rather than digital media.

A more elaborated plan appeared in 2015, as one of the programs proposed for the 125th anniversary of the 1890 incorporation of The Astronomical and Physical Society of Toronto (predecessor of the RASC) in 2015, or the 150th anniversary of the 1868 founding meeting of the Society in 2018, should either be formally celebrated (Rosenfeld et al. 2015, 9, no. 11). The formulation “the astronomical landscape



Figure 3 — Morris Office I. This and the following figures illustrate the range of sites available in a single geographic area, in this case Halifax. This building is associated with the Morris dynasty of Surveyors General of Nova Scotia (ca. 1749–1851), and is possibly the oldest extant workplace for applied astronomy in the country. This image shows it at a temporary site in 2012 awaiting restoration. While the Morris Office is now at a more long-term site, this illustrates the case that some structures of astronomical importance may be in temporary locations, and this will be reflected in their ALC entries. In the key to category site icons this is a mathematical practioner’s premises (see Figure 2). Photograph R.A. Rosenfeld.

of Canada” appears there for the first time, and it is defined as “a resource giving access to the sites across Canada of astronomical history and heritage.” A few models are even cited. The 1890 anniversary was ignored, but the Society did decide to formally celebrate the sesquicentennial of 1868; as it turned out the ALC was not part of the programming in the end. Even though its projected costs were minimal, there was just too much going on otherwise for the project to be realized then.

The History Committee retained interest in the project subsequent to 2018, and decided to again consider its “development and implementation” given its “potential to enhance the landscape of resources for the culture of astronomy in Canada,” and the Committee noted that the ALC could offer “long-term opportunities for the involvement of Centres, and individual members.” The project was described in the following terms:

“The Astronomical Landscape of Canada [would be] a cumulatively compiled resource of sites significant to astronomical history and heritage across Canada, in the form of a web-based online catalogue illustrated with images, modern and historical, descriptions, and links to literature and other resources in print, and electronic media. It would include past and present active professional institutions, significant amateur observatories, sites



Figure 4 — Morris Office II (2500 Creighton St.). This figure shows the Morris Office with its exterior sympathetically restored. Despite the fact that in its present location it is removed from the original site where practical astronomers may have plied their trade, and in its current guise as housing it is far removed from that professional use, nevertheless it unquestionably merits a place on the astronomical landscape of Canada. It is not a public site, but it can be seen from the street. Photograph R.A. Rosenfeld.

of observing campaigns, sundials, astronomical instrument-making workshops, domestic and other buildings associated with figures from the astronomical past, buildings with astronomical decorative or design elements, realized, imagined, or conceptual astronomical landscapes, museums with significant astronomical content, planetaria, science centres, and Canadian Earth impact sites. The Astronomical Landscape of Canada could become a resource for the tourism sector of the Canadian economy (under the category of science tourism);” Edgar et al. 2020, 26.

Due to a variety of causes, such as COVID-19, and the limited time available which its designers could devote to the ALC, the project was not officially inaugurated till this year (www.rasc.ca/astronomical-landscape-canada). In light of the span of time covered by the entries (ca. four centuries and counting), and the projected life of the project, the delay of a few years in getting it off the ground may not seem significant over the life of the project.

What is the ALC, and What is its Purpose?

It is probable that people have been interacting creatively with the night sky from what is now known as “Canada” since the Paleolithic. Interactions of peoples, places, and sky have left their marks on the landscape, in vestiges both material, and conceptual. Besides the human alterations to the landscape in response to astronomical phenomena, some astronomical events can themselves alter the terrestrial landscape, via tidal interaction, or asteroidal, or cometary impact.



Figure 5 — Historical plaque marking the “original” site of the Morris Office (ca. 1273–1274 Hollis St.). This plaque, from the first decade of the 21st century, reveals much about this sort of document. Plaques, of whatever period and source, despite the great aura of authority endowed by their material form (traditionally stone and metal) and issuing authority (often governmental, even at a remove) should be treated as any other document and read with a critical eye. They pose a special challenge, because of the limited space available to convey information. And even recent plaques may not be based on the latest, or best research at the time of composition, or, if they are, new work may soon render them obsolete. Within a few years of this plaque being installed, new archival and archaeological work revealed that the Morris Office was not originally located where Charles Morris I (1711–1781) conducted his astronomical business, but that it was probably acquired by his successor Charles Morris II (1731–1802), and may have been turned to that use subsequent to Charles Morris I’s demise, despite what the plaque asserts. In the key to category site icons this is an historical plaque (see Figure 2). Photograph R.A. Rosenfeld.

The astronomical landscape to be discovered in Canada is more varied and less sparse than one might think. It includes the places associated with astronomers of the past (dwellings, places of education, research, and observation), natural features named after astronomers or astronomical phenomena, and places physically shaped by astronomical events. Much of the astronomical landscape of many regions of the country is a terra incognita, as it remains the preserve of purely local knowledge, or stands entirely unknown. There is much that remains to be discovered, and, once discovered, experienced.

The Astronomical Landscape of Canada (ALC) is intended to be a portal to sites associated with astronomy in Canada, an evolving information-rich guide mapping locations of interest. At the most basic level it will alert users to the existence of places, should they just be curious about what is out there, or should that curiosity become a desire to visit, for informed leisure, or research, or something in-between. As a cultural resource it can be sampled in passive, or active modes.

The ALC is curated in order to establish and maintain reliable scientific standards in the evaluation of evidence for the sites, and to ensure that the entries follow a standard format. The



Figures 6a-b — Old Burying Ground (Spring Garden Road and Barrington St.). There are monuments to several members of the Morris family in the oldest cemetery in Halifax (1749–1844). Mary Morris (†1789), the wife of Charles Morris I, was the matriarch of the dynasty, and her grandson Charles Morris III (1759–1831) was surveyor general (1802–1831). Their monuments show that relative chronology is no sure indication of relative condition of artifacts or sites in the ALC. Mary’s stone (6a) is in considerably better condition than that of her grandson’s (6b). And its iconography is less bland. This site is publicly accessible. In the key to category site icons this is a site of funerary monuments (tombstones) (see Figure 2). Photographs R.A. Rosenfeld.

element of crowd-sourcing comes from the necessary involvement of citizen scientists in proposing sites for inclusion, to build content.

Models

There are several models which have influenced the form and development of the ALC. The oldest is non astronomical, the venerable Victoria County History (VCH), founded nine years after the 1890 revival of the RASC (then the Astronomical and Physical Society of Toronto). The VCH was established with “the goal to produce a history of every parish in England” (VCH). The unifying theme of the VCH is location, which brings together disparate sorts of sites, the information attesting to them, and the information they in turn can convey as source material for historical purposes of many sorts. Two other models are astronomical. One is the UK based Society for the History of Astronomy’s Survey of Astronomical History, which itself is inspired in part by the VCH, and is the closest to the ALC in purpose and form of the models cited here (SHA). The other astronomical exemplar, Charles P.T. O’Dale’s Crater Explorer website, is a model of what such a web-based resource can be ([O’Dale Crater Explorer](#)). O’Dale’s site achieves an enviable level of clear and interesting exposition, richly informative illustration, and thorough documentation. The VCH, SHA Survey, Crater Explorer, and the ALC

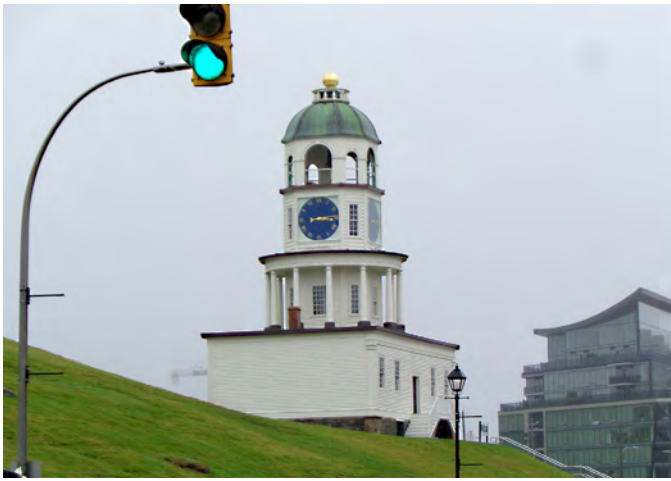


Figure 7 — Citadel clock (1799/1803-). This is an astronomical monument that was public from the time of its erection. It is also practical, in that it provided time for any who could see, or hear it. Of the sites listed here thus far, it (like the grave markers above) is still performing its practical function at its original site. It is publicly accessible. In the key to category site icons this is an astronomical monument (see Figure 2). Photograph R.A. Rosenfeld.

all have features in common but they differ in their parameters, subjects, and geographical range. And, although they have inspired the ALC, the latter is not a close imitation of the earlier projects.

Range of Sites

Eligible sites can be any of the following:

- birthplaces of important astronomers
- homes of important astronomers
- places where they were educated their workplaces
- natural features, or parts of the built environment named after astronomers
- places named after astronomical objects, or phenomena
- places where significant astronomical observations were made
- places where recurrent astronomical observations of cultural significance happen
- past or present observational facilities
- workshops where instruments were (or are) developed, and produced
- institutions devoted to popular education in astronomy
- institutions devoted to higher education in astronomy
- astronomical research institutes
- the seats of amateur and professional associations
- places where significant astronomical meetings happened
- institutions which research and display collections of cosmic materials (meteorites and impactites)
- museums of astronomical instrumentation
- libraries or other institutions with significant holdings of



Figure 8 — Comet weathervane (ca. 1835) atop St. George's Round Church (1801). This weathervane is said to commemorate the 1835 apparition of comet 1P/Halley. An astronomical feature atop a private building, it is fully publicly accessible, as it has been since its erection. Like the Citadel Clock, it too remains fulfilling its practical function at its original site. In the key to category site icons this is an astronomical monument (see Figure 2). St. George's crypt also holds the remains of one of the most remarkable practical astronomers active in Georgian Canada, Lieutenant Governor the Honourable J.F.W. DesBarres (1721–1824). Photograph R.A. Rosenfeld.

- media important for astronomy (logbooks, glass plates, rare books, printed ephemera, data centres)
- comet and asteroid impact sites (meteor craters/ astroblemes)
- architectural monuments (buildings, landscapes, sculptures) embodying and reflecting astronomical themes (including buildings of all sorts with astronomically-themed decorative, or applied art)
- sites of recurrent cultural events with astronomical themes
- space-science sites (preference is given to those whose activity directly advances astrophysics)
- sites that have figured in cultural expressions of astronomy in literature, fine, or performative arts, or sites whose names or practices refer to those cultural expressions

This list is not exhaustive.

Cultural Context

Complexity is found in the issues around the cultural context of the sites in the ALC, and how we relate to what history offers us. Many of the sites of science belong solely to the past,



Figure 9 — Halifax Dockyard Observatory (1828–1869). A good number of sites on the astronomical landscape of Canada have left scarcely a physical trace on the ground and may exist solely in documents. Many of these are still imperfectly known or are awaiting discovery. The Halifax Dockyard Observatory was one such site, but thanks to the work of Dr. Randall Brooks and Joel H. Zemel, we now know much more about an installation for practical astronomy at one of the major ports of North America which until recently had escaped any mention in the standard accounts of astronomy in Canada (www.rasc.ca/origins-halifax-dockyard-observatory). In the key to category site icons this is an observational facility (see Figure 2). The figure after Brooks & Zemel is a detail from a pen & ink sketch by Captain Michael Seymour done 1845 June 19, now in the Art Gallery of Nova Scotia.

but not all; some have continued into the present as active places for the production of science. All of these locations (of whatever period) are best viewed within multiple concurrent contexts; as part of the original cultures which brought them forth; and as cultural signifiers—either positive or negative—operating within later cultures. Think of non-hierarchically superimposed maps of cultural naming.

Cultural context has always been important, but open consideration of context has become even more important with increased calls for social justice, and demands for accountability from current institutions in light of their origins and legacies. A project such as the ALC is not immune from such considerations, for that is the world we now live in. Each generation must frame its own past. There is nothing new in this.

The starting point of the ALC is the “western” tradition that gave birth to the RASC. Given our origins, and the long trajectory of the intellectual commitments and approach stemming from them, this is the natural place to commence our story. There are other cultural astronomical landscapes mapped onto the same geography, with the First Nations’ ones obviously taking temporal precedence. But there is more context to account for beyond those of the “western” scientific culture (assuming one can even speak of it as a monolith), and the many First Nations topographies. Every culture that was formative for someone who has arrived here from wherever has its astronomical aspects, and, consequently, there



Figure 10 — Front facade of the Nova Scotia Discovery Centre (1990–, current building 2017), with the frieze of superimposed lunar map sections (1215 Lower Water St.). The astronomical past is inextricably linked to the astronomical present as we move into the future, as is evident from our current practice (just think of lunar nomenclature). A good number of the sites in the ALC are of the present, such as the Discovery Centre (thediscoverycentre.ca). The promise of its astronomically attractive front announcing that “science happens here” is realized via its Dome Theatre (planetarium), and other active programming, often delivered with the assistance of the Halifax Centre of the RASC. An institution such as The Burke-Gaffney Observatory of Saint Mary’s University, a very active site for astronomy (academic research and education and public outreach) in the city, also obviously belongs in the ALC (observatory.smu.ca). In the key to category site icons the Discovery Centre is an institution for popular education in astronomy, and The Burke-Gaffney Observatory is an observational facility (see Figure 2). Photograph R.A. Rosenfeld.

is the potential for those cultures to leave their marks on the astronomy read into the Canadian landscape. It should be possible for them to find a place in the ALC.

As different cultural traditions can coexist in the landscape, so they can coexist in people. An astronomer can live concurrently in more than one astronomical tradition if she, he, or they (sic.) is part of them.

Structure of the ALC, and the Structuring of the Entries

The entries are grouped by modern political or administrative jurisdictions (i. province, or territory; ii. city, or municipality, or town, or township, or informal settlement), and then ordered alphabetically within them. The entries include the following information:

1. name of the site
2. the site type (also indicated by an icon for quick reference)
3. its geographical location
4. date (when known)
5. brief statement on its significance (single sentence)
6. description of its history and physical features

7. indication of whether the site is now private or public
8. sources (bibliography)
9. illustrative material (images or maps)

Exercising Good Sense

A First Nations' site under the cultural management of a First Nation should not be submitted without their permission.

If a site is on public land, then it is probably permissible to visit it, but it would be prudent to check on the status of the site by consulting the responsible authority; this is almost always discoverable through a web search.

If a site is in private hands, then respecting the owners' privacy should be paramount. There may be the option to contact them to inquire whether their site can be visited. A web search may disclose this.

Good sense and due caution should be exercised at all times when visiting a site. The advice and directions of those who run the sites should be followed at all times.



Figure 11 – Map of some of the Halifax sites listed in this article, identified by figure number. Map adapted by R.A. Rosenfeld.

Users of the ALC visit sites at their own risk, and the RASC accepts no liability for any accident or mishap that may occur in the course of a visit.

Participation

RASC members, and the general public can submit sites for consideration by using the form available at rasc.ca/rascforms/alc-suggestions. Any reader of this article interested in being more actively involved with the ALC is invited to contact the project via the present author. No one person possesses the omniscience to know the landscape of astronomy in Canada equally well for all times and places, peoples, and cultures. The cumulative success of the project depends on the suggestions of people across the country with an interest in the astronomical culture of their area. Researching how astronomy shows up in the local landscape has the potential to reveal local traditions and cultural expressions which may not occur elsewhere, and which may not be known to those interested in astronomical culture in the wider region. The addition of those sites and the practices which created them will help to give the ALC a meaning beyond being a mere list. The project has the potential to change how people see the cultural landscape of Canada. ✨

Acknowledgements

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

Endnotes

- 1 IYA2009 grew out of the efforts of the Italian astronomical community to mark “the 400th anniversary of the first use of the telescope by Galileo Galilei” (UNESCO 2005).

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Pulsars Bobbing in a Sea of Spacetime



by Erik Rosolowsky, University of Alberta
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Einstein's general theory of relativity, published in 1915, is one of the crown jewels of modern physics. This theory is an elegant mathematical formulation of how the force of gravity can be reinterpreted in terms of the curvature of space and time. This mind-bending interpretation of gravity leads to amazing predictions that keep getting confirmed. Recently, astronomers have used observations of pulsars from more than 15 years to measure gravitational waves predicted through general relativity, which trace the presence of supermassive black holes across the Universe.

While counterintuitive, this theory provides a model that allows physicists to make predictions for the motion of light and matter in a gravitational field. These effects are particularly noticeable near dense objects like black holes or white dwarfs. However, even in comparatively weak gravitational fields near the Earth, general relativity is required to understand the motion of all types of light from radio waves to gamma rays. Notably, getting a position on the Earth exactly right through communicating with Global Positioning System satellites requires including the small corrections from general relativity.

Physicist John Wheeler once summarized general relativity by stating: "Spacetime tells matter how to move; matter tells spacetime how to curve." The first part of this summary visualizes the motion of matter through space as the inevitable forward progress of an object through the conflation of space and time: spacetime. If the object is motionless, it moves forward through time. If it is moving, this is moving through both the space and time parts of spacetime, and objects always take the shortest (carefully defined) path through spacetime toward their futures. Then the presence of matter also shapes the spacetime around it, causing other objects to experience curved paths around a massive object. These curved paths then appear as ballistic trajectories or orbits under the effects of gravity. The mathematics of this peculiar view of motion and gravitation are what make general relativity such an effective theory.

Wheeler's summary is a useful first step, but it is incomplete. The first revision is another Einstein insight: matter can be converted to pure energy and vice versa, and the equivalence

between these two is summarized in the oft-quoted $E=mc^2$, where c is the speed of light. Combining this with Wheeler's summary: this means that energy alone can also distort spacetime. Finally, a curved spacetime itself can carry a form of energy in the equivalent of a gravitational field, which in turn can distort spacetime around it. This interaction of spacetime with itself means that curvature can move over the course of time, leading to one of the most peculiar features of general relativity: the gravitational wave. The mathematics implies that spacetime can be thought of as elastic, so that a distortion of spacetime from passing mass or energy will then flow outward from the disturbance like waves across the surface of a lake. While all these summaries are technically flawed, these are useful pieces of intuition for understanding why gravitational waves can occur.

Gravitational waves were so counterintuitive that Einstein himself did not believe they occurred. However, like all predictions of general relativity, gravitational waves were eventually detected. The first inference for gravitational radiation came from the study of pulsars. Pulsars are neutron stars, the ultradense cores of stars left behind after a supernova explosion. Neutron stars pack the mass of a star like our Sun into the size of a city like Edmonton. When pulsars spin, they send out a narrow beam of radio light that rotates around, like a lighthouse. When the beam of light passes across Earth, we see a pulse of radio radiation, hence "pulsar." Because of their huge mass and small radii, pulsars are excellent spinning tops, and they keep excellent time. We can measure the timing of pulses as they arrive at Earth to exquisite precision, counting off literally billions of pulses to gain a precise measurement of the time of arrival.

The first sign of gravitational waves came from pulsars, watching two pulsars in orbit around each other. Since we could study the timing of the arrival of one of the pulsars as it moved around its orbit, radio astronomers could deduce changes in the orbit with high accuracy. They noted that the orbit appeared to be decaying at a rate consistent with the predictions of general relativity. Specifically, the binary system was losing energy and the two pulsars were spiraling in toward each other. The energy loss from the binary was predicted to come in the form of gravitational waves. While all accelerating objects technically do create gravitational radiation, only extremely massive objects like binary pulsars moving around each other quickly generate a measurable amount of radiation that we can detect on short timescales. Despite the strong suggestion, this pulsar evidence was not clear proof that gravitational waves exist since we did not see a wave passing by.

The direct evidence for gravitational waves instead came from a very different system: the Laser Interferometer Gravitational-Wave Observatory (LIGO) made the first detection.

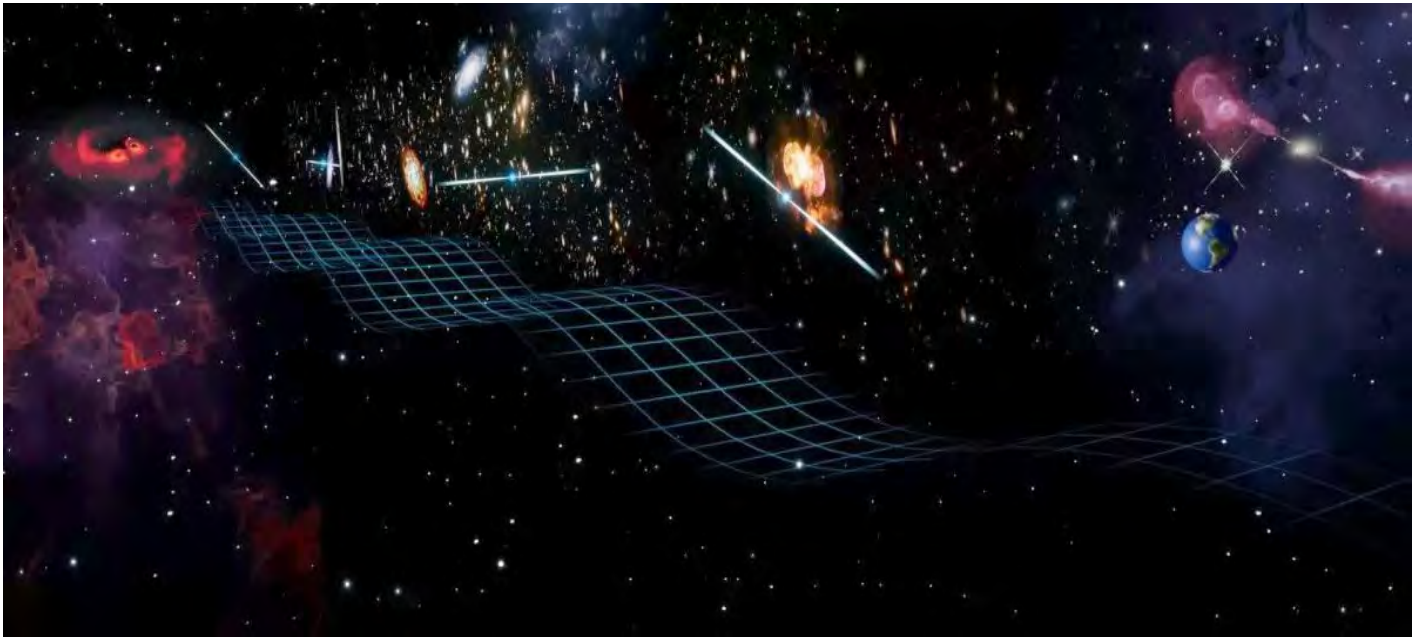


Figure 1 — Artist's conception of using pulsar timing arrays to detect the passage of gravitational waves near Earth. Image credit: US National Science Foundation/Keyi "Onyx" Li

Here, LIGO measured the separation between test masses at long arms of a laser interferometer, which is a device that uses light to measure the separations between objects carefully. As a gravity wave passed by, the spacetime holding the interferometer was compressed and then expanding in the predicted pattern of a gravitational wave. LIGO detects waves from massive gravitational-wave events like two black holes merging. LIGO's first detections in 2015, one century after general relativity, showed that gravitational waves did indeed exist and opened a new way to view the Universe.

More recently, a new way to detect gravitational waves has had its first detection. Here, astronomers are again using pulsars. But this time, the pulsars are found around us in the Milky Way Galaxy instead of being found in a single binary system. These pulsars form a natural way to observe gravitational waves on a vaster scale than LIGO. Pulsars are essentially an array of clocks scattered around the galaxy. Since pulsars are so precise, we know when individual pulses will arrive to sub-microsecond precision. If the pulse arrives a little early or a little late, something must be perturbing the passage of the radio wave as it arrives here on Earth. There are several possible causes for these changes to the time of arrival, one of which is gravitational waves distorting the spacetime between the pulsars and the Earth. Using these arrays of clocks as a gravitational-wave observatory takes patience since astronomers have to observe each pulsar over a sufficiently long time that other causes of delay will average out over time, leaving only the signal of gravitational waves. Figure 1 shows an artist's conception, trying to illustrate this process.

The NANOGrav collaboration has been observing an array of pulsars for 15 years with some of the best radio telescopes available. Recently, they have announced, thanks to their patience and care, the discovery of a background sea of gravitational waves. Unlike LIGO, they are not seeing the passage of a single wave from a single source. Instead, they see pulsar timing shifting around almost randomly. However, the size of the shifts is exactly consistent with a set of gravitational waves passing through the pulsar array from all directions. These distortions are slow. The nano in NANOGrav means nanohertz, or one cycle of a wave every 1 billion seconds, i.e. about 30 years. The waves are being generated by massive objects in the Universe moving around each other on this timescale. The primary cause of this is thought to be binary and merging supermassive black hole systems across the Universe creating a choppy sea of gravitational waves moving pulsars over several years.

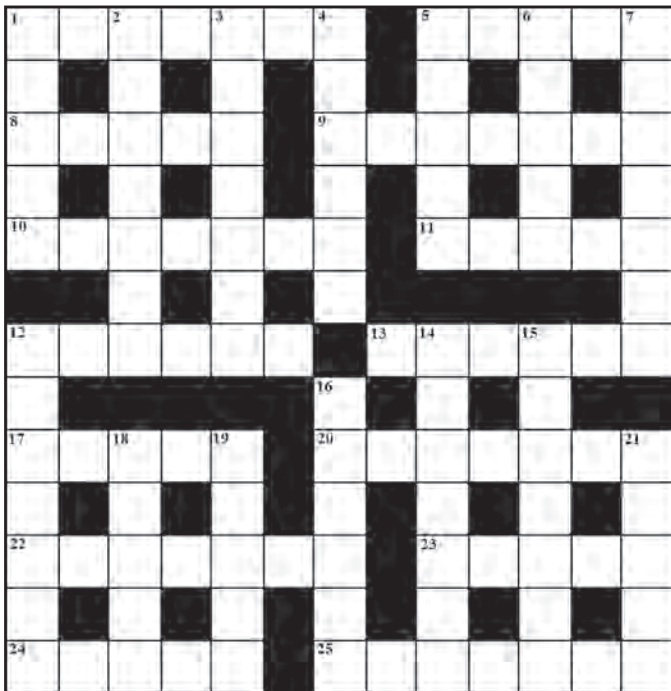
This discovery is an amazing feat of precision, taking advantage of some of the Universe's best clocks. Another genius part of this experiment is that, over time, the measurements will improve, and we will have a novel way to understand all the massive black holes in the Universe, just by watching how some pulses arrive from natural clocks.

Read more: nanograv.org ★

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

- Alexandrian star charter tossed one in apathy (7)
- Space telescope namesake was not Italian (5)
- Diurnal cycle I'd left in shambles for another type (5)
- Popular telescope most can use from home (7)
- Hard metal named for the namesake of asteroid 71 (7)
- In the meantime, look for the north once (5)
- She seeks exoplanets with messy grease (6)
- SETI specialist is not really more bitter (6)
- Homemade-dish maker spilled beer after starting radio sweep (5)
- Swirling big lane of dust near a star in Pegasus (7)
- The Spanish bask in light from a dragon's eye (7)
- Easterners initially rule out his work on lunar orbital theory (5)
- Time asteroid 6 orbiting Jupiter (5)
- Scottish engineer had focus of National Academy of Sciences legend (7)

DOWN

- Rather than ships, she faced the launch of 1000 Toronto Star articles (5)
- Goat boy leads TV explorer around Saturn (7)
- Power plant component where astronomer Vera turns in the ends of time (7)
- Sailor starts Mars rotating at Michigan State planetarium (6)
- Her research on galaxy clusters disturbed Bruin fans (5)

- Lunar cycle makes me gain a lot of weight (5)
- This clue ran around the source of solar energy (7)
- When AAS president, she distributed grants around east (7)
- Geometric sportsmen cast a line in Pisces (7)
- As a galactic cosmologist she was oddly in style at Yale (9)
- She was a big gun in stellar classification (6)
- CNO cycle co-founder found in Thebe rotation (5)
- The extent of lunar Apennines (5)
- Hydrogen seen after crater near Rupes Recta was born (5)

Answers to previous puzzle

Across: 1 MIMAS (anag-a); 4 TITANIA (anag); 8 RICHEST (2 def); 9 MERAK (hid); 10 NAOMI (2 def); 11 NUSHABA (hid); 12 AQUILA (AQ(ui)L+a); 14 BAADER (baa+der); 18 NEBULAE (n(anag)e); 20 TORUS (hom); 22 ILIAD (r(I)ev.); 23 HEAVENS (anag); 24 DOLLARS (anag); 25 AYERS (anag)

Down: 1 MIRANDA (MIR+and a); 2 MACHO (2 def); 3 SPECIAL (an(I)ag); 4 TITANS (2 def); 5 TIMES (re(IM)v); 6 NORMAND (Normandy-y); 7 ANKAA (Anka+a); 13 UMBRIEL (anag); 15 ASTRAEA (anag+ea.); 16 RESISTS (anag); 17 TETHYS (2 def); 18 NAIAD (Diana anag); 19 LYDIA (anag); 21 REESE (Rees+e)

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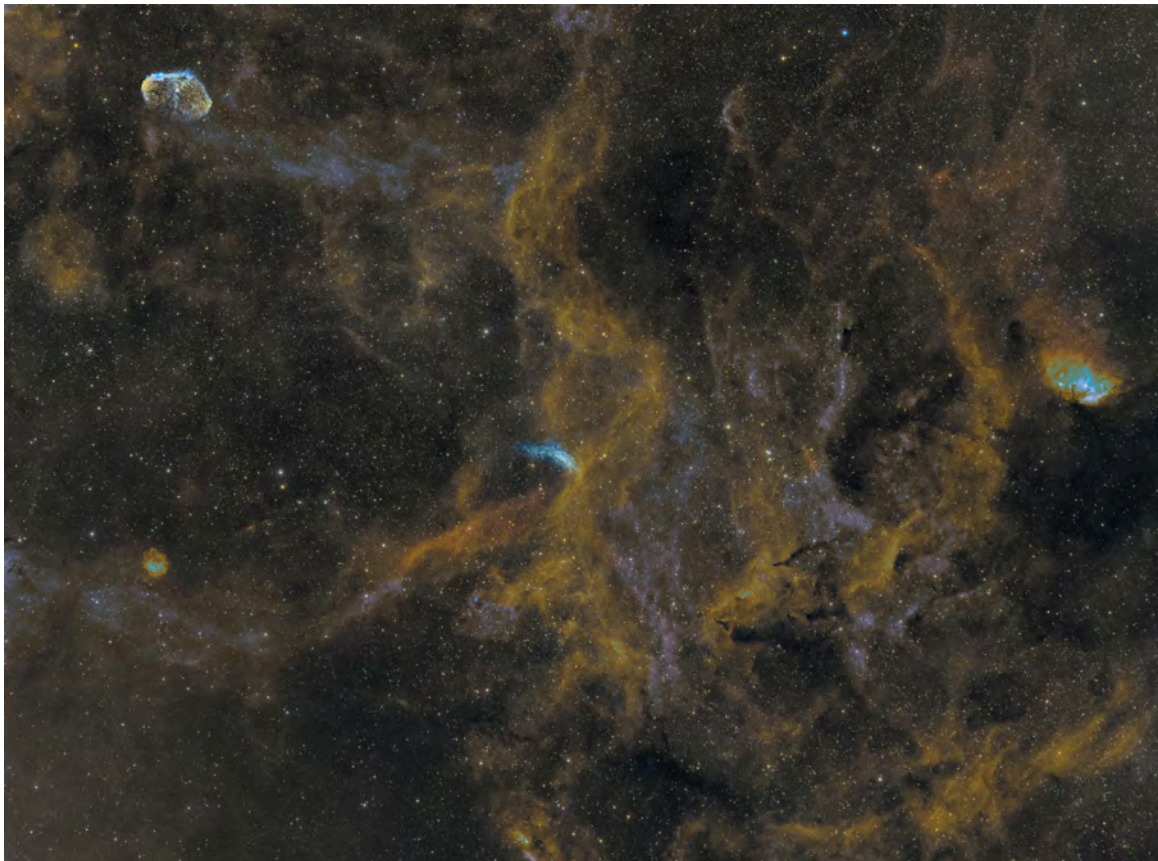
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Great Images

by Shelley Jackson / Dolphin, Crescent, and Tulip



This wide-field image has plenty of treats including WR134 (sometimes called The Dolphin), the Crescent Nebula, and the Tulip Nebula, all within the Cygnus Region. We have been blessed with several consecutive clear nights, although forest fire smoke has been an issue. "To achieve an SHO version, I had to do a false Hubble image, as I only have two narrowband filters for this rig, H α and OIII. It took a bit of experimentation with Pixel Math to finally get a colour I was happy with," she said. "It was worth waiting up 'til past midnight, six nights in a row to capture this gorgeous region of space." Shelley used an Askar 200-mm astrograph lens, along with a ZWO ASI1600-mm and a ZWO five-position electronic filter wheel (with H α and OIII filters) on a Sky-Watcher AZ EQ5 Pro mount. She used NINA, ASTAP platesolving, ASCOM device management, PHD2 guiding, EQMOD mount control, and SharpCap for polar alignment. All processing and editing was done with PixInsight. 203 \times 180 sec H α , along with 171 \times 180 sec OIII, plus master dark and master flats. Total integration was 18.7 hours



Journal

Comet 2023 E1 (Atlas) is seen here, taken by Gary Cawford from his backyard in Lowbanks, Ontario, from 2023 July 10–11, for 3.45 hours. "I decided to take advantage when a brief window of clear skies opened over my backyard," he says. "At that time, 2023 E1 was relatively close to Earth (87.5 million km) and visible in Ursa Minor." Gary imaged the comet from his SkyShed using a William Optics FL156 and WO flattener/reducer (focal length of 900 mm, f/5.8) on a CEM120 mount. He captured the image using NINA and the final image was processed in PixInsight.