The Journal of The Royal Astronomical Society of Canada

Journal

Le Journal de la Société royale d'astronomie du Canada

PROMOTING ASTRONOMY IN CANADA

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Volume/volume 117
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Ground-Based Photometry

A Roaring Nebula

David Thompson Astronomical Observatory

DTAO

Fort William Historical Park, Thunder Bay, Ontario

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Journal

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Société Royale d'Astronomie du Canada

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This rich and stunning image of the Lion Nebula was taken by Steve Leonard. "This image was processed to bring out the incredible diversity in structure and detail among the different ionized gases, with an emphasis on colour and contrast," Steve says. "I think that this image is unique in how the colour resembles a spectrum, with intense red hydrogen emission dominating the left side of the image, bright blue oxygen emission on the right, and yellows and greens in the middle." Steve used an Astro Tech AT115EDT 4.5″ triplet refractor at f/5.6, on an HEQ5 mount, using NINA, an ASI 1600MMPro camera, Chroma 3-nm Hα, OIII, and SII filters and then processed in PixInsight, for a total of 23 hours of integration.

Journal

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

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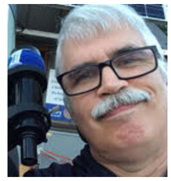
President's Corner

Generations



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

I was in the warm room of our observatory a couple of days ago amongst Dobsonian telescopes and parts of many others that dated back to the founding of the astronomy club that later became our Centre 35 years ago. The founders of our club were telescope builders: That was the only way back then to get a decent sized telescope without exceeding your budget. The keystone of observing four decades ago was the Dobsonian telescope invented by John Dobson in 1965 to make observing more accessible to the public. In the observatory next door to me was our Go-To 14-inch SCT, which I've used to spend many happy hours searching the sky since we opened in 2015. The next day I was on the seawall at Davis Bay with some of my colleagues with our telescopes: Part of our monthly "Astro Café" event where we view the skies together and share the view with any passersby. Two of our astronomers had shown up with refractors on equatorial tracking mounts; my first telescope 55 years ago was a refractor. One newer member arrived with a new 4-inch reflector onto which she attached her cellular phone to direct her telescope to the things she wished to observe in the sky. And the smallest telescope present was my new Vaonis Vespera observing station. 4.5 kilos, small enough to easily fit into a backpack. No eyepiece: The telescope is operated using a wireless connection from a cellular phone or laptop, which is where the image will appear. It knows its GPS location, it scans the sky with its star-pattern recognition software to align itself, focuses itself, and then takes the object(s) you've asked it to view, snaps shots every 10 seconds, stacks these photos, and in a few minutes gives you a JPEG on your device and FITT files you can download to further process with applications like *Photoshop* or *Gimp*. Vaonis created Vespera and its predecessor Stellina for the same reason Dobson invented his telescope—to make astronomy more accessible and, to quote the Vaonis website, "getting rid of all complexity and create a new kind of experience." What a transformation in technology in just three and a half decades.

I mention this as the end of my term as President approaches, as it reminds me that our Society is also evolving to deal with these and other changes. "Change is inevitable," Benjamin Disraeli reminded us, "Change is constant." Change is essential if you're to survive. I look forward to what our Society will evolve into as a result of these changes. ✶

News Notes / En manchette

Compiled by Jay Anderson

Proplyd jet in high resolution

Proplyds (PROtoPLanetarY Disk) are embryonic planetary systems around young stars. As newly born stars materialize from a nebula's dust and gas, they are accompanied by their own disk of dust and gas that is in turn embedded in a larger surrounding cocoon of gas. Material from this cocoon, falling into the nascent star, fuels a powerful bipolar jet of material that flows outward perpendicular to the orbiting disk. While the mechanism that creates the jet is not understood, it is known that its strength is related to the amount of infalling material.

If the proplyd forms in the neighbourhood of a hot ultra-violet-emitting star, the material in the cocoon will be heated and ionized, giving shape to a glowing tadpole of argon, iron, nitrogen, oxygen, and other emissions, embedded in a hydrogen bubble and stretched out by radiation pressure from the nearby star. If there is no hot star nearby, the proplyd will be a dark object around the forming star, visible, in the Orion Nebula for example, as a shadow on background nebular emission.

Astronomers using facilities at the European Southern Observatory (ESO) have recently captured a high-resolution image of a chain of six distinct knots in a roughly S-shaped pattern inside a proplyd known as 244-440, which lies in the Orion Nebula at a distance of about 1,350 ly. The image was acquired by the Multi Unit Spectroscopic Explorer (MUSE) instrument on the ESO's Very Large Telescope (VLT) in northern Chile, in a study led by Andrew Kirwan at Maynooth University in Ireland. MUSE is equipped with adaptive optics that compensate for atmospheric distortion and allow observations of very high resolution.

Errata

In the June *Journal* 2023 page 125 (first column, bottom paragraph), the following information should read as:

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

Figure 1 — The Multi Unit Spectroscopic Explorer (MUSE) instrument on the ESO's Very Large Telescope captured a jet of matter shaped like an S expelled from a stellar object named 244-440. Red, green, and blue colors show the distribution of iron, nitrogen, and oxygen respectively. Image: ESO/Kirwan et al.

The strange curve in the jet may be due to one star orbiting another star, according to an ESO statement. "The S-shaped jet of 244-440 suggests that what lurks at the centre of this object isn't one but two stars orbiting each other," officials wrote. "This orbital motion periodically changes the orientation of the jet, similar to a water sprinkler," though the authors acknowledge that it could also be a structure caused by the strong UV radiation from other stars in Orion.

The study authors suggest that the proplyd's jet emerges from a source $M_\star < 0.2\ M_\odot$ in orbit around a larger companion of $M_\star \simeq 0.5\ M_\odot$, separated by 30–40 au: two M-class brown dwarfs. The jet seems to be emerging from the smaller companion. From the position of a knot from the proplyd core and the jet's proper motion, a minimum age of ~300 years was calculated for the jet, implying a structure that is still active. The true age is probably much greater than this, given the stage of evolution of the visible central star. It may be that the jet, in passing beyond the proplyd's gas cocoon, has become invisible.

Compiled in part with material provided by the ESO.

Missing twins

When supermassive stars form, the majority are paired with an orbiting twin. Now, a new study from astronomers at UCLA's Galactic Center Group and the Keck Observatory have found that this doesn't seem to be a reliable estimate for stars near the Milky Way core. After analyzing over a decade's worth of data about 16 young B-type supermassive stars orbiting the supermassive black hole at the centre of the Milky Way galaxy, they arrived at a startling conclusion: all of them are singletons.

Are the stars, which are about 10 times larger than our Sun, being formed alone in the hostile environment around the black hole? Have their "twins" been kicked out by the black hole? Or have pairs of stars merged to form single stars?

The findings support a scenario in which the central supermassive black hole drives nearby stellar binaries to merge or be disrupted, with one of the pair being ejected from the system. The stars the scientists observed are known as S-stars, and most of them are young—formed within the past six million years—and massive. S-stars are members of a distinct cluster that closely orbit Sagittarius A*, the name given to the black hole at the Milky Way's core. They are mostly located within a light-month of the black hole.

"Stars this young shouldn't even be near the black hole in the first place," said UCLA postdoctoral scholar Devin Chu, the study's first author. "They couldn't have migrated to this region in just 6 million years. But to have a star form in such a hostile environment is surprising."

Chu and his colleagues used data taken with Keck's adaptive optics instruments to conduct the first-ever search for spectroscopic binary stars among 28 S-stars, all within a 2×3 arcsecond region surrounding Sagittarius A*. Sixteen of these were young, massive stars; the remainder were old low-mass giants. Spectroscopic binary stars appear to be single stars but, when the light they emit is analyzed, are revealed to instead be pairs by the back-and-forth motion of their spectral absorption lines.

All of the young S-stars that appeared to be single were, in fact, alone. Even more surprising, the researchers found that the number of binary S-stars that could possibly exist near the black hole was much lower than the number of comparable stars in our section of the Milky Way.

They did this by calculating a metric called the binary fraction, which defines how many stars in a given area could come in pairs; the higher the binary fraction, the more stars that could exist in pairs. Previous studies have shown that the binary fraction for stars similar to S-stars in Earth's solar neighborhood is around 70 percent. In the new study, the researchers found that near the Milky Way's black hole, the upper limit is just 47 percent—suggesting that the extreme environment of the black hole is limiting the survival of stellar binaries.

"This difference speaks to the incredibly interesting environment of the centre of our galaxy; we're not dealing with a normal environment here," Chu said. "This also suggests that the black hole drives these nearby binary stars to merge or be disrupted, which has important implications for the production of gravitational waves and hypervelocity stars ejected from the galactic center."

Figure 2 — The region surrounding Sagittarius A created by Prof. Andrea Ghez and her research team at UCLA from data sets obtained with the W.M. Keck Telescopes. The image is a composite of He I (1.43 micron) and K continuum (2.29 micron) observations. Image: UCLA Galactic Center Group/ W.M. Keck Observatory Laser Team.*

The UCLA researchers now plan to explore how the limit on the binary fraction they calculated compares to the binary fraction for similar stars that are located farther from the black hole, but still within its gravitational influence.

Compiled with material provided by UCLA.

Jupiter's clouds have magnetic feet

Images of Jupiter, taken over a period of several years, show long-term variations in the colour and structure of the planet's cloud bands and the Great Red Spot. Visually, these changes are most obvious as a change in the appearance of clouds at Jupiter's equator, which usually appear white due to overlying ammonia clouds, but occasionally turn a distinct yellowish-brown when the ammonia clouds disappear. Previous work has shown that the change comes around every six to seven years and lasts for up to 18 months.

Now, thanks to a new discovery made possible by NASA's *Juno* mission, which provided new information about Jupiter's magnetic field, Dr. Kumiko Hori of Kobe University and Professor Chris Jones from the University of Leeds believe they could have found an explanation for the changes. Other members of the research team included Professor Steve Tobias at Leeds, Professor Leigh Fletcher at the University of Leicester, and Dr. Arrate Antuñano at the Universidad del País Vasco in Spain.

Professor Jones said, "If you look at Jupiter through a telescope, you see the stripes, which go round the equator along lines of latitude. There are dark and light belts that occur, and if you look a little bit more closely, you can see clouds zipping around carried by extraordinarily strong easterly and westerly winds. Near the equator, the wind blows eastward but as you change latitude a bit, either north or south, it goes westward. And then if you move a little bit further away it goes eastward again. This alternating pattern of eastward and westward winds is quite different from weather on Earth.

"Every four or five years, things change. The colours of the belts can change and sometimes you see global upheavals when the whole weather pattern goes slightly crazy for a bit, and it has been a mystery as to why that happens."

Scientists already know the changing appearance of Jupiter is somehow linked to infrared variations about 50 km below the top of the gas giant's surface, and this fresh research has shown that these variations could in turn be caused by waves produced by the planet's magnetic field, deep within its interior. Using data gathered by *Juno*, which has been orbiting the planet since 2016, their research team was able to monitor and calculate changes in its magnetic field.

Professor Jones added, "It is possible to get wavelike motions in a planetary magnetic field which are called torsional oscillations. The exciting thing is that when we calculated the periods of these torsional oscillations, they corresponded to the periods that you see in the infrared radiation on Jupiter."

The amazing longevity of *Juno* in the harsh radiation environment of Jupiter has seen the probe stay in orbit for much longer than originally planned. This has led to the Leeds researchers getting magnetic-field data over a much longer period, which is much more useful to their work.

By looking at the magnetic field over several years, they have been able to track its waves and oscillations and have even been able to follow a specific spot of magnetic field on Jupiter called the Great Blue Spot. This spot has been

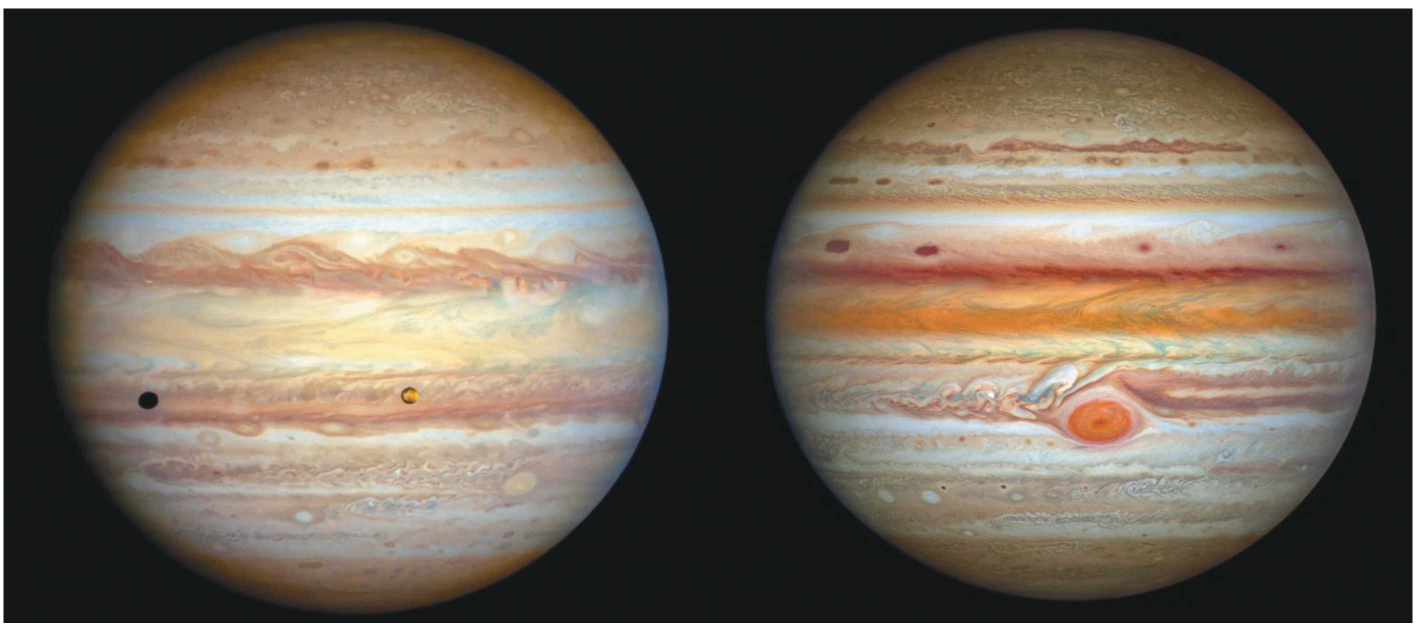


Figure 3 — Two images of Jupiter from the Hubble Space Telescope showing the changes in Jupiter's equatorial cloud bands. The right image was acquired in January 2021, the left in November 2022. Images: NASA.

moving eastward, but the latest data shows that movement is slowing—leading the *Juno* team to believe this is the beginning of an oscillation, with the movement slowing before it reverses and starts going westward.

The research team has produced an explanation for the long-running mystery of Jupiter's changing bands and stripes and filled in the missing link between the two largest areas of Jupiter study—scientists interested in the planet's weather and what happens on the surface, and those working on the deep interior.

Dr. Hori said, "There remain uncertainties and questions, particularly how exactly the torsional oscillation produces the observed infrared variation, which likely reflects the complex dynamics and cloud/aerosol reactions. Those need more research. Nonetheless, I hope our paper could also open a window to probe the hidden deep interior of Jupiter, just like seismology does for the Earth and helioseismology does for the Sun."

For Professor Jones, the breakthrough is the culmination of a lifelong passion for Jupiter. He said, "I am incredibly pleased that NASA finally managed to get to see Jupiter's magnetic field in detail. I have been studying Jupiter for an exceptionally long time and I got interested in what lies below the surface of Jupiter when I was a child—it has been a 60-year progression."

Compiled with material provided by the University of Leeds.

Not your usual BBQ starter

An international scientific team, including the researchers from the Instituto de Astrofísica de Canarias (IAC) Cristina Ramos Almeida, Patricia Bessiere, and Giovanna Speranza, has discovered that quasars, some of the brightest and most powerful objects in the Universe, are mainly ignited by mergers between galaxies. The finding sheds new light, after years of controversy, on what causes the emission of large amounts of energy in the most powerful active nuclei. The research has used observations from the Isaac Newton Telescope (INT) and the William Herschel Telescope (WHT) at the Roque de los Muchachos Observatory in La Palma.

First discovered 60 years ago, quasars can shine as brightly as a trillion stars packed into a volume the size of our Solar System. In the decades since they were first discovered, just what could trigger such powerful activity has remained a mystery. New work led by scientists at the Universities of Sheffield and Hertfordshire (UK), together with researchers of the IAC, has now revealed that quasars are the consequence of galaxies merging.

The high incidence of mergers in quasars was discovered when the research team, using the deep-imaging capabilities of the Wide Field Camera (WFC) on the INT and the PF-QHY camera on the WHT, observed the presence of distorted, low-surface-brightness structures in the outer regions of the galaxies that are home to quasars.

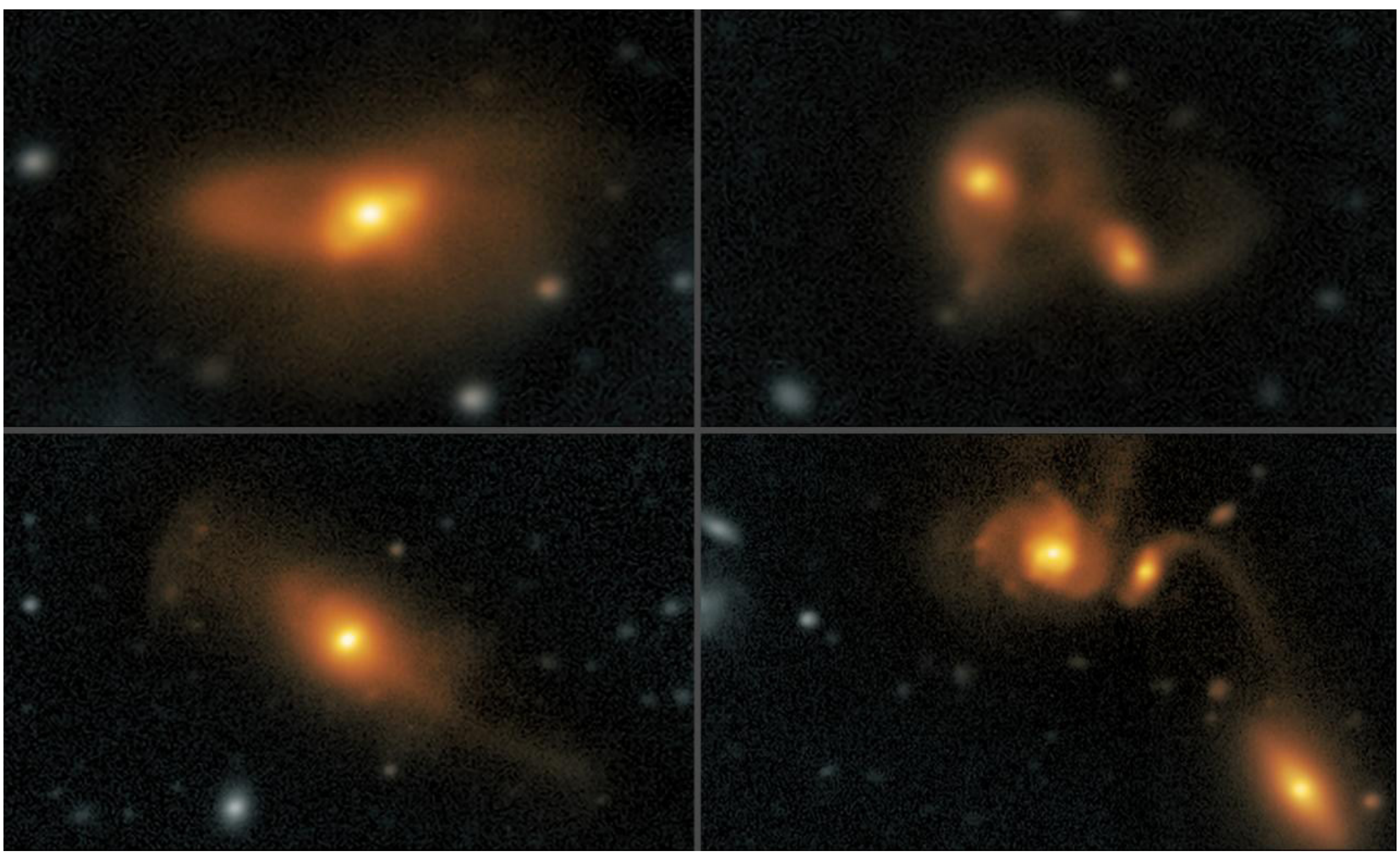


Figure 4 — Example of WFC/INT images of quasars showing distorted structures in the outer parts of systems that are characteristic of galaxy mergers. Design: Gabriel Pérez Díaz (IAC).

Most galaxies have supermassive black holes at their centres. They also contain substantial amounts of gas, but most of the time this gas is orbiting at large distances from the galaxy centres, out of reach of the black holes. When two galaxies merge, gravitational forces drive the gas toward the black hole at the centre of the remnant galaxy system; just before the gas is consumed by the black hole, it releases extraordinary amounts of energy in the form of radiation, resulting in the characteristic quasar brilliance.

The ignition of a quasar can have dramatic consequences for its host galaxy—it can drive out the remaining gas, which will prevent the formation of new stars for billions of years.

This is the first time that a sample of this size of obscured quasars has been observed with such a high level of sensitivity, thanks to the depth and quality of the images obtained at the Roque de Los Muchachos Observatory. By comparing observations of 48 quasars' host galaxies with images of over 100 non-quasar galaxies, researchers concluded that quasar hosts are approximately three times as likely to be interacting or colliding with other galaxies. This suggests that mergers between galaxies are the main ignition mechanism for quasar-like activity. The research group also noted that the quasar activity seemed to begin while the galaxies were in the early stages of their collision, rather than at peak coalescence.

The study has provided a significant step forward in our understanding of how these powerful objects are triggered and fuelled. Clive Tadhunter, a researcher at the University of Sheffield who co-led the study, says: "Quasars are one of the most extreme phenomena in the Universe, and what we see is likely to represent the future of the Milky Way when it collides with the Andromeda galaxy in about five billion years. It's exciting to observe these events and finally understand why they occur."

"Quasars are important to astrophysicists because, due to their brightness, they stand out at large distances and therefore act as beacons to the earliest epochs in the history of the Universe," explains Jonny Pierce, a postdoctoral research fellow at the University of Hertfordshire and first author of the paper.

"Finding out how quasars ignite is key to understanding the evolution of galaxies, as they have a very big impact on the gas and stars in the galaxies that host them," says Cristina Ramos Almeida, an IAC researcher who leads the international QSOFEED project in the framework of which this study has been carried out, and in which Patricia Bessiere and Giovanna Speranza, both IAC researchers and co-authors of the study, also participate. "This project aims to understand how the energy and winds produced by these quasars modify the properties of the central region of galaxies," she concludes.

Compiled with material provided by the Instituto de Astrofísica de Canarias.

Thick-skinned Mars in marsquake data

In May 2022, the Marsquake Service at ETH Zurich recorded the largest quake ever observed on another planet. This event, with an estimated magnitude of 4.6 was recorded on the surface of Mars by the seismometer deployed as part of the NASA Mars InSight mission. "This marsquake sent out strong seismic waves that travelled along the surface of Mars," says Doyeon Kim, a seismologist at the Institute of Geophysics at ETH Zurich.

After more than three years of daily monitoring and with the power levels decreasing on InSight's seismometer, researchers were rewarded with data from a sizeable marsquake. Surface waves observed from this large marsquake continued to travel around the entire planet several times. This data not only provided information about specific areas of Mars, but also enabled a global view of the planet.

"From this quake, the largest quake recorded during the entire InSight mission, we observed surface waves that circled Mars up to three times," says the seismologist and lead author of a study just published in the journal *Geophysical Research Letters*. In order to gain information about the structure that the waves passed through, the researchers measured how fast these waves propagate at different frequencies.

These seismic velocities provide insights into the interior structure at different depths. Previously, observed surface waves from the

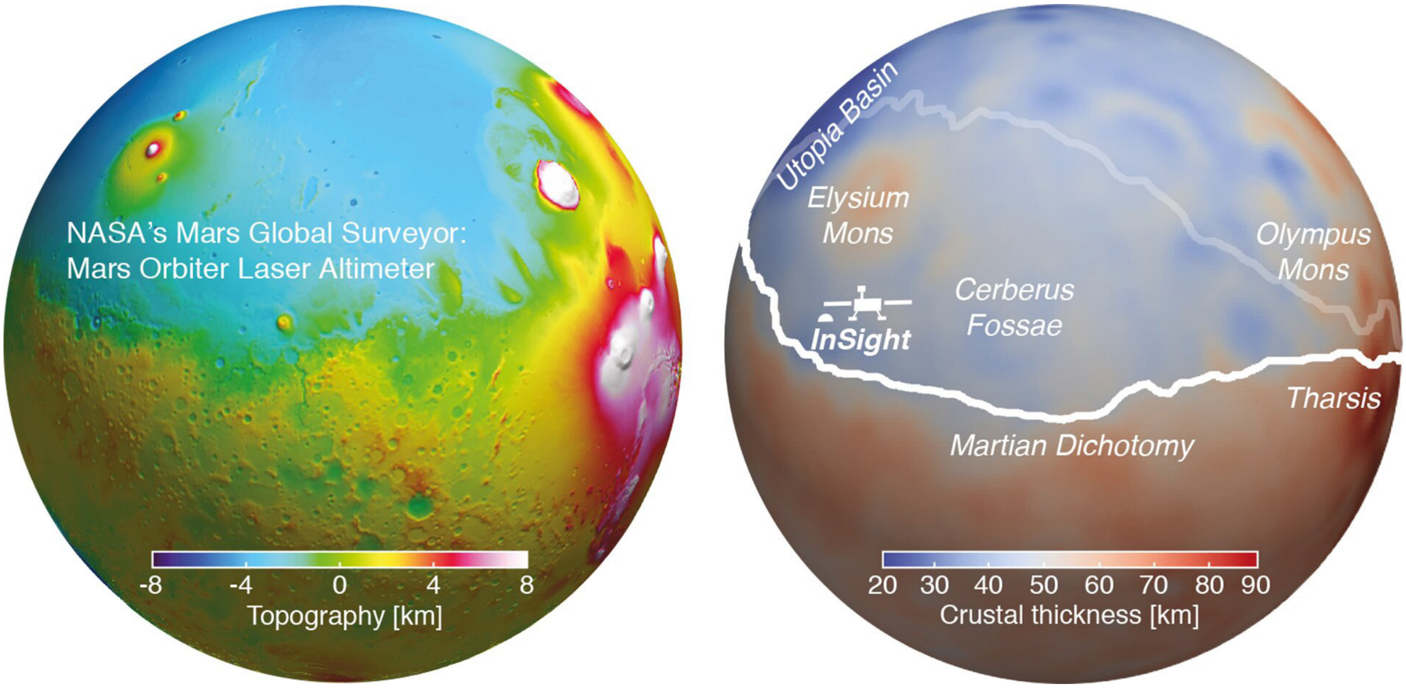


Figure 5 — Topographic map of the Martian surface (l.) and representation of the crust thickness (r.). Illustration: MOLA Science Team / Doyeon Kim, ETH Zuric

two large meteorite impacts also allowed regional findings along their specific propagation paths. "Now, we have seismic observations that represent the global structure," says Kim.

Combining their newly obtained results with existing data on the gravity and topography of Mars, the researchers were able to determine the thickness of the Martian crust. It averages 42 to 56 kilometres. On average, the crust is thinnest at the Isidis impact basin at ~10 km, and thickest at Tharsis province at ~90 km. To put this into perspective, seismic data indicates that the Earth's crust has an average thickness of 21 to 27 kilometres, while the lunar crust, as determined by the Apollo mission seismometers, is between 34 and 43 kilometres thick.

One of the most important results of this research concerns the difference between the northern and southern hemispheres of Mars. This contrast has been observed for as long as there have been telescopes; it is particularly visible in images from Mars satellites. The northern hemisphere on Mars consists of flat lowlands, while there are high plateaus in the south, a division known as the Martian dichotomy.

"One might think that this difference could be explained by two different rock compositions," says Kim: "One rock would be denser than the other."

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

See the published schedule at

rasc.ca/sites/default/files/jrascschedule2023.pdf

While the composition may be the same in the north and south, the thickness of the crust varies. If the crust is thicker in the south, there would be less dense Martian mantle material underneath it, whereas a thinner crust in the north would have more of this dense, heavier material.

Precisely what have the researchers have been able to prove?

"Based on the seismic observations and the gravity data, we show that the density of the crust in the northern lowlands and the southern highlands is similar," they write. In contrast, the crust in the southern hemisphere extends to a greater depth than in the northern hemisphere. "This finding is very exciting and allows an end to a long-standing scientific discussion on the origin and structure of the Martian crust," says Kim. After all, analysis of meteorite impacts on Mars last year already provided evidence that the crusts in the north and south are made of the same material. Further conclusions can also be drawn from the thick Martian crust. "Our study provides how the planet generates its heat and explains Mars's thermal history," says Kim. As a single-plate planet, the main source of heat produced in the interior of Mars today is a result of the decay of radioactive elements such as thorium, uranium, and potassium. The study found that 50 to 70 percent of these heat-producing elements are found in the Martian crust. This high accumulation could explain why there are local regions underneath where melting processes may still be taking place today.

Compiled with material provided by ETH Zurich. ✶

Research Article /
Article de recherche

Ground-Based Photometry Followup for Transiting Exoplanet Candidate TOI–1516 b

by Nuha Akhand[1 3], Seif Atwa[1 3], Jaidan Boehm[1 3], Mark Eaton[2 3 4], Charis Ho[1 3], Veronika Markovich[1 3], Kayla Raharjo[1 3], Ali Rahbar[1 3], Anna Shellhammer[1 3], Athena Xu[1 3]

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Abstract

We report the ground-based confirmation of exoplanet TOI–1516 b transiting every 2.056 days identified by TESS (Transiting Exoplanet Survey Satellite), a space telescope for NASA's Explorer Program, and confirmed through observation by the RASC (Royal Astronomical Society of Canada) Robotic Telescope located at Sierra Remote Observatories, California, USA, which orbits the star TYC 4480-382-1 in the constellation Cepheus. Using the transit method, we measured the relative dimming in brightness of the star revealing the transit of TOI–1516 b. The distinguishable change in brightness matched the value predicted by TESS, as well as the time of the ingress. The time of the egress was found to begin 11 minutes earlier than predicted by TESS, resulting in an overall shortening of the transit time.

Section 1: Introduction

We present the confirmation of TOI-1516 b (TESS Object of Interest No. 1516), an exoplanet with a planetary radius of 16.4042 ± 0.707635 R⊕ and an equilibrium temperature of 1840 K (Caltech, 2022). TOI-1516 b orbits the star TYC 4480-382-1 with a period of 2.056 days and is located in the constellation Cepheus. The exoplanet was first identified through photometric measurements from TESS, (the Transiting Exoplanet Survey Satellite) designed by NASA to search for exoplanets. Our paper outlines the process of confirming the presence of TOI-1516 b using the transit method. This technique indirectly detects exoplanets around a star by observing the change in brightness of the corresponding star. When the exoplanet passes between the star and the observer, a dimming of the star's brightness can be recorded showing the existence of the transiting exoplanet. Nowadays, thanks to artificial intelligence and the power of image processing, scientists are able to generate these patterns more efficiently (Franz, N. et al., 2022). However, in order for an exoplanet discovery to become official, researchers confirm TESS's space-based observations with ground-based follow-up observations (*Followup*, n.d.) Our research confirms TOI–1516 b.

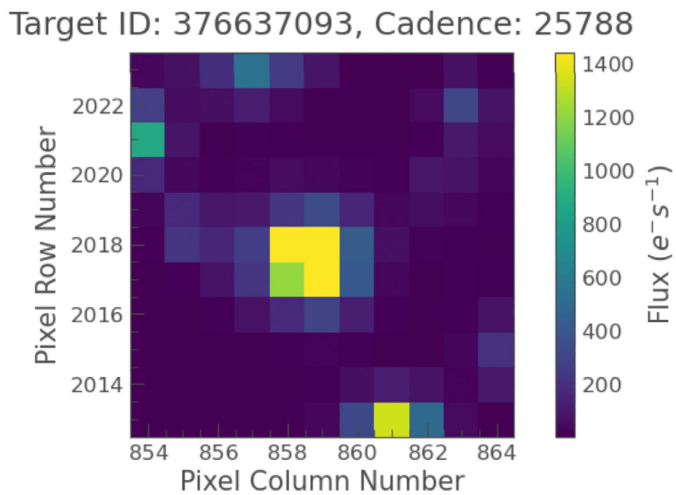

Figure 1 — Target pixel files (TPF) of TOI-1516 b (TIC 376637093) collected by TESS Sector 17.

The target TOI–1516 b was chosen because it was identified by TESS as an exoplanet candidate. It was transiting during December when the brightness of the moon would not interfere with the data collection, and it offered one hour of baseline data before ingress and after egress, which would ensure reliable data. Using the robotic telescope from The Royal Astronomical Society of Canada, ground-based photometry was conducted on the night of 2021 December 1–2, to collect measurements of the brightness emitted by the star during the proposed exoplanet orbits. This data was then analyzed through image-processing software, *AstroImageJ* (Collins et al., 2017), and the resultant transit curve provided strong evidence to suggest that the target exoplanet does indeed exist shown, in Figure 6.

In Section 2, we describe the data collected through TESS, as well as the procedure done to record data using the RASC robotic telescope. In Section 3, we present and analyze our results and examine the stellar parameters of TOI–1516 b to rule out the possibility of stellar companions or other phenomena. This section also explains the outlier within the data and finally we compare the predictions made by TESS to our results. Section 4 includes the discussion of the significance of our results. Finally, we summarize our findings in Section 5 and state our acknowledgements in Section 6 as well as our references in Section 7.

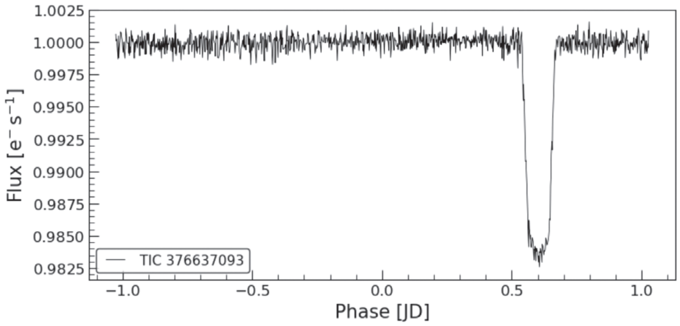

Figure 2 – Plot of the photometric data collected by TESS Sector 17 shows light curve phase-folded to the planet orbital period of 2.056 days.

Section 2: Procedure

2.1. TESS

TOI-1516 b (TIC 376637093, 2MASS J22402026+6930134, APASS 59710322, Gaia DR2 2226107083103120640, TYC 4480-00382-1, UCAC4 798-036573, WISE J224020.28+693013.4) is an exoplanet first observed by TESS on 2019 October 8, with observation ID TESS-s0017-3-2 in Sector 17 in Camera 3 from at 140 seconds cadence (*Community Tools - TESS Science Support Center*, n.d.). The exoplanet candidate was observed by the team at TESS led by principal investigator George Ricker with an exposure rate of 1800 seconds.

2.2. Ground-Based Photometry Followup

On the night of 2021 December 1–2, we observed the transit of TOI-1516 b using the robotic telescope owned by The Royal Astronomical Society of Canada (RASC). The telescope is located in the Sierra Nevada Mountains in California (Hinds, 2021). The telescope uses a f/8.9 16-inch Ritchey-Chrétien Optical System and is equipped with a 4K x 4K SBIG STX16803 CCD camera with a pixel size of 9 microns (Hinds, 2021). A luminance filter was used; exposure time for each photo was 30 seconds.

A total of 488 frames of images of the transit were collected by the RASC robotic telescope. We then performed a photometric analysis using *AstroImageJ* (Collins et al., 2017). Using this method, first, the data is calibrated. This is done by creating a master bias, a master flat, and a master dark. Bias frames are taken with a zero-second exposure and show the locations on the CCD chip where data tends to be over– or under–exposed. Flat frames are overexposed images that reveal the vignette of the central part of the frame that tends to be overexposed compared to the outer parts of the frame; they also show the location of dust particles on the mirror. Dark frames are taken with the same exposure rate as the science data but with the lens cap on, they show the location of the hot pixels at the given exposure rate (in this case, 30 seconds). All these frames are used to adjust the collected images to display the true brightness at each location of the data.

First, a master bias was created and applied to the dark frames. The master dark was created from the bias-subtracted dark frames. The master dark was then used to calibrate the science data for optimal results. The flat frames needed to be omitted from the process as they were improperly collected and unusable. To compensate for the missing flat frames, and maintain the accuracy of the data, the check stars were chosen near the targeted star, avoiding the outer vignette, so the exposure would be the same. Therefore, reliable results are still obtainable from the use of only the dark and bias frames. The next step was stabilizing the data using the Stack Aligner function in *AstroImageJ*. Finally, we performed multi-aperture photometry with light-curve fitting and produced a chart with the light-dimming data of TYC 4480-382-1 versus six reference stars.

Section 3: Observations and Analysis

3.1. Results

This graph depicts the shift in the observable brightness of the target star as the exoplanet transits. The y-axis plots the normalized relative flux of the star, and the x-axis indicates the frames taken of the star in chronological order throughout the night of observation. Throughout the graph, the observable brightness can be seen dimming throughout roughly 150–200 frames as the graph dips down and eventually returns to its original brightness around frame 400. These results can be seen because, as the exoplanet transits the target star, it blocks part of the light coming from the star. Since this light does not reach the telescope, it does not contribute to the brightness and the object appears dimmer. From these graphs, it is confirmed that the change in brightness is about magnitude 0.02. The ingress and egress can also be observed at 0.66 and 0.78 respectively. Therefore, it is evident that an exoplanet is present orbiting the star.

3.2. Stellar Parameters

A transiting exoplanet is not the only phenomenon capable of causing a dip in the light curve of a star. To confirm the existence of the exoplanet TOI-1516 b, the possibilities

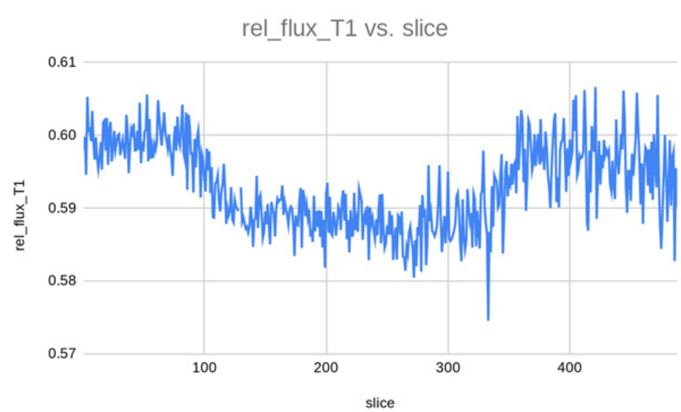

Figure 3 — Light Curve of Transiting Exoplanet TOI–1516 b

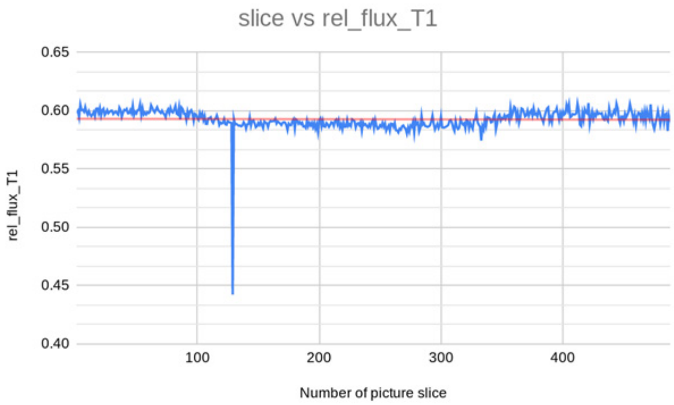

Figure 4 — Light Curve of Transiting Exoplanet TOI–1516 b depicting significant dimming of star TYC 4480-382-1.

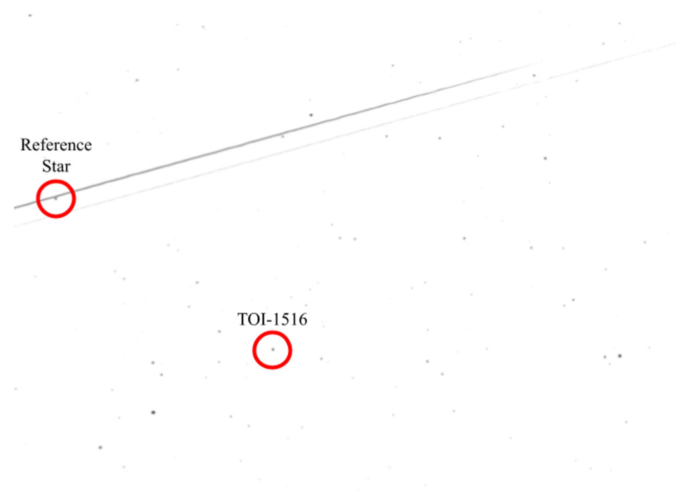

Figure 5 — An unknown artifact can be seen blocking parts of the frame.

of stellar companion, eclipse, or variable-star system were eliminated with data collected from the observation on 2021 December 1.

The curve-fitting on *AstroImageJ* showed a graph with a single square-shaped dip. It proves that TOI-1516 b is not a part of a binary-star system, which would show a periodic large and small dip in luminosity. The dimming chart also proves that TOI-1516 b is not a part of a variable-star system, which would show a sawtooth dimming pattern. An eclipse has also been ruled out as in that case, the graph would depict two dips, one large, one small. Therefore, it is possible to confirm that TOI-1516 b is truly an orbiting exoplanet.

3.3. Outlier in Flux

In frame 129 of the above graph, the flux of the target star dropped by over 25%. In comparison, a regular exoplanet transit only causes a change in flux of around 1%. When visually observing frame 129, an unknown artifact can be seen blocking parts of the frame (see Figure 5). This is likely a Starlink or another satellite that passed by Reference Star 1, reflecting light and increasing the brightness significantly. Since the program assumes the check stars stay at a constant brightness, this relative difference between the brightness of the check star and the targeted star is taken as a dramatic dimming of the targeted star. Thus this frame of data is considered to be an outlier and will not be included in further analysis.

3.4. Predictions vs. Outcome

The predicted ingress and egress times from TESS for exoplanet TOI–1516 b were 0.66 and 0.79 respectively (Julian Date), with a predicted depth for the transit curve of 0.02 and predicted transit time of 3 hours 3 minutes.

On 2020 August 10, research led by David Baker at the Austin College Adams Observatory observed TIC 376637093.01 (TOI-1516 b) and detected a transit. Baker et al. noted that the transit appeared ~4–6 minutes earlier than predicted. However, they used a telescope with a cadence of 188 seconds, and it was hard to obtain the exact timing of ingress and egress. Our study observed the target star with a shorter cadence of 36 seconds, and thus can determine a more exact timing for transit.

Our results yielded the expected depth of 0.02, contrary, however, to Baker et al.'s observations that the transit of TOI-1516 b is occurring earlier than the prediction from TESS, the ingress time observed from this research yielded the previously predicted time of 0.66 as seen in Figure 6. However, the egress was measured to be 0.78 rather than 0.79. This translates to a transit time of 2 hours 52 minutes – 11 minutes shorter than what TESS recorded. Therefore, our study as with Baker et al.'s confirms that the transit is complete before the expected time. The variability between the results of these two studies could be because the Sun was starting to rise, causing noise and interfering with the data collection at the time of the egress. Further observations would be needed to calculate the exact value of the egress and transit time.

Parameter	Description	Value	Reference
Teff	Effective temperature in K	6485 ± 136.004	TESS mission
log(g)	Surface gravity in cgs units	4.37164 ± 0.086542	TESS mission
RO	Radius in terms of the sun	1.2421 ± 0.0533669	TESS mission
MO	Mass in terms of the sun	1.324 ± 0.221627	TESS mission
ρ	Density in g/cm3	0.97417 ± 0.219076	TESS mission
L	Luminosity in terms of the sun	2.458383 ± 0.1311845	TESS mission
d	Distance in pc	247.054 ± 1.361	TESS mission
ν sin i	Rotational velocity in km/s	14.64 ± 0.5	Allyson Bieryla
[Fe/H]	Metallicity in dex	0.218 ± 0.08	Allyson Bieryla

Table 1 – Chart of stellar parameters. (Exofop TIC 376637093)

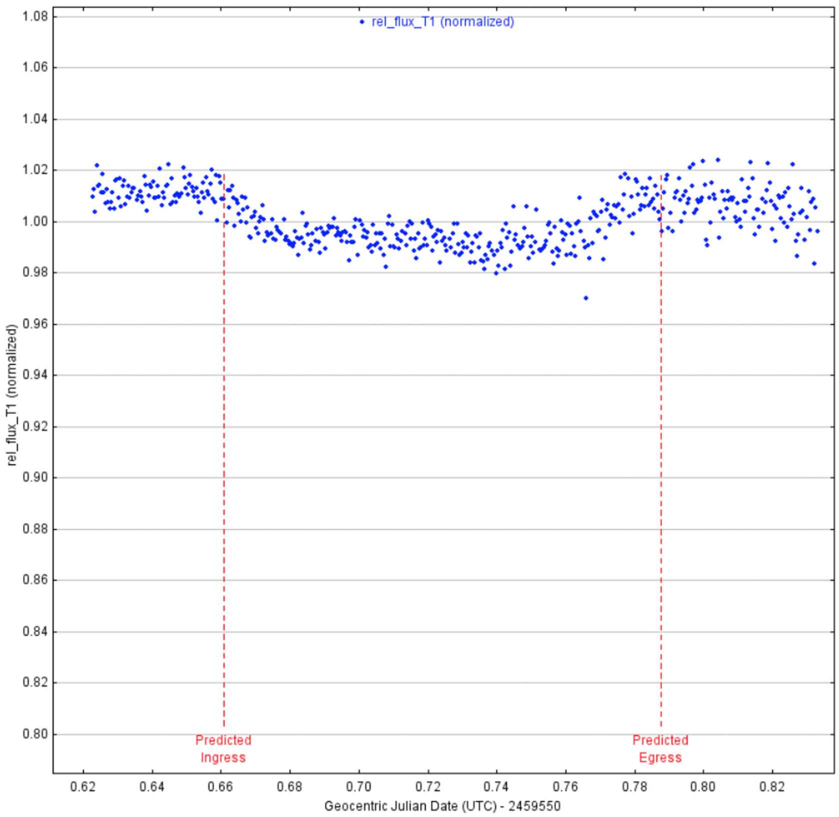

Figure 6 — Light Curve of Transiting Exoplanet TOI 1516 b demonstrating that the predicted ingress lines up with the result, whereas the actual egress occurs before the predicted time.

Section 4: Discussion

The key traits of an exoplanet were identified in the gathered data, and a long dip in the graph was displayed. This indicated that TOI-1516 b is in fact an exoplanet. This long dip in the graph is a dip in light as the exoplanet moves in front of its star, also known as the transit time. The transit time gathered by Baker et al.'s study suggests that the exoplanet transits slightly earlier than the time predicted by TESS, our study indicates the predicted ingress is correct, however, the egress is also appearing early, yielding a shorter transit time. These studies together strongly suggest that the exoplanet's transit time finishes earlier than predicted.

The transit method is effective at identifying the period, orbit, and size of the exoplanet, as well as if there are other planets in the system. Combined with the radial-velocity method, it is possible to learn about the planet's mass, density, and composition. In addition to the location of an exoplanet that could possibly harbour life, these details are important for indicating exoplanets most likely to host life. The data gathered in this study and others like this aids in the search for life outside of our planet. In addition, the observations of some exoplanets may be so different from Earth that they help researchers and physicists understand better how the Universe works as a whole and how the Solar System we exist in fits into it. Researching exoplanets also provides information about how they were formed, providing insight into the formation of our Solar System. It is clear that the analysis of each exoplanet transit furthers our knowledge of the Universe.

Section 5: Conclusion

In this study, we report the discovery and characterization of the TOI-1516 b detected by TESS. We confirm the planetary nature of TOI-1516 b through a combination of cadence TESS observations, ground-based photometry, and high-angular-resolution imaging. Our observations, as well as Baker et al.'s, suggest an earlier egress than that observed by TESS. To confirm the exact egress and transit time further data collection is needed. This analysis of TOI-1516 b will be used in the search for life and in the effort to more deeply understand theU.

Section 6: Acknowledgement

The Waterloo Collegiate Institute is situated on lands traditionally used by the Haudenosaunee, Anishinaabe, and Neutral People. The robotic telescope used is situated on lands traditionally used by the Western Mono/Monache People. We acknowledge and honour the enduring presence and deep traditional knowledge, laws, and philosophies of the Indigenous Peoples with whom we share this land today.

Results of this report are based on observations obtained with the robotic telescope from the Royal Astronomical Society of Canada. We would like to thank RASC staff Jenna Hinds and Samantha Jewett for their tremendous support on this project. Finally, we want to express our gratitude to the RASC members for their generous contributions to the outreach projects. ✶

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Skyward

Wendee Among the Stars and a Little Religion

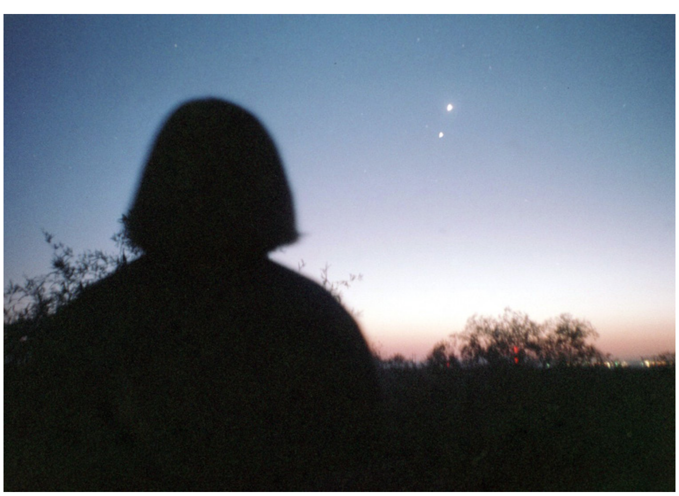
by David Levy, Kingston & Montréal Centre

Never in my life did I appreciate the peace and beauty of the night sky as I do now. It offers solace; it brings peace. And now more than eight months since my wife Wendee's death, it is an easy reminder of why I love the sky.

Over many years, I have been reading brief poems for multiple online and personal sessions. One of my favourites is the Denver Astronomical Society, which I first joined in May of 1963 while I was a patient at the Jewish National Home for Asthmatic Children in Denver. Recently, they even elected me as their poet laureate. Like the night sky, poetry brings peace.

The days go on; I watch the news, the details of war, of debt, of artificial intelligence well beyond my own, of murder, theft, and lies. But as the Sun sinks in the west, the shadow of our planet rises in the east, and with the daily darkening of the sky comes a bigger picture. The Universe does not care about the details; our days and years are nanoseconds in the cosmic timescale. But when we look toward the sky, with our eyes in the hope of catching a shooting star, through binoculars to make out a new pattern of stars, or with a telescope to celebrate a planet's rings or a far-off galaxy, we can enter that cosmic picture and be part of it for a brief time.

In my professional life, I have tried to connect the night sky to poetry, but those rhymes are rarely my own. I make an exception this month. Besides raising my insight and bringing me peace, I find nothing that so stirs my heart as the joy of the night sky.



Each day I awake; today is the day!
I look toward her, she is not there.
My heart goes on, but do I care?
Will anything—anything—let in some ray.

The night is dark, as dark as coal.
The sky is stars from west to east
From south to north, just like a feast
A pill, heav'n sent to calm my soul.

A telescope stands, it stands and waits
For my eye, it asks, "just one brief look."
Forward through space, like an open book;
And back through time, open wide the gates.

I see a star; why is it there?
Lapis philosophorum, philosopher's stone
That strikes the night, it ushers me home
As part of a pattern to learn, I dare.

But reason not. General relativity;
Gravity's geometry, no speck of thought;
No idea works, no system bought,
A spacetime crash, to save its dignity.

She's part of me, a beam of light
Among the stars, in the sky a plant
Not there, but there, my soul enchant.
From grief to joy, all through the night.

Figure 1 — A silhouette of Wendee as she observed a conjunction of Venus and Jupiter.

A little religion, but not too much

As an undergraduate student at Acadia University in Nova Scotia, my geology professor was trying to teach us about the water cycle. Despite reams of published evidence, the best document he could come up with was this beautiful line from Ecclesiastes:

> All the rivers run into the sea,
>
> Yet the sea is not full,
>
> Unto the place whither the rivers go,
>
> Thither they go again."
>
> —Ecclesisastes 1.7

Dr. George Stevens's comment had a profound impact on me. First, as a budding young scientist, it opened my mind to the relationship between the night sky and Scripture, and second, later as my passion for the arts grew, it reminded me of how ancient peoples viewed the night sky. From the "eleven stars" symbolizing Jacob's brothers, to the line in Amos about "the seven stars" of the Pleiades, to his aggressive tone with Job (9:5-8): "Who removeth the mountains, and they know it not, (possibly referring to the evolution of the Earth); Who maketh the Bear, Orion, and the Pleiades? Who shaketh the Earth out of her place (a big earthquake or a major comet impact), Who commandeth the Sun, and it riseth not (if it rises during an eclipse like the event I saw in 1999 when only a thin crescent of sunlight rose). This is not to mention Joseph's dream "the Sun and the Moon and eleven stars bowed down" (Genesis 37:9-10.) It must have been a very cloudy or hazy night if all he saw was 11 stars instead of the 2,500 to 4,000 stars he should have seen from his obviously dark location.)

After a lecture I gave in 1994 at my childhood synagogue, The Shaar Hashomayim in Montréal, the associate Rabbi pointed out how the ancient Israelites followed astrology, right from the line "And let there be lights in the heaven, to divide the day the day from the night; and let them be for signs, and for seasons, and for days and for years." (Genesis 1.14) He went on to emphasize that these people never worshipped the stars, but they followed astrology out of interest and fun. (Full disclosure: Like most people who observe the night sky, I do not follow astrology, but perhaps unlike most of them, I do appreciate that were it not for the thousands of years of meticulous records kept by ancient astrologers, we would probably have no real astronomy, nor a Webb telescope, this evening in 2023.

I did promise not too much, so I shall end here with a quotation from Psalm 19: with a new line added for fun, courtesy Peter Collins:)

Figure 2 — Two of the telescopes the author uses in the observing at Jarnac Observatory. The telescope on the right is used for astrophotography (which he doesn't do much of anymore), and the telescope on the left is Pegasus. It is used for visual observation. It is the highest quality telescope he has. The mirror was made by Aleka Herring, one of the most prominent telescope makers in the last century.

> The Heavens declare the glory of God,
>
> And the firmament showeth his handiwork.
>
> Day unto day uttereth speech,
>
> And night unto night revealeth knowledge
>
> ("So long as the sky is clear.") ✶

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.*

Dish on the Cosmos

Detecting Exoplanets in the Radio

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

The principal role astronomy has played in the rise of civilizations has come through the study of time- and calendar-keeping. A precise knowledge of where stars, planets, and moons were in the skies was essential for navigation and setting wide-ranging standards for timing and calendars. It was only in the later part of the 20th century that the atomic clock supplanted astronomical timekeeping standards. While our standards for timing and clocks have shifted, for a few decades, we invested a great deal of effort in keeping the celestial and terrestrial calendars synchronized.

Only recently has the connection between these two timekeeping standards been broken, opting to move to a single, atomic standard. In many ways, it is a logical choice. To maintain synchronization between the two standards, we occasionally had to add or subtract a leap second to our terrestrial time standard to account for changes in the Earth's rotation speed. This kept the Earth's rotation lined up with atomic time so that the Sun would, on average, cross the meridian at local noon. The problem with this approach is that communication now relies on having a well-established timing standard for transmissions between computers. Having an occasional minute that has 61 seconds could, in principle, be accommodated. But if one computer shifts time by a second and another doesn't, our communication standards break down. Several major internet service outages can be traced to incorrect application of leap seconds. Driven by large technology companies, we have moved to a primary atomic standard where each minute has 60 seconds perpetually. Over the decades, a shift will build up with respect to astronomical time, but simplicity has won out, leaving astronomical timing to go its own way.

There is ample opportunity in astronomy for precision measurements of time and position, which now drives entire subfields on its own. Historically, these studies were the province of optical astronomy: stars are bright in the optical, we can easily see through the Earth's atmosphere to map their locations, and stars are sufficiently far away to appear as singular points of light and not the resolved disks of planets and moons. In its relatively short history, radio astronomy has developed its own techniques for astrometry: the precise measures of celestial positions, driving discoveries of its own.

The key method here is very-long-baseline interferometry (VLBI) between radio telescopes, a novel method first demonstrated by Canadian radio astronomers. VLBI takes advantage of our ability to measure radio waves as *waves*. Radio waves have low enough frequencies that we can detect where we are in a wave's up-and-down cycle at any given time, which we call the "phase." With VLBI, we measure the difference in phase between radio waves from an astronomical source arriving at Earth, which just means that we are measuring how much earlier or later a peak of a wave arrives at one telescope compared to another telescope at a different location. When those telescope locations are far apart (thousands of kilometres), we can detect small differences in the timing of the waves if the source is at one position vs another nearby position. Hence, our precise timing allows us to map out the locations of radio-bright objects in the sky to extreme precision.

VLBI techniques provide the best measurement of the locations of distant radio galaxies, and we use a coordinate grid of those distant galaxies to set the reference positions on the celestial sphere. VLBI is also essential for terrestrial applications since the Earth is spinning underneath this fixed reference system set by those unmoving distant galaxies. These measurements can be inverted to make very precise measurements of where the radio telescopes are on Earth, which in turn calibrates the Global Positioning Systems. The VLBI measurements are sufficiently sensitive that they are needed to measure the relative drift of continents with respect to each other. Early in my career, I had a geologist explain to me that studying tectonic drift was a nightmare because there was "no fixed reference system," but now VLBI can provide exactly that reference.

One of the latest advances with VLBI has been to discover a new extrasolar planet orbiting around a star. Exoplanets are old news at this point, with thousands of planets known to be orbiting our nearest stars. Most exoplanets are known from the transit method, which uses the slight dimming of a star's light when the exoplanet passes between the observer and the distant star, forming a mini-stellar eclipse. The transit method is limited since it requires the relatively rare coincidence of seeing the planetary orbit edge-on. The other methods for seeing planets rely on careful observations of the star. A star and its planet orbit their common centre of mass with the planet moving proportionally more than the star based on the ratio of the masses. For example, Earth goes around the centre of mass at 30 km/s and the Sun orbits at a mere 1 cm/s. This may seem amazingly tiny, but radio telescopes routinely obtain velocity precisions at this level.

Similarly, if we monitor the position of the star over time, we can see it move around in position. These motions are tiny but readily observed if we are careful. Stars appear to move because of parallax motion, namely their apparent motion from the

Earth's orbit around the Sun (Figure 1). They also undergo "proper motion" from their actual motion through space. Finally, stars can wobble around because of a planet orbiting around them. All these motions have scales from micro- to milliarcseconds in scale. Again, VLBI can routinely measure positions to this precision. But this is the first time that we have detected an exoplanet using radio waves and VLBI, so the big question is really "Why did it take so long?"

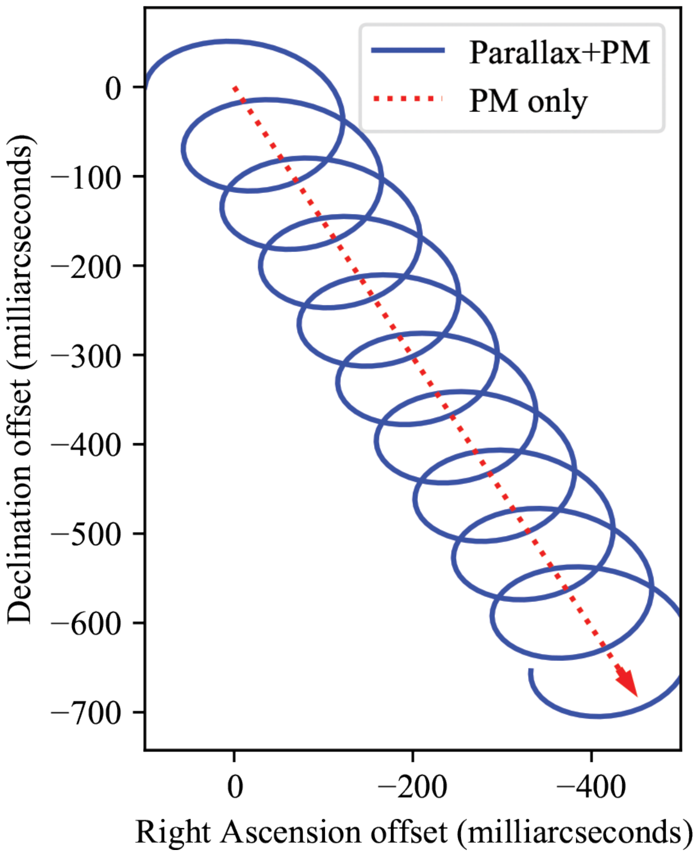


Figure 1 — The apparent motion of a star on the sky due to its parallax (apparent motion from Earth's orbit) and proper motion (PM: actual motion through space). The combination of these two motions traces out a helix on the sky (blue path). Each loop of the helix represents one year of time, reflecting the Earth's orbital period. Any apparent motion of the star that deviates from this path could be from a planetary companion to the star.

The main reason is that stars are not usually bright in the radio, typically fainter than is possible to study with VLBI using current telescopes. Instead VLBI studies bright maser emission or the central black-hole engines in other galaxies. When a star becomes radio bright, the radiation is coming from stellar flares and other magnetic activity. The emission moves around and changes as the flares develop, making it hard to track a star's position. Similarly, the bright spectral lines needed to measure a star's velocity are lacking in the radio, and when bright lines like masers are found, they are ephemeral like solar flares. What was needed was to find a star that was close by so that the normal radio emission from

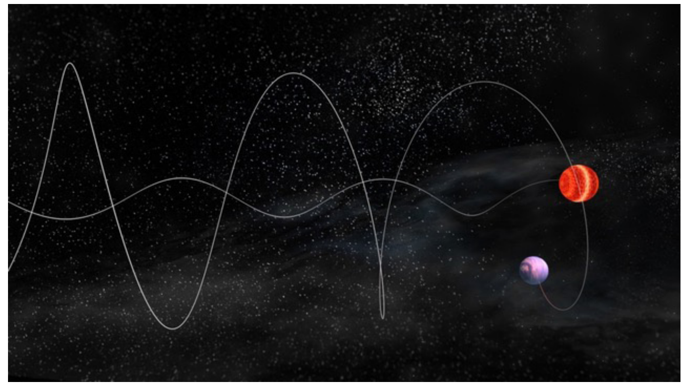


Figure 2 — Schematic rendition of a planet orbiting a red-dwarf star. The apparent motion of the two objects is shown over time. Note that the motion of the more-massive star is smaller. Credit: Bill Saxton, NRAO/AUI/NSF

the star would be bright enough to be seen with VLBI and sufficiently low mass that it could be wobbled by a planetary companion. In a study led by Salvador Curiel from Mexico, a team of astronomers monitored just such a star: a red-dwarf star only 10 pc (35 light-years) away. In studying the motion of the star, they corrected for parallax and proper motion and found that the star still showed a wobble with a period of 221 days, corresponding to a planetary-mass companion. This star is not special apart from being easy to detect. Future radio telescopes will be able to overcome the challenges from sensitivity with VLBI and see down to fainter emission levels, which will make it possible to extend this method out to much farther distances. The era of planet hunting will be coming to the radio soon. Tune in!

Read more at https://arxiv.org/abs/2008.01595 ✶

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.

Figure 1 – Katelyn Beecroft imaged the Dark Seahorse Nebula, also known as Barnard 150. She captured this one using an Askar FRA400 telescope with the ASI533MC camera. The image consists of just under 20 hours of integration and was processed using PixInsight. "I really love the variety of colour found in the star field and worked to bring out the faint dust around the main dark nebula structure," she says.

Figure 2 – Here we have both the Heart Nebula (IC 1805) and the Fish Head Nebula (NGC 896), imaged by Shelley Jackson. She used an 81-mm WO GT APO triplet, with a 50-mm guide scope, a ZWO 120 mono guide camera on a Sky-Watcher EQ6-R pro mount with a ZWO ASI183MM CMOS cam cooled to –10 °C, with Hα, SII, and OIII filters for a total integration time of 26 hours, along with RGB filters for an additional integration time of 27 minutes. The final image was stacked and processed with PixInsight.

Continues on page 155

What's Up in the Sky?

July/August/September

Compiled by by Scott Young, Winnipeg Centre

July 2023 Planetary Highlights

On July 1, Mars is above and to the left of much brighter Venus, low in the evening twilight. Over the first 2 weeks of July the two planets appear within the same binocular field of view, moving in formation toward the bright star Regulus as they sink lower into the evening twilight. Mars passes within a degree of Regulus on the evenings of July 9 and 10.

During the third week of July Mercury joins the scene, reaching about the same altitude as Venus on the 19th and standing at its highest above the horizon about the 25th. These planets become very challenging targets throughout the month as they sink lower into the bright twilight. What is the last day you can spot Mars, Mercury, and Venus?

Meanwhile, the two largest planets are at their best in the pre-dawn sky. Saturn rises near midnight at the beginning of the month and just after 10 p.m. by month's end, remaining relatively low in the sky among the stars of Aquarius. Much brighter Jupiter has emerged from solar twilight and is high in the southeast at dawn.

Also of note, the brightest dwarf planet, Pluto, reaches opposition on July 22. A finder chart is on page 239 of the *2023 Observer's Handbook.*

The Moon passes each of the planets in turn during its orbit around the Earth, helping to call attention to the planets and forming a nice photo opportunity. Precise details depend on your time zone and latitude, but the following events are applicable for most of southern Canada:

July 6–7: Saturn is 3 degrees above the waning gibbous Moon, rising near local midnight

July 10–11: Jupiter is about 5 degrees away from the waning crescent moon in the pre-dawn sky

July 19: a very thin waxing crescent Moon forms a triangle with Venus and Mercury, very low in the western twilight after sunset

July 20: the crescent Moon has moved higher, above Mars, in the evening twilight

Other events: The annual South Delta Aquariids meteor shower peaks a day before full Moon, which will dramatically reduce the observed rate of meteors.

August 2023 Planetary Highlights

Venus finally disappears into the sunset, passing between us and the Sun on August 13 (an event called *inferior conjunction*). Much fainter Mars sticks around but will be difficult to spot without binoculars. Mercury reaches its greatest elongation east from the Sun on August 9, but the angle of the ecliptic conspires to keep the innermost planet too low to be easily observable from Canadian latitudes.

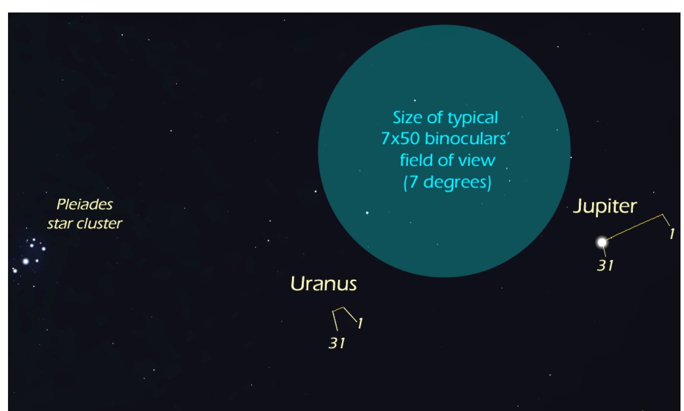
The planetary highlights finally transfer back to the gas giants. Saturn rises after 9 p.m. local time and is reasonably high in the southeast by midnight, giving many observers their first look at the rings this year (at least at a convenient hour!) By 3 a.m. Saturn is barely 30 degrees above the skyline, so for many Canadian observers it never truly clears the turbulent air close to the horizon. Southern Ontario and Maritimes observers have the advantage of being a few degrees of latitude farther south, which moves Saturn a few degrees of altitude higher into the clearer air. On August 27, Saturn reaches opposition, the point in its orbit when it is opposite the Sun and thus visible all night long.

Jupiter rises later but will get higher in the sky in the early morning. In August, Jupiter is almost stationary, about 15 degrees from the Pleiades star cluster. It stands high in the south at dawn, making the last few hours of darkness the best time to observe the giant planet.

Normally inconspicuous, Uranus is about 10 degrees to Jupiter's left (east), about halfway between the giant planet and the Pleiades. Though technically visible to the unaided eye under dark skies, most people need binoculars and a good finder chart to track down this planet.

The Moon once again passes various objects in its monthly circuit of the sky. In August 2023, the following events are of interest:

August 3–4: The waning gibbous Moon is 4 degrees below Saturn



Jupiter and Uranus in August 2023
Image created with Stellarium
open software (Stellarium.org)

Continues on page 154

The Sky July/August/September

Compiled by James Edgar with cartography by Glenn LeDrew

Celestial Calendar *(bold=impressive or rare)*

Jul. 1 Antares 1.5° south of Moon

Jul. 3 Full Moon at 7:39 a.m. EDT

Jul. 7 Saturn 3° north of Moon

Jul. 10 *Mars 0.7° north of Regulus

Jul. 11 ***Jupiter 2° south of Moon**

Jul. 12 *Uranus 2° south of Moon

Jul. 13 **Moon 1.7° south of Pleiades (M45)**

Jul. 14 Mercury 0.2° north of Beehive (M44)

Jul. 19 Mercury 4° south of Moon

Jul. 20 Moon at apogee (406,289 km)

Jul. 28 *Antares 1.3° S of Moon

Jul. 28 *Mercury 0.1° S of Regulus

Jul. 29 South delta Aquariid meteors peak at 1:00 p.m. EDT

Aug. 1 Full Moon at 2:32 p.m. EDT

Aug. 2 Moon at perigee (357,310 km) Large tides

Aug. 3 *Saturn 2° north of Moon

Aug. 8 Jupiter 3° south of Moon

Aug. 8 Moon at last quarter

Aug. 9 *Moon 1.4° south of Pleiades (M45)

Aug. 13 *Perseid meteors peak at 4 a.m. EDT

Aug. 13 Pollux 1.7° north of Moon

Aug. 18 Pallas 1.1° south of Moon

Aug. 18 Mars 2° south of Moon

Aug. 25 *Antares occulted by Moon

Aug. 30 Saturn 2° north of Moon

Aug. 30 Full Moon at 9:36 p.m. EDT (largest in 2023)

Sep. 4 *Jupiter 3° south of Moon

Sep. 5 *Moon 1.2° south of Pleiades (M45)

Sep. 9 *Pollux 1.5° north of Moon

Sep. 16 *Mars occulted by Moon

Sep. 19 Venus greatest illuminated extent

Sep. 21 *Antares 0.9° south of Moon

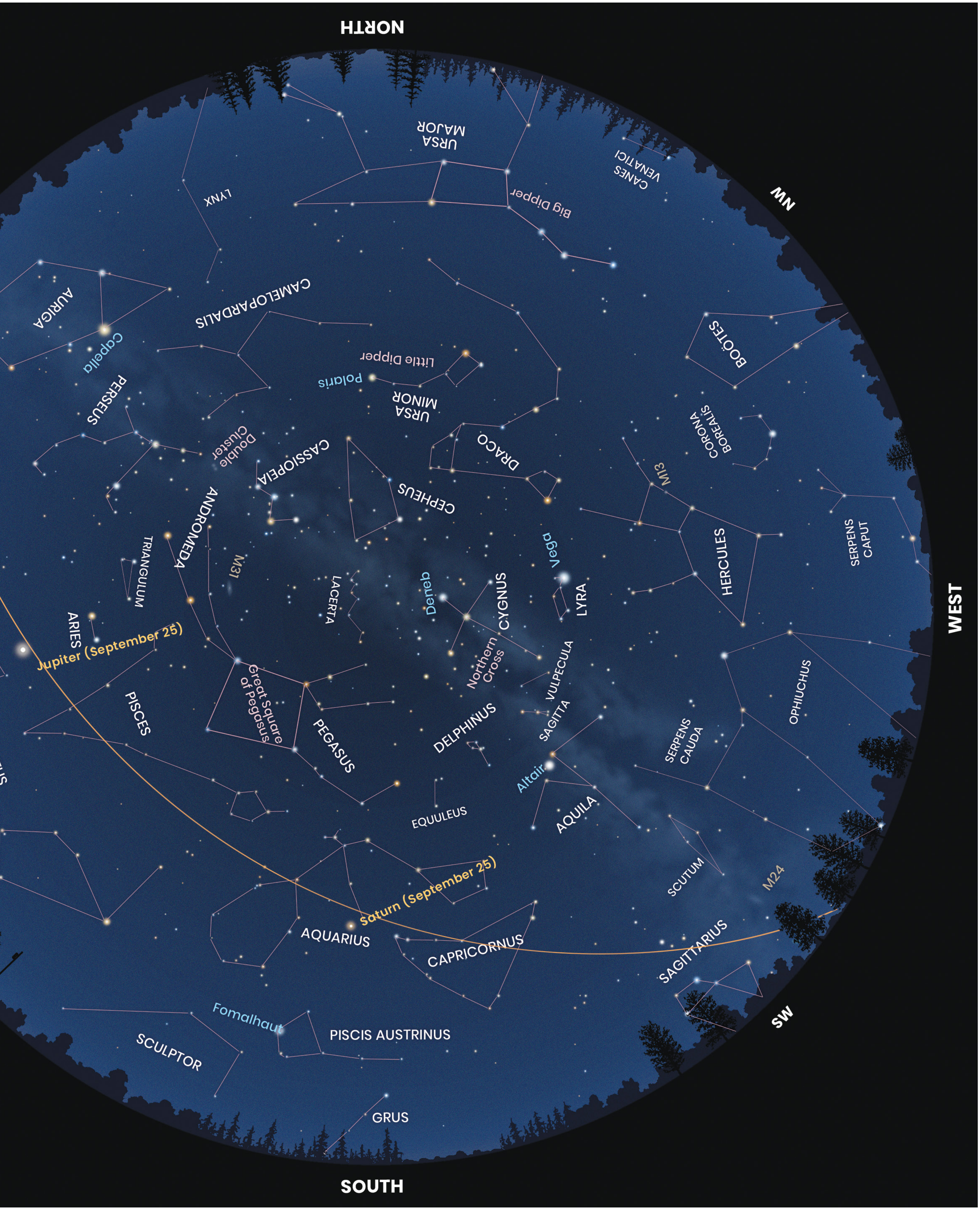
Sep. 23 Autumnal equinox

Sep. 27 Saturn 3° north of Moon

Sep. 29 Full Moon

Planets at a Glance

	DATE	MAGNITUDE	DIAMETER (″)	CONSTELLATION	VISIBILITY
Mercury	Sep. 1	—	10.6	Leo	—
	Oct. 1	—	5.8	Virgo	—
Venus	Sep. 1	–4.6	49.9	Cancer	Morning
	Oct. 1	–4.7	31.9	Leo	Morning
Mars	Sep. 1	–	3.8	Virgo	—
	Oct. 1	–	3.7	Taurus	—
Jupiter	Sep. 1	–2.8	43.9	Aries	Evening
	Oct. 1	–2.9	47.7	Aries	Evening
Saturn	Sep. 1	0.4	19.0	Aquarius	Evening
	Oct. 1	0.5	18.6	Aquarius	Evening
Uranus	Sep. 1	5.7	3.6	Aries	Evening
	Oct. 1	5.7	3.7	Aries	Evening
Neptune	Sep. 1	7.8	2.3	Pisces	Evening
	Oct. 1	7.8	2.3	Pisces	Evening



NORTH
SOUTH
WEST
NW
SW
URSA MAJOR
Big Dipper
CANES VENATICI
LYNX
AURIGA
Capella
CAMELOPARDALIS
Little Dipper
Polaris
URSA MINOR
BOÖTES
PERSEUS
Double Cluster
CASSIOPEIA
DRACO
CORONA BOREALIS
CEPHEUS
M13
ANDROMEDA
TRIANGULUM
M31
LACERTA
Deneb
CYGNUS
Vega
LYRA
HERCULES
SERPENS CAPUT
ARIES
Jupiter (September 25)
Great Square of Pegasus
Northern Cross
VULPECULA
OPHIUCHUS
PISCES
PEGASUS
DELPHINUS
SAGITTA
SERPENS CAUDA
Altair
AQUILA
EQUULEUS
SCUTUM
M24
Saturn (September 25)
AQUARIUS
CAPRICORNUS
SAGITTARIUS
Fomalhaut
PISCIS AUSTRINUS
SCULPTOR
GRUS

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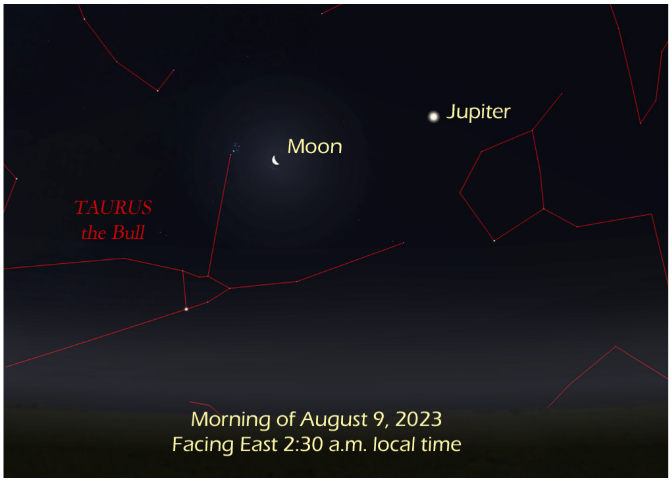


August 8–9: The last-quarter Moon is 2 degrees above Jupiter

August 24–25: The first-quarter Moon occults the bright star Antares (see below)

Perseid Meteor Shower: This annual meteor shower is one of the most famous, if not one of the best, meteor showers of the year. This year the shower peaks only a few days before new Moon, which means that only a thin crescent Moon will illuminate the pre-dawn hours—the best time to observe meteor showers—after midnight on August 12 and into the pre-dawn hours of August 13, when from a dark sky you might see a meteor every minute or two. Activity is often decent on the night before and after the peak, in case you have clouds on the 13th.

Antares Occultation: On August 24, the first-quarter Moon occults the bright star Antares in Scorpius. The occultation of a bright red star like Antares is spectacular, and video observers might be able to measure Antares's diameter by recording the "partial" phase of the occultation (which will only last a fraction of a second). Details for your location can be found at the International Occultation Timing Association's prediction at lunar-occultations.com/iota/bstar/0824zc2366.htm. IOTA also has observing guides and suggestions on how to observe and time the event as part of a citizen science effort.

September 2023 Planetary Highlights

Saturn is visible all night, just past its August 27 opposition. This year Saturn's famous rings are tilted only about 10 degrees to our line of sight, still visible in a small telescope but making it more difficult to see details. The angle of the rings will remain nearly constant for the rest of the year but will decrease rapidly throughout 2024. The rings will next be edge-on to our line of sight in 2025.

Jupiter rises in mid-evening and stands high in the south at sunrise. The giant planet rises out of the murky air near the horizon before midnight, beginning several months of evening observing.

Venus is visible in the morning sky, rising 3 hours before the sun and shining brightly in the east at dawn. It is joined briefly by Mercury toward the end of the month. Mercury reaches its greatest elongation west of the Sun on September 22, so the few days before and after that date are your best chance of spotting the innermost planet this month.

Mars is behind the Sun and out of view this month.

Distant Neptune reaches opposition on September 19, but still requires binoculars or a telescope to spot.

Finally, planet Earth reaches a milestone in its orbit this month: the autumnal equinox occurs on September 23 at 6:50 Universal Time. (This means it actually occurs on the 22nd for those in the Pacific time zone.)

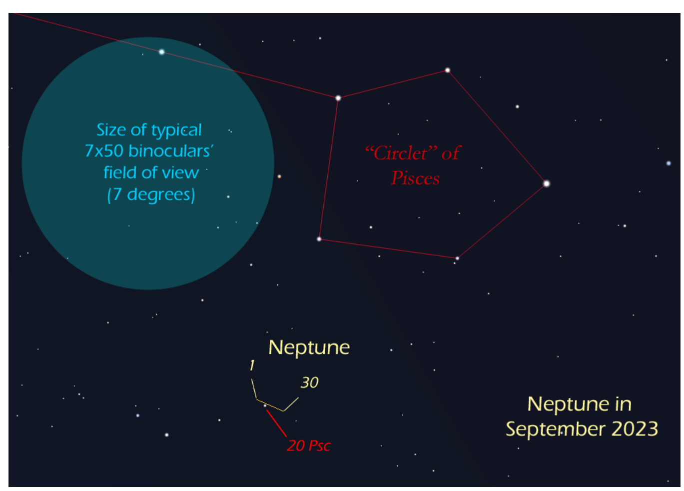
The Moon passes near the planets and some bright stars as it orbits Earth. This month, the following events happen at convenient times for Canadian observers:

The waning gibbous Moon is above Jupiter on the evening of September 4 as they rise in the east. By the following night, the Moon has passed Jupiter and the two rise nearly level with each other.

On the evenings of September 11 and 12, the waning crescent Moon is near Venus.

The waxing crescent Moon is close to the bright star Antares on the evening of September 20, low in the southwest at sunset. The Moon will actually occult the star as seen from an area which includes much of Japan and some areas of the south Pacific, but we won't see it from North America.

The waxing gibbous Moon is less than 4 degrees below Saturn in the sky on the evening of September 26.



Continued from page 150

Figure 3 – As all amateur astronomers know, more and more satellites are visible streaking across our starry skies. Basudeb Chakrabarti captured this troubling phenomenon across the sky of Hanle, Ladakh, India, in May. Basudeb used a Nikon Z6-II, Tokina Opera 16-28, an I-Optron Sky Guider Pro on a Benro Rhino Series Tripod. The final image consists of 30×60 seconds at f/4, ISO 4000, and FL of 16 mm. Post-processing was done in Sequator, PixInsight, and Photoshop.

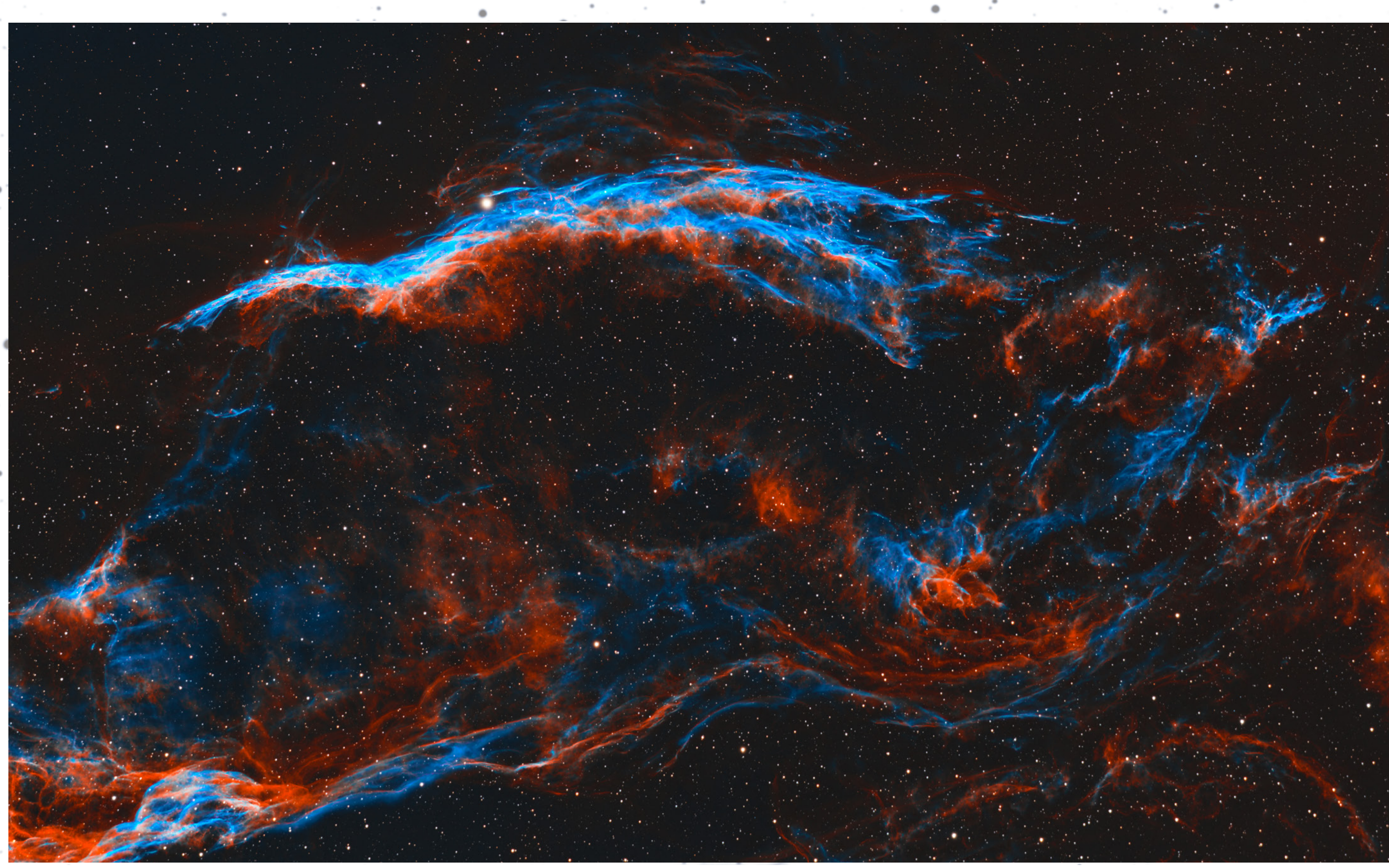


Figure 4 – Steve Lesser captured the West Veil in Cygnus over five nights in September 2022 from Calgary. "The narrow Hydrogen Alpha and Oxygen III emission wavelengths are exceptionally strong in this region, and I mapped the HHOHO colour palette to try and make something truly unique!" he says. "The stars are true colour RGB blended in at the final stage of editing." Steve used a William Optics FLT120, William Optics Flat7A, Sky–Watcher EQ6-R Pro, along with a ZWO ASI2600MM-Pro for a total of 24 hours and 36 minutes of total integration.

Astronomical Art & Artifact

Comet 109P/Swift-Tuttle and a Lost Technique for Astrosketching

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Abstract

References to published observing reports from the 1862 apparition of comet 109P/Swift-Tuttle have revealed a forgotten astrosketching technique which, while unorthodox, led to a very effective lithographic image of the comet. The intaglio (knife) sketching technique is described here, some obscurities in its description are addressed, and a selective trial of its use is reported.

Periodically Encountering the New in the Old

Roaming in the older astronomical literature can deliver more than the pleasurable ensnarement of nostalgia. Delving into the past, the reader encounters a mix of the familiar and the unfamiliar, whose ever-changing proportions reflect the ever-changing state of science. Reflecting on the differences between present and past knowledge, and the evolving techniques and technologies of discovery, can lead to new creative approaches, even at the earliest stages of asking "how could that have possibly worked?," or "was that really observed?," and searching for answers through experiment. It is useful to be open to the unexpected observations and technical possibilities that encounters with past observations can suggest. The observational history of Comet 109P/Swift-Tuttle offers just such an unexpected technical possibility worth exploring.

Discovered in 1862, a mere handful of years before the first founding of what became the RASC (1868), Comet Swift-Tuttle, while not a "great comet" like C/1858 L1 (Donati) of the previous decade, did put on a show of more than passing interest for telescopic observers (Kronk 2003, 307–313).[1]

Active observers in the mid years of Victoria's reign enjoyed diverse channels for communicating and discussing their cometary observations. A letter could reach a range of people depending on its form and intended audience, from a single intended recipient, to a moderate multitude (if destined for publication). An oral report would directly engage its hearers on the occasion of its delivery, and a larger audience afterward if it too were published (as regularly happened with the proceedings of some groups). Or the choice could be to go to print first through the formal mode of a paper in a periodical. In practice these modes of communication were frequently not that far apart, particularly the first two; one could readily meld into the other.

Some of the periodicals experienced a good run (e.g. *Monthly Notices of the Royal Astronomical Society* 1827–), whereas others were more fleeting. *The Intellectual Observer* was one of the latter, appearing for a mere six years, 1862–1868. Brevity of existence was not always a result of mediocre quality. The influential British-American popularizer of astronomy, Richard A. Proctor (1837–1888), remarked two decades after the demise of *The Intellectual Observer* that it was "one of the very best science magazines ever published," high praise indeed from one of the major players in the Victorian knowledge economy (Lightman 2007, 332).[2]

Of particular interest within the pages of *The Intellectual Observer* are descriptions of some observers' techniques used to sketch comet 109P/Swift-Tuttle.

Removing Paper to Reveal a Comet

In the 1860s, the most commonly encountered medium for the reproduction of observational drawings was probably the wood engraving (Figure 1), due to the relative inexpensiveness of hardwood compared to metal, and the adequate level of detail achievable when cutting end grain. More expensive, but capable of greater verisimilitude to observation (i.e. more detail, a cleaner image, and the rendering of some colour), were chromolithographs (Figure 2). An article might include a clutch of wood engravings, but only one or two chromolithographs.

The October issue of the second volume of *The Intellectual Observer* contains articles on the comet by two of the century's most skilled popularizers of observational astronomy, the Rev'd Thomas William Webb (1806–1885), and the Honorable Mary Ward (1827–1869) (Robinson & Robinson 2006; McKenna-Lawlor 2003, 19–51). Webb's paper is confined to his own observations, but Mrs. Ward conveys her observations along with those of the Rev'd Frederick Howlett (1821–1908), and M. Jean Chacornac of the Paris Observatory (1823–1873) (Lynn 1909; Tobin 2014). It was only a few years after the first editions of Webb and Ward's respective books on observational astronomy (Webb 1859; Ward 1859). They were amateurs of influence.

As Webb's paper doesn't discuss his sketching technique, it won't detain us for long. He does make one general comment on the limitation of hand-drawn representations of phenomena worth quoting:

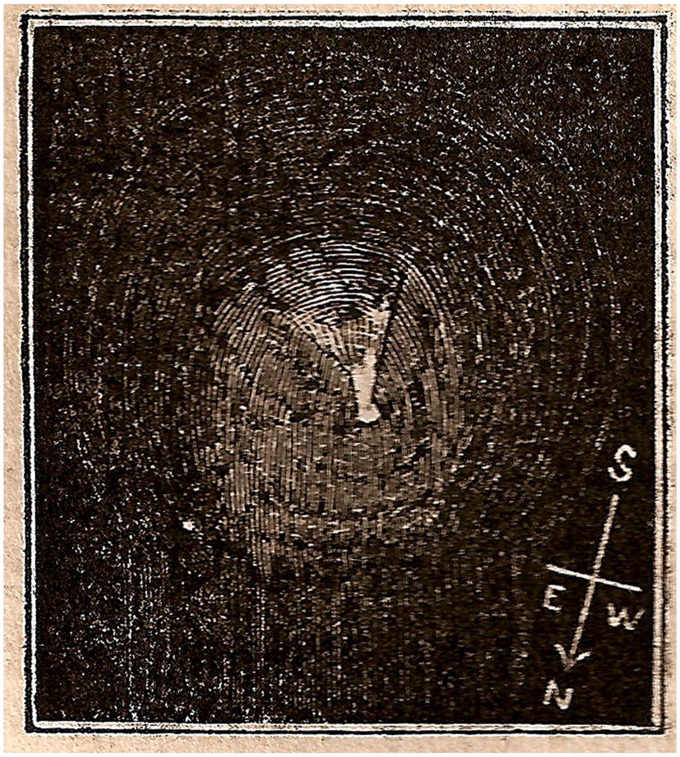

Figure 1 — Rev'd Frederick Howlett, Comet 109P/Swift-Tuttle, 1862 August 27, from Ward 1863, 216. Wood engraving. Reproduced courtesy of the Specula astronomica minima.

Figure 2 — The Honorable Mrs. Ward, Comet 109P/Swift-Tuttle, 1862 August 26, from Ward 1863. Chromolithograph. Reproduced courtesy of the Specula astronomica minima.

> "It is well known to all who have compared the records of cometary phenomena how variously their appearance is given by different instruments and observers; and when even the comparatively well-marked features of Donati's Comet [C/1858 L1] have met with discordant delineation at the hands of such men as Struve, Bond, Secchi, Lassell, Dawes, and De La Rue, it cannot in fairness, be expected that any set of representations should be found in perfect agreement with others, especially under unequal circumstances as to optical power and transparency of atmosphere" (Webb 1868, 198–199).

There was no alternative to the observational sketch as a visual record in his time, but Webb's statement should perhaps not be taken as a complete condemnation of the practice as scientifically worthless; rather he is being responsible in acknowledging a technological constraint.

Mrs. Ward presents descriptions of considerable interest regarding techniques for astrosketching. Her own technique, which "I am inclined to think is also very efficient" (Ward 1863, 213), is as follows:

> "I place my telescope [a 2.25-inch O.G. achromatic refractor on a library stand] on a table out of doors nearly opposite a window. Inside the window stands a lighted candle, and in front of it a powerful condensing lens (belonging to my microscope), placed at that precise distance from the candle that it casts a narrow stream of light to a great distance. I have a piece of card or paper and a pencil on my table, and when I choose I can place the paper in the brilliant light from the lens without allowing the glare to reach my eye. My drawings, being done in pencil, represent stars by black dots, and the brightest parts of the comet by the darkest shading, but I frequently copy them at once in imitation of the real appearance" (Ward 1863, 213).

Many—perhaps most—contemporary astrosketchers' first-generation images are also pencil on paper "negative" drawings (light celestial objects rendered in black on a white background), although it's interesting that Mrs. Ward often copies them in reverse soon afterwards, to make "positive" second-generation images (rendering bright celestial objects in light colours on a dark background) as they are seen in the eyepiece. Unfortunately, she doesn't describe the media she used to make the positive images. Judging by surviving examples by others from the 1860s, she may have used white "crayons"/"chalk" on black paper. Again, many modern practitioners also turn their "negative" first-generation images into "positive" second-generation ones (most often through image editing algorithms!). What is unlike modern practice is her method of illuminating her work when she is executing it at the eyepiece. Using a concentrated beam of white light would, according to modern canons, interrupt dark adaptation. But would it? The only way to find out would be to set a candle (preferably of wax, and shielded from the wind) behind a condensing lens 3-m or 4-m from the telescope, and see how effectively it works to illuminate the drawing surface, and its effect on one's night vision. It might in fact work.

More interesting still is what she recounts concerning the technique employed by "Mr. Howlett, F.R.A.S. (to whose kindness I am indebted for the figures which illustrate this part of the narrative, as well as for much information concerning the comet)…" (Ward 1863, 211). One reason she includes his images is the matter of aperture:

> "I should here perhaps explain that my reason for employing Mr. Howlett's drawings in preference to my own (which strongly resemble them), is, that the telescope which he employs, being three and a quarter inches aperture, brings out the delicate details of the comet with more completeness than I can expect from mine, which is an inch less in aperture…" (Ward 1863, 212).

It is what follows that is striking:

> "…and his plan of drawing is likely to ensure much correctness. He does not make his sketches literally at the telescope, being impeded by the well-known obstacle in the way of representing faint objects by night, namely, the difficulty of seeing the object in the greater brightness of the lamp used to throw light on one's drawing. He first obtains a good general idea of the comet by carefully viewing it with an opera-glass or an eye-piece of thirty diameters, to ascertain the direction of the tail, and also of the jet from the nucleus, and having carefully observed these particulars for about a quarter of an hour (the telescope being out of doors), Mr. Howlett, re-entering his house, marks them down by slightly scratching on black paper with a penknife, the paper being supported on a pane of glass, and held before a lamp, which renders the slightest scratch at once apparent. He then repairs to the telescope, applies a higher power, generally 120, and earnestly scans the comet till some new feature is fully impressed on his mind. Then he returns to the lamp, and very carefully notes down what he has seen. Sometimes ten minutes are employed in making sure of a fact, and as long a time in fitly representing it. Thus the drawing goes on till completed. Any scratch *de trop* [i.e. a mistake] is rectified by a little thick ink applied to obliterate it. These transparencies represent nearly the whole comet; but except in my tinted plate, I have copied only the head of each" (Ward 1863, 212–213).

The Rev'd Howlett's approach to preserving his dark-adaptation is certainly different from Mrs. Ward's. He literally doesn't sketch at the eyepiece, but relies entirely on the memory of what he has seen. In other words, he takes the time to really observe what is before him. (Astrosketching as a discipline encouraging those at the eyepiece to *really* observe what they see is one of its modern recommendations—it makes for a better observer). A memorable Astronomer Royal of Scotland, Charles Piazzi Smyth (1819–1900), who had a reputation as an excellent astronomical artist, relied even more on memory, observing intently at night, but only committing his observations to paper the next day—and he was renowned for the accuracy of his drawings (Warner 1983, 111). The Rev'd Howlett's method is anything but casual "grab and go" astronomy. It is time-consuming.

One would like to know if the Rev'd Howlett needed to take time to re-establish his dark adaptation before returning to the eyepiece; if so, it has been left out of the accounting of the time involved. And what was the nature of his indoor source of light described as a "lamp?" Was it an oil lamp, or was it powered by a candle?

Part of his preferred drawing medium is certainly unexpected; a knife in place of a pencil, crayon, or pen, on dark paper. Instead of adding pigment to create the image, which the pencil, crayon, and pen do, he removes part of the ground with the knife to create the image. It is an intaglio process. Mistakes are corrected by filling them in with India ink, which restores the opacity of the ground. It is clear that the image can only be properly seen if backlit. Unfortunately, he doesn't specify what sort of knife he used, and there was a great variety of knives available in his time. My guess is that it was either a pen knife, or an erasing knife, for both are easy to control and capable of removing small amounts of paper to create subtle effects.

To judge by the lithographic image of comet 109P/Swift-Tuttle based on his sketches his intaglio process must have worked quite well (Figure 3).

Figure 3 — Rev'd Frederick Howlett, Comet 109P/Swift-Tuttle, 1862 August 24, from Ward 1863. Chromolithograph. Reproduced courtesy of the Specula astronomica minima.

To test Rev'd Howlett's technique, or at least the material part of it, a trial was made with antique pen knives and erasing knives on back-lit black paper (Figure 4). The part of his technique that wasn't tested was the use of memory, and possible 1860's lighting technologies. The goal was to see if removing material from black paper with similar knives to those Howlett may have used in the 1860s could produce a successful representation of an astronomical object. No attempt was made to use a modern black paper with the characteristics of paper from the 1860s that could have been used for astrosketching.

Figure 4 — Pen knife, George Wostenholm, Sheffield, late 19th century, and erasing knife, first half of the 20th century, Japan. Reproduced courtesy of the Specula astronomica minima.

The chosen image to copy was one of Evered Kreimer's classic astrophotos of M16 (Mallas et al. 1979, 58; any suitable black and white image in any medium would have done for this test).

The results thus far have been a complete failure. With backlighting provided by a modern light-table it has proved impossible to remove enough material from modern black sketching paper in a controlled way to produce a successful representation of an astronomical object. According to Howlett a transparency effect should result, but that was not the case in the trial.

In the modern experiment there was either a failure of materials, or techniques. It is possible that the paper used by Howlett was substantially different from that which is available now; it may have been thinner, or possessed characteristics that made it easier to remove material in a controlled way. Or the blade and tip of his unspecified knife may have had a different profile from that of the pen knife and erasing knife used in the experiment. His backlighting technology may have been more powerful (although that seems counterintuitive). Or he may have used his knife with a different technique than that employed by the experimenter. Or the failure may be due to a combination of the above factors.

Howlett's intaglio technique may never have been widely employed, but the end result of his lithograph, and Mrs. Ward's confidence in his results indicate that it would be worthwhile to continue the experiment. For now, despite the detail in Mrs. Ward's description, there remains something intriguingly mysterious about the mechanics of the Rev'd Howlett's astrosketching technique. ✶

Acknowledgements

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

Endnotes

1 The comet also rose to theoretical importance when Giovanni Schiaparelli showed that its orbit was similar to that of the Perseid meteor stream; Schiaparelli 1867; Jenniskens 2006, 97–99.

2 The bibliographical citation provided by Lightman seems to be not quite right. Nall 2019 offers a recent attempt to depict Proctor's adroit use of the periodical and press options to communicate science in his treatment of the use of different media by astronomers in the Mars wars of the late 19th and early 20th century.

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CFHT Chronicles

A Focus on the Solar System

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

Spring at CFHT brought two exciting new insights to our Solar System from CFHT users. Although, I could say 63 new insights…

More Moons for Saturn

In May, a team led by Edward Ashton, postdoctoral fellow at Taiwan's Academica Sinica Institute of Astronomy and Astrophysics, announced the discovery of 62 new moons around Saturn. Other members of the worldwide team included professor Brett Gladman (Department of Physics & Astronomy at the University of British Columbia), Mike Alexandersen (Harvard Smithsonian Center for Astrophysics), Jean-Marc Petit (Observatoire de Besancon), and Matthew Beaudoin (University of British Columbia).

Ashton used a technique known as "shift and stack" in his search around Saturn. Using MegaCam at CFHT, the team took sequential images of the sky surrounding Saturn at a rate similar to the expected rates that the moons would travel across the sky, i.e. "shifting" the camera, for three hour spans. The team then stacked the images creating a greater depth, uncovering moons up to 2.5 km in diameter.

Ashton and Beaudoin started the search in 2019 while students at the University of British Columbia, finding moons in a search of CFHT data taken that year. One observation of an object is not enough to declare it a moon, rather the objects must be tracked for years. After years of searching, the team had enough data and confidence to announce the discovery of 62 new moons.

"Tracking these moons makes me recall playing the kid's game Dot-to-Dot, because we have to connect the various appearances of these moons in our data with a viable orbit," explains Edward Ashton, "but with about 100 different games on the same page and you don't know which dot belongs to which puzzle."

The new moons all fall into the irregular moon classification. Irregular moons have large, elliptical orbits, and inclined orbits compared to "regular" moons, leading astronomers to hypothesize the irregular moons were captured by Saturn long ago. Irregular moons in the Saturn system tend to clump together into three orbital groups, each named from different mythologies: the Inuit group, the Gallic group, and the Norse group. The Norse group is the most populated group and its ranks only swelled with this new discovery. The team hypothesizes the large number of Norse moons in retrograde orbits are the leftover pieces of a moderately sized irregular moon impacted in the past 100 million years, aka recently.

Gladman explains: "As one pushes to the limit of modern telescopes, we are finding increasing evidence that a moderate-sized moon orbiting backwards around Saturn was blown apart something like 100 million years ago."

The team offered a very warm *mahalo* to CFHT by stating that "this project is only made possible due to the superb data provided by CFHT's attention to excellent image quality, the huge field of view of its MegaPrime digital camera, and the excellence of its telescope operations staff."

Congrats to the team! The paragraphs above are a summary of a recent UBC news release from mid-May.

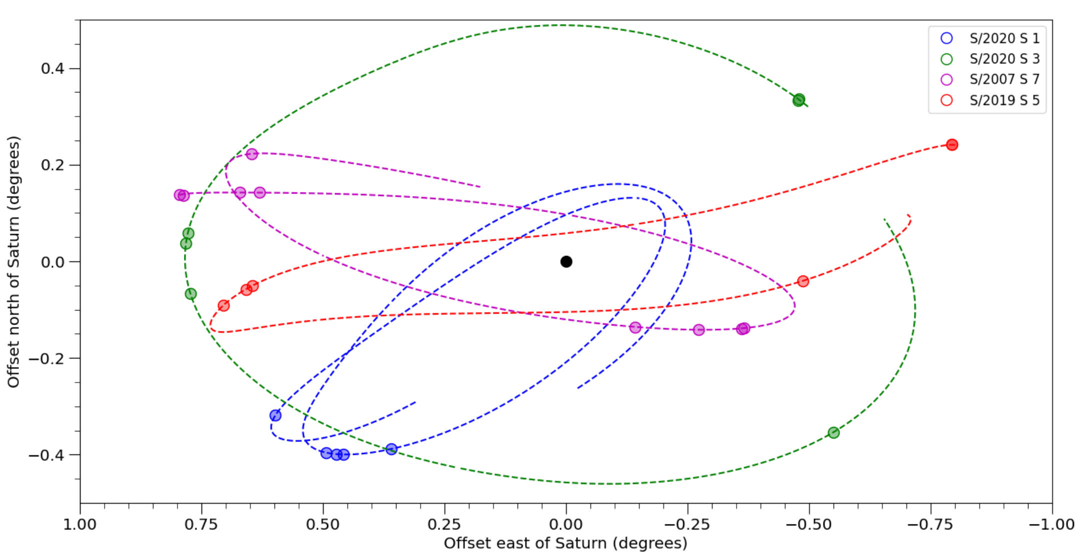

Figure 1 — The paths of four of the new moons as they orbit Saturn (black circle at centre) during the period 2019–2021. The coloured dots mark the observed position for each moon; the dashed curve shows the orbit that connects them.

Crazy Rings

A recent stellar occultation has revealed the presence of a second ring outside the Roche limit orbiting Quaoar. The discovery, led by Chrystian Luciano Periera, a Ph.D. student at the Observatório Nacional (RJ) and affiliated researcher at Laboratório Interinstitucional de e-Astronomia (LIneA), was published in the journal *Astronomy & Astrophysics Letters* on 2023 April 28. This study utilized the Canada-France-Hawaii Telescope and the Gemini North Telescope on Maunakea, along with robotic telescopes and members of the United States amateur astronomer community.

Rings around bodies in the Solar System were first observed by Galileo Galilei when he pointed his telescope at Saturn in 1610. In the following centuries, rings would be discovered around the other three giant planets: Jupiter, Uranus, and Neptune. Until the 2013 discovery of the first ring system around the Centaur object (10199) Chariklo, astronomers were unsure if rings could form around small Solar System bodies. The team demonstrated Chariklo was not alone as a ringed system with the 2017 discovery of a ring surrounding the dwarf planet Haumea.

In February 2023, the same team led by Bruno Morgado (UFRJ/BR) announced the discovery of the third ring system, now around the Trans-Neptunian object Quaoar. Further analysis shows Quaoar's system is more complex than previously thought, having a second, innermost ring to the one published earlier this year. These discoveries were made by observing stellar occultations, which occur when an object in the Solar System passes in front of a star and blocks its light for a few moments. By measuring the duration of the occultation and if there are secondary, fainter occultations, astronomers can determine characteristics of the Solar System object.

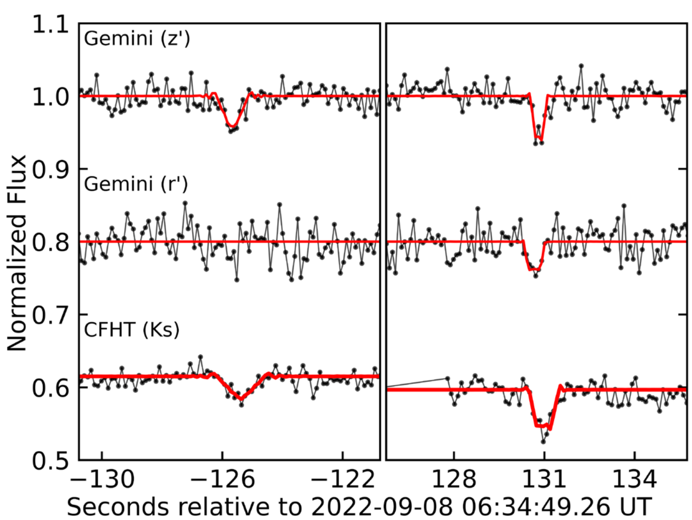

Figure 2 — Detections of the new ring (Q2R) around Quaoar using Gemini North and CFHT. The flux drops in the light curve are the rings occulting the star. Credit: Pereira et al. 2023

Unlike the rings observed at Chariklo, Haumea, and the four giant planets, Quaoar's rings lie in an unexpected region, well beyond the Roche limit for the body. The Roche limit is a region where the gravity of the central body (Quaoar) balances with the gravity of the individual ring particles, preventing the particles from forming a moon. Quaoar's Roche limit is estimated to be 1,780 km or 1,100 miles from the centre of the object. Another interesting and unusual property of the Quaoar ring is the variability, very narrow and dense in one region while tenuous and extensive in another.

To obtain more information about Quaoar and its curious ring, the team organized an observational campaign for a stellar occultation observed on 2022 August 9, involving amateur and professional telescopes. The team used the Gemini North Telescope and CFHT, neighbours on Maunakea. The results of this observational campaign were published in the journal *Astronomy & Astrophysics Letters*, with Chrystian Luciano Pereira, a doctoral student in astronomy at the Observatório Nacional, Rio de Janeiro, as the first author.

The high performance of the instruments attached to the Gemini North and CFHT telescopes, the 'Alopeke and WIRcam cameras, respectively, combined with their location on Maunakea in Hawaii, allowed for obtaining unique quality light curves. The dense and narrow region of the previously discovered ring (preliminarily named Q1R) was probed by this occultation, revealing a narrow, confined structure approximately 5 km wide.

"This narrow core of the ring is surrounded by an envelope of dispersed material about 60 km long, resembling in structure the F ring of Saturn or the arc observed in Neptune's rings," said Pereira. This ring's most extensive and tenuous region was also detected, having an average width of 90 km and less than 1% of the density of the thickest region. The calculated distance between Quaoar and this ring is 4,060 km (2,522 miles).

These data also revealed the presence of a second ring orbiting Quaoar, previously named Q2R. This ring is about 10 km wide and, despite being closer to Quaoar, it is also outside the Roche limit, orbiting 2,520 km (1,565 miles) from the object's centre. This reveals how curious and complex Quaoar's system can be.

The outermost ring orbits Quaoar at a distance very close to a stable region. Quaoar rotates three times and the ring's particles orbit once. This relationship is called a 1:3 spin-orbit resonance, The innermost ring is close to the 5:7 spin-orbit resonance region, i.e. while Quaoar completes seven rotations, the ring particles complete five orbits. This dynamic behaviour is observed in the rings around Chariklo and Haumea, which are also close to the 1:3 resonance region. This suggests that resonances may be closely related to the maintenance and location of these rings. Another factor that could cause these

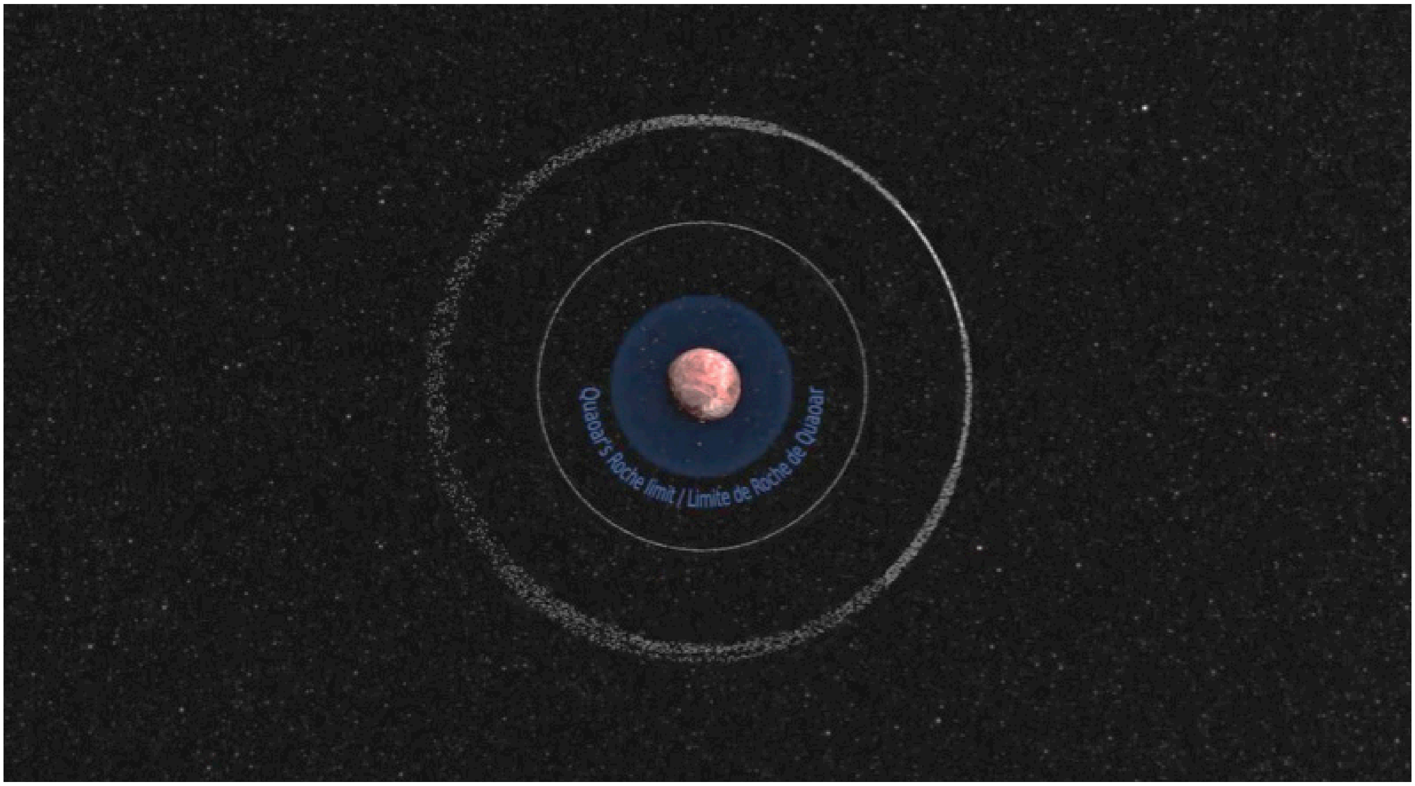

Figure 3 — Artist's rendering of the overhead view of the Quaoar system.

rings to be confined is the presence of small "shepherd" satellites that have yet to be discovered.

Future work on the precise determination of Quaoar's shape and new observations of these rings will be important for a better understanding of the dynamic system in which Quaoar and its rings are inserted and the real role of resonances in the maintenance and confinement of these rings.

"WIRCam is an exceptionally stable instrument and observations were taken in a very efficient and fast, almost video-like mode allowing for the high precision measurements needed to detect a short occultation by a faint ring around a distant object in our Solar System." said Benoit Epinat, WIRCam instrument scientist at CFHT. "It is incredible to realize we can see a 6-mile [9.7-km] ring from over 3 billion miles [4.8 billion kms] away."

The team would like to acknowledge this work was carried out as part of the "Lucky Star" project under the leadership of Dr. Bruno Sicardy of the Paris Observatory (Paris, France) and was made possible through a worldwide collaboration involving professional and amateur astronomers. This study had the participation of researchers from several international institutes, such as Instituto de Astrofísica de Andalucía (Granada, Spain), Observatório Nacional (Rio de Janeiro, Brazil), Federal Technological University of Paraná (Curitiba, Brazil), Interinstitutional Laboratory of e-Astronomy (Rio de Janeiro, Brazil), Florida Space Institute (Orlando, Florida), among others.
Gemini North is part of the International Gemini Observatory, operated by NSF's NOIRLab. ✶

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.

Binary Universe

The Inner Circles of Collimation

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

Struggling with telescope collimation? This very new application, *Collimation Circles*, might be just the ticket to ease the process.

saimons-astronomy.webador.com/software/collimation-circles

The Dark Arts

Learning the Dark Arts is the price of admission for people entering the astronomy hobby. One must learn about combating dew and ice; one must determine how to power equipment in the field; observers are encouraged to learn star hopping; one must learn the Greek alphabet; if one procures an equatorial mount, you're staring down the barrel of polar alignment; and one must learn how to collimate his or her telescope.

It is ironic that the most recommended telescope type (the Newtonian on a Dobsonian base) is the class that regularly requires checks and adjustments to the collimation.

While documented procedures abound on the internet and in official manufacturer user manuals, these collimating directives are often poorly written, confusing matters at best, or causing the telescope user to make things worse. Be careful of the YouTube video you watch. Turn the screw on an SCT secondary mirror a quarter of a turn, and possibly you've made the alignment much worse. Turn the collimation screws counterclockwise too many times and the secondary mirror might fall out of the holder. Not good.

Over the years, I have collimated binoculars, large and small Newtonians, Schmidt-Cassegrain telescopes (SCT), Ritchey-Chrétien reflectors, and Maksutovs (MCT). That's good on one hand: I've gained experience on a variety of systems. But I don't apply these corrective actions on a frequent basis, so I get rusty. Even I have to dig out my notes to remember the steps.

Happily, the two telescopes I use most often—a vintage 1980's Celestron 8-inch SCT and Meade ETX-90 MCT—do not require regular adjustments. They "hold" their collimation well. I adjust the SCT once in a blue Moon.

The ETX is off a bit, but that's primarily due to an issue that is not easily resolved. The secondary is slipping. This is a famous known problem where the adhesive weakens at some point, allowing the spherical mirror, under the pull of gravity, to slide out of position. That said, it appears exactly the same as when I received the telescope from Charles Darrow in April 2012.

It was the Edmund Scientific 6-inch Newtonian that I cut my teeth on aligning a reflector. I haven't used this 'scope much to date—but I plan to when I finish the home-made Dobsonian base.

Collimating a large or long Newtonian is easily done by two people, one in the front and one at the back. This can however create spiralling arguments not unlike those between a driver and a navigator on a long road trip.

It was this practical problem that spurred me to try something different. One can complete the task with a camera with a live-view function. I first attempted this on 2012 August 25 . "Holy cow." I said in my blog. The process was very convenient. "I don't think I'll ever go back!"

And now there's another reason...

Collimation Tool

There's an app for that!

If I remember correctly, it was in February or March that I spotted the post in Cloudy Nights, titled "Collimation Circles, app for easy telescope collimation." Easy collimation? Yes, please!

This thread had actually started earlier, initially created by the software developer, in December 2022.

The developer was actually prompting for feedback, essentially looking for guinea pigs—er, beta testers—for his new program and, in short order, a few people jumped into the fray, sharing observations and testing the application in different scenarios.

I was reluctant to get involved at the early stages, so I just watched from afar. I lurked. But by April and May, it was clear to me that the application was working well so I decided to give it a go. And in very short order, I was quite pleased; extremely impressed, actually. While simple on one hand, it is brilliant in terms of what it does and offers.

Easy Installation

I decided to do testing in the Windows environment partly to avoid inevitable challenges presented by Linux. Windows experiments would afford a speedy analysis. Others on Cloudy Nights are using Linux. I might test on the Macintosh platform, but I'll need some time in my mom's office to do that.

A preliminary step was to install the framework. The developer had used a new version of the .NET coding tools from Microsoft that I had never used, so I went about downloading and launching the Version 7 package. No issues with this on John Gomez, the Dell laptop computer running Windows 10, 64-bit.

Then I downloaded the application proper from GitHub. The developer prepared a distribution for the Windows environment, assembled in a ZIP file. Again, no issues downloading and opening this archive. In fact, the program did not require a formal installation process. I was up and running after launching the main executable .EXE file from the application folder.

Thar she blows.

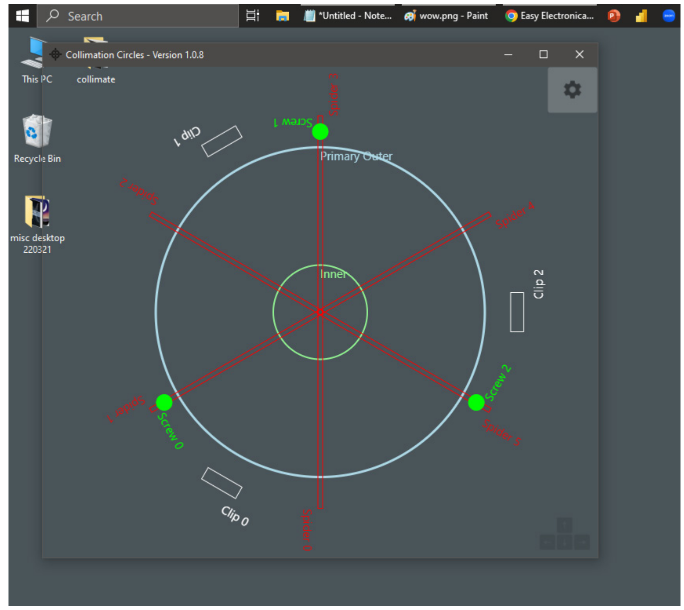

Figure 1 — Collimation Circles application main window with transparent background.

Transparency

On launching *Collimation Circles*, a window is displayed (Figure 1) with various circular patterns, crosshairs, and other shapes.

Beyond these various circles and shapes, in the background of the window, you will see whatever is on your computer desktop display.

I wonder how many users hearing about this program truly understand what that means. It is a bit of a brain bender, at first glance, but the spirit of this is that you, the user, will place this window with its graphical elements over top of, and carefully aligned with, the image underneath. And the image underneath will be from your camera-acquisition software.

You can tell some people don't grasp this, as CN members were asking about if the app supported a certain camera or supported a certain acquisition program. *CC* doesn't do that—it has no acquisition capability. By design, it's simple in that regard, it relies on the acquisition being done normally by some other piece of software. *Collimation Circles* literally lies on top of the external camera software.

The default view presented shows a light-coloured outer circle, and a light-coloured inner circle, three green, small disks for the screw positions, a set of red lines radiating from the centre corresponding to spider vanes, and then finally white rectangles for the clips. All these shapes and patterns are fully adjustable.

To adjust the settings in *CC*, one simply clicks the gear or cog icon at the top right.

The Live View

Another reason I decided to drop the *Collimation Circles* application onto the Dell is because I was already using it with the *Backyard EOS* software! I could rapidly begin testing by opening *BYE* and carefully positioning the *CC* transparency window over top of the image presented by the camera in the live view in the *Backyard* software.

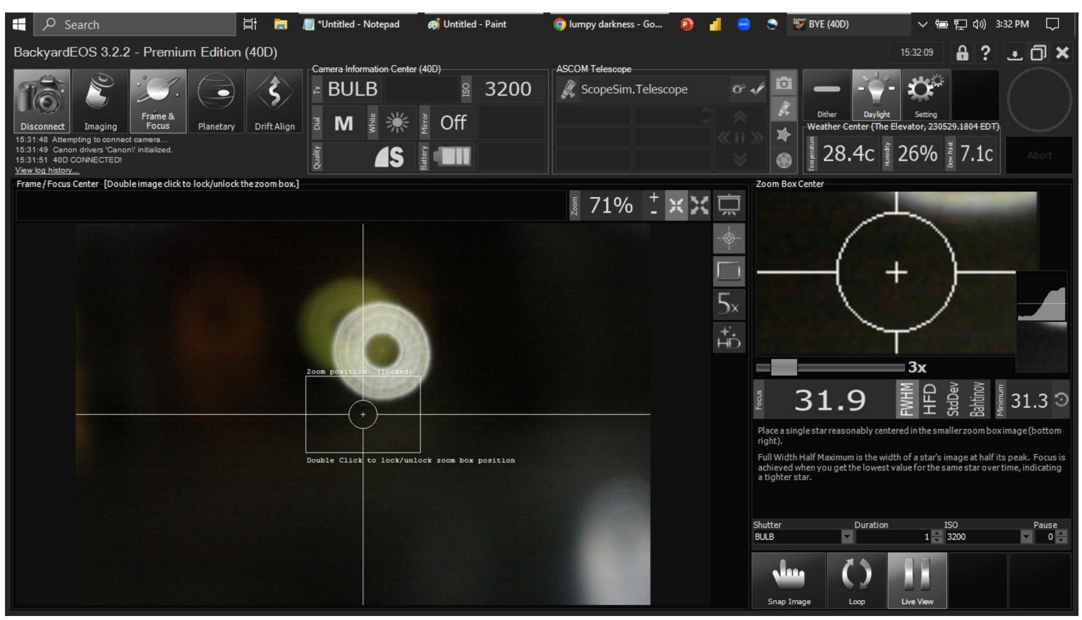

Figure 2 — Backyard EOS showing a live view of a (false) star to assess collimation.

In the interest of time, and with a deadline looming (er, slipping), I decided to do an indoor test with a false star. I grabbed the Orion soft-cover case with the C8 within, and I set up the optical tube assembly on a work table. I attached the Canon 40D to the output of the Williams Optics focuser. I aimed the OTA down the hall toward a shelf in the kitchen pantry. Here I had a Christmas tree decoration—a shiny, glass ball—off which I bounced the beam from a single LED flashlight. Back at the Dell computer, I launched *Backyard EOS*, switched to Frame and Focus, which flipped open the shutter. I adjusted the exposure settings to darken the scene.

With the false star so close to the OTA, 5 metres versus 347 400 000 000 000 000 metres, I had to rack the onboard focuser to an extreme limit before seeing a hint of the defocused disk of light in the camera software. Then I used the WO focuser to create a defocused ring typical of that used while collimating (Figure 2).

I zoomed in the live view in *BYE* to produce a reasonably sized disk.

And finally, I dragged the *Collimation Circles* transparent window to be roughly aligned with the image presented by the camera.

Adjusting the Patterns

The *CC* Settings window (Figure 3) shows a list on the left corresponding to the elements shown in the transparency window. Items may include an inner circle, primary outer circle, a spider, a screw, and a clip. The Add menu at the top-left allows more elements to be shown, as needed. Items in the list may be removed with the trash-can button. Items can be made active or inactive with the check-mark box.

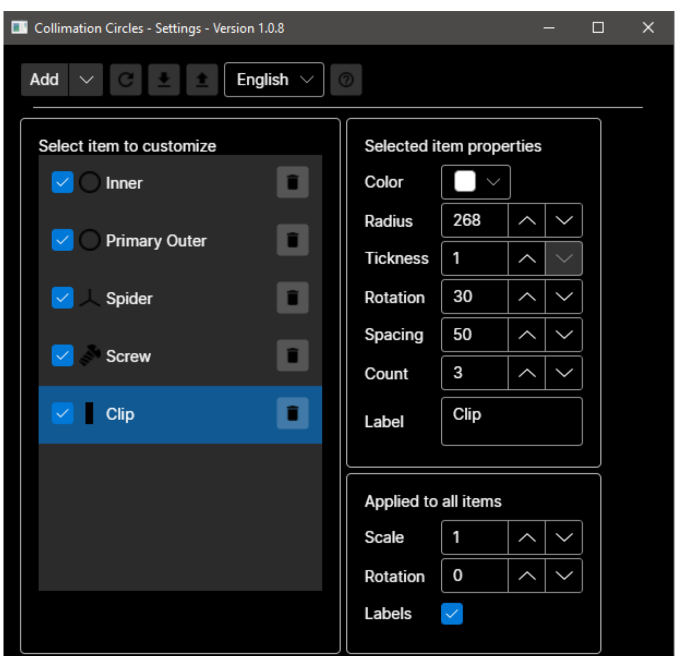

Figure 3 — The Settings screen allowing complete control over the appearance of all added shapes.

For each item, various parameters can be adjusted. For all, the colour can be set, as can the radius or distance from centre, the line thickness, and the annotation label. For some elements, e.g. the spider, a few other options are exposed: the rotation angle, spacing between lines, and the number of elements.

A master control for all objects exists at the bottom-right and here we can set overall scale and rotation.

I found this all very easy to use.

I then created templates for the SCT (Figure 4) and the Newt (Figure 5) and saved each profile using the JSON format. Handy for people who own multiple 'scopes or who have access to multiple instruments.

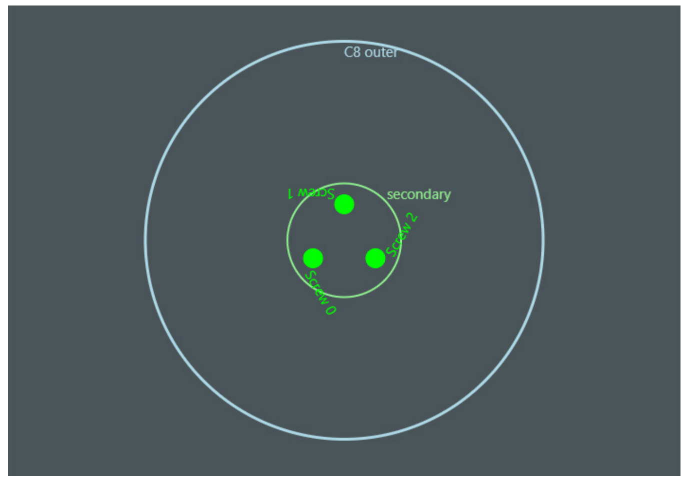

Figure 4 — SCT with adjustment screws on secondary mirror.

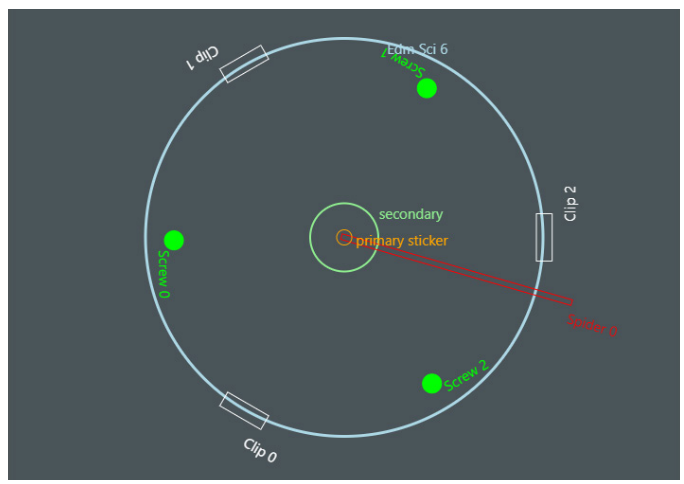

Figure 5 — Newtonian with secondary suspended by single post and adjustment screws behind primary mirror.

It was while playing with the templates that I noted the little toolbar at the bottom right of the transparency window. Hovering, I learned of welcome keyboard shortcuts, notably to nudge the window by one pixel. Perfect!

With a tuned set of collimation circles, a telescope operator is ready to undertake the task easier than ever before.

Help Along the Way

The author has been very involved with the Cloudy Nights crew, responding to issues and suggestions. I, myself, submitted a few observations.

There is a Help button within the Settings window that links to a web page. This actually walks through the app setup and the collimation process. The author refers to Astro Baby's good, detailed webpage on collimating a Newtonian.

Master Collimation

Good collimation is important, obviously. Excellent collimation is needed for exacting work. It was a breakthrough for me to employ a camera as it allows working solo and in comfort. Now, using *Collimation Circles* takes it up a notch by showing precise symmetrical patterns taking any remaining guesswork out of the process. All for free thanks to the generous contribution by *sajmons*. Now you can easily master one of the dark arts in our hobby.

Bits and Bytes

There are a couple of updates for *hello aurora*: The "now" and "today" screens have been merged. Unfortunately, Figure 3 was the same as Figure 6—my apologies. I learned that some fees are a one-off for which the author is grateful, but it is the monthly subscription fees that unlock additional features. And finally, the CARISMA model only covers western Canada. ✶

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

John Percy's Universe

Why We Should Care about the Cosmos

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

Yes, this may seem like "preaching to the choir." By reading this *Journal*, you have already demonstrated your interest in astronomy—perhaps even your passion—and your care for the cosmos. I originally intended this column for a general audience, but then decided it would be equally appropriate for you. It may remind you why you care about the cosmos. Even more, it is "ammunition" that you can use in your important outreach to those millions of Canadians who have not yet learned about the wonders of the Universe. So here is my message to them—and you.

In these times of pandemic, war, and disaster, why should we care about the cosmos? It will not cure cancer or solve the inequality crisis. At least not directly. But astronomical research helps to reveal the fundamental laws of physics and chemistry—from quantum physics to relativity—which underlie all the practical benefits of science. The Universe is the ultimate scientific laboratory.

Astronomy is also engaging. It can promote public awareness, understanding, and appreciation of science and technology, among people of all ages from children to seniors. It can attract young people to careers in STEM (science, technology, engineering, math). They can then continue astronomy as a lifetime interest or pastime. Unlike theoretical physics, for instance, astronomy can be enjoyed as a hobby. Millions do! Anyone can be an armchair astronomer, or a recreational skygazer. You could even be a citizen scientist, participating alongside professional astronomers in astronomical research.

There are advantages to connecting with the Universe eyes–on, in person, even in an urban environment. That way, you know it is real. First find a safe place with a clear view. Let your eyes acclimatize to the dark for a few minutes. Then, enjoy! A seasonal star chart for your latitude really helps. You can find one on the internet, or in RASC publications. Binoculars can help too but are not essential. There's no admission charge; the stars belong to everyone. You may not be able to see the faintest of galaxies, but the Sun, Moon, planets, and bright stars all have fascination and messages for us. You may even want to image them with your camera.

A useful strategy, for the beginner, is to connect with your local astronomy club. This is where the award-winning Royal Astronomical Society of Canada, with its 30 branches across the country, can help. They all have programs, including star parties for the general public. Their members are volunteers who are passionate about astronomy.

The cosmos stretches the mind, through its vast scales of distance and time. Because of the finite speed of light, we see the stars as they were, hundreds or thousands of years ago, and the galaxies as they were, millions or billions of years ago. If you start to feel insignificant, just remember the words of Henri Poincaré, the French scientist and philosopher:

Figure 1 — The Crab Nebula, a supernova remnant. It represents the death of a star, and the birth and dispersal of new chemical elements. It was observed and recorded in 1054 CE by astronomers in the Far East, while Western science was in the "dark ages." Credit: HST/ESA/NASA.

"Astronomy is useful because it shows how small your body, how large your mind."

As we look into the cosmos, we can appreciate our cosmic roots—the origin of the atoms and molecules of which we are made, the planet on which we live, and the star that nourishes life and holds the Solar System together. As Carl Sagan said, "We are star stuff." And the laws of physics and chemistry seem to be universal. Among the billions of stars in each of the billions of galaxies, life— either simple or complex—must surely be widespread, and diverse, as it is on Earth. Just looking at the Moon and planets reminds us that ours is not the only world in space.

We can witness cosmic evolution and death, as well as birth. But the cosmos is benign. Stars may explode, and galaxies may collide, but all we see is the wonder and beauty of it. The exception is a possible collision with a rogue asteroid or comet. We must be alert, but the odds are minuscule, compared with the certainty of climate change.

Around the world, and through time, astronomy has also connected with culture and spirituality. Archaeoastronomy delves into artifacts of this. Ethnography, past or present, can help us to learn the astronomical stories and beliefs from the people themselves. Pyramids and stone circles, churches, and graves have been aligned with sunrise. The Sun, Moon, and stars have marked the passage of time and season, and guided travel in the days before GPS. Constellations have carried the stories of the gods. The heavens have inspired great works of art, music, and literature through the ages, including a whole genre—science fiction. Great astronomers have become public figures: Galileo, Hubble, Einstein, Sagan, and Hawking, for instance. (Yes, all white males, but diversity is slowly catching up.) Nowadays, astronomy helps to drive frontier areas of technology, including optical and radio imaging and image-processing, computation, AI, and communication. But its cultural applications and connections remain.

Astronomy is often thought of as an activity of wealthy nations. But astronomical facilities now exist on all seven continents—even at the South Pole. Many of them are situated on the traditional land of Indigenous communities—the peaks of Hawaii, for instance—or in underdeveloped regions. The astronomical community must continue to support research, education, outreach, and development in these underserved areas, for the benefit of the local population. In May 2023, the University of Toronto hosted an international conference on astronomy education, where we welcomed educators from around the world—in-person and virtually—to review progress, and plan for an improved future. Cultural astronomy, and equity, diversity, and inclusion were major themes of the conference. There is still much to be done, including right here in Canada.

We astronomers don't know everything. We are still seeking the nature of the "dark matter" that makes up most of the mass of the cosmos, and the "dark energy," which accelerates the expansion of the Universe. What is the nature of black holes, supermassive and otherwise? Which planets are not only habitable, but inhabited? Through the many outreach events organized by professional and amateur astronomers, we invite you to join us on this voyage of shared exploration and discovery. And keep looking up! ✶

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

Awards Committee Report

The Awards Committee is pleased to present the 2023 Award Recipients. These awards recognize the extraordinary efforts of the named individuals and on behalf of the Society, we thank and congratulate all recipients for this good work.

Fellowship Award

Colin Haig, David Levy

The award of Fellow of the RASC is to recognize the long-term and ongoing contributions of members whose service to the Society has been exemplary and substantive for an extended period of time. Such contribution will far exceed the level required for our Service Award. Nominees may already hold the Service Award, but it is not a prerequisite for Fellowship.

Colin Haig's service to the Royal Astronomical Society of Canada goes back more than a quarter century, starting in the Hamilton Centre, where he served as newsletter editor starting in 1995 and then as president. Colin soon became interested in national activities and in 2010 he joined the national executive as second vice-president.

He spent a decade on the National Executive and the Board of Directors, capped by a year as National President in 2017 and 2018 as the Society celebrated its sesquicentennial. During those years, Colin played important roles on committees as the RASC dealt with issues such as government-mandated changes to the Society structure. Colin's service to the Society goes far beyond the positions he held. Colin's business acumen has often been called upon, and his advice has proven valuable to fellow executive and board members, executive directors, and other staff during his many visits to National Office in Toronto. More than once he provided important assistance to treasurers before he served in that position himself when it unexpectedly came open in 2017. Colin is well known in RASC Centres in Ontario due to his frequent appearances at Centre events, often as a highly regarded speaker on astronomical topics. He is also known for his high level of technical knowledge that has proven valuable to the RASC when equipment needs to be wired or when computer systems have required expert attention. With his knowledge of digital imaging, Colin played an important role in launching the RASC Robotic Telescope Project, and he is continuing to use that knowledge in his work today.

Colin Haig's service to the RASC has previously been honoured with a Service Award in 2015. He has been credited with reviving the concept of the Fellowship Award in the RASC, and so it is most appropriate that his service to the RASC be honoured with this award.

David Levy is noted in the RASC website as "Possibly the RASC's most famous member and most active observer. He has been an ambassador for astronomy both amateur and professional throughout his many years in the discipline. David received the Chant Medal in 1980 and the Simon Newcomb Award in 2002." Levy received the Chant Medal in 1980, the year he was the AAVSO's most prolific observer with over 10,000 estimates made in one year. He is best known as co-discoverer of Comet Shoemaker-Levy, but amongst the worldwide observing community he is known for his long-term and extraordinary efforts in comet hunting. As with Charles Messier, Levy catalogued the many unique and interesting non-comets and created his Deep-Sky Gems list, first published in the RASC *Observer's Handbook* in 2008.

David Levy studied physics at McGill Univrsity and geology at Acadia University and switched to English Literature at Queen's University where he received his M.A. in 1979. This combined talent in astronomy and literature has resulted in a broad portfolio of books encompassing general astronomy, observing, comets, advanced observing techniques and astronomy's place in literature. His books have been variably aimed for beginners, observers, historians, and children. They have been well received.

For his lifetime service to the astronomical community, whose roots remain in the RASC, the Society is honoured to bestow a Fellowship Award upon David Levy.

Qilak

Wilfred Buck

Established in 2011, this award is intended to recognize individual Canadian residents, or teams of residents, who have made an outstanding contribution, during a particular time period, either to the public understanding and appreciation of astronomy in Canada, or to informal astronomy education in Canada, and to promote such activities among the members of the sponsoring organizations.

CASCA and The Royal Astronomical Society of Canada are pleased to announce that Wilfred Buck is the recipient of the 2023 Qilak Award for Astronomy Communications, Public Education, and Outreach. This award recognizes outstanding outreach efforts over a career, in particular the incredible impact Mr. Buck has had sharing Indigenous knowledge of the sky with both Indigenous peoples around the world and the Canadian public. Wilfred Buck is a member of the Opaskwayak Cree Nation and a well-known Indigenous star-lore expert. He worked for over a decade as a Science Facilitator at the Manitoba First Nations Education Resource Centre and has researched and consulted with elders for more than 15 years to learn more about the astronomical knowledge of Cree, Ojibway, and Lakota peoples. He is highly regarded internationally for his efforts in communicating this knowledge with educators and researchers, having shared his expertise for museum exhibits and films, panel discussions, and in many public lectures. For nearly two decades, Wilfred Buck has been using portable planetariums to teach First Nations students about the stars ("atchakosuk" in Cree) visible in the night sky. He is the author of two books exploring the night sky from an Indigenous perspective. His third book and autobiography *I Have Lived Four Lives*, outlines a heart-stirring journey from an impoverished upbringing to pursuing a career in teaching and speaks to discovery and healing for Indigenous youth. He was recognized in 2018 by the Canadian Teachers Federation with its Outstanding Indigenous Educator Award and is the subject of an upcoming National Film Board-sponsored documentary, *Wilfred Buck*.

CASCA and the Royal Astronomical Society of Canada are delighted to recognize Wilfred Buck's efforts with this award.

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La CASCA et la Société Royale d'Astronomie du Canada ont le plaisir d'annoncer que Wilfred Buck est le lauréat du Prix Qilak 2023 pour la communication, l'éducation et la sensibilisation du public à l'astronomie. Ce prix récompense les efforts de sensibilisation exceptionnels déployés au cours d'une carrière, en particulier l'impact incroyable que M. Buck a eu en partageant le savoir autochtone du ciel avec les peuples autochtones du monde entier et le public canadien. Wilfred Buck, membre de la Nation crie Opaskwayak, est un expert autochtone réputé en matière d'astronomie. Il a travaillé pendant plus de dix ans comme animateur scientifique au "Manitoba First Nations Education Resource Centre" et a mené des recherches et consulté des aînés pendant plus de 15 ans pour en savoir plus sur les connaissances astronomiques des peuples Cris, Ojibwés et Lakotas. Il est reconnu à l'international pour ses efforts de communication de ces connaissances avec les éducateurs et les chercheurs, ayant partagé son expertise dans le cadre d'expositions, de films, de tables rondes et de nombreuses conférences publiques. Depuis près de vingt ans, Wilfred Buck utilise des planétariums portables pour enseigner aux élèves des Premières Nations les étoiles ("atchakosuk" en cri) visibles dans le ciel nocturne. Il est l'auteur de deux livres qui explorent le ciel nocturne d'un point de vue autochtone. Son troisième livre et autobiographie, "I Have Lived Four Lives" (J'ai vécu quatre vies), retrace un parcours bouleversant, d'un milieu modeste à la poursuite d'une carrière dans l'enseignement, et parle de découverte et de guérison pour la jeunesse autochtone. En 2018, la Fédération canadienne des enseignantes et des enseignants lui a décerné le prix Outstanding Indigenous Educator Award et il fait l'objet d'un documentaire à paraître parrainé par l'Office national du film, "Wilfred Buck".

La CASCA et la Société royale d'astronomie du Canada sont ravies de reconnaître les efforts de Wilfred Buck en lui décernant ce prix.

Ken Chilton Prize

Chris Gainor

Established in 1977 in memory of Ken Chilton, this prize is awarded for a specific piece of astronomical research or work carried out or published recently.

Chris Gainor's book, *Not Yet Imagined*, documents the history of the *Hubble Space Telescope* from its launch through its first 30 years of operation in space. Focusing on the interactions among the general public, astronomers, engineers, government officials, and members of Congress, the book reveals the decision making related to service missions that made the *Hubble Space Telescope* a model of supranational cooperation.

The book also covers the impact of the *Hubble Space Telescope* and the images it produces on the public's appreciation for the universe and how the *Hubble Space Telescope* has changed the way astronomy is done.

Dr. Gainor offered the PDF version of the book to the RASC membership in advance of the publication of the hard copy of the book, published by the National Aeronautics and Space Administration, Office of Communications, NASA History Division.

Young Astronomers Award

(new for 2023)

Artash and Arushi Nath

Artash and Arushi Nath have been members of the RASC Toronto Centre since they were just young children.

The young brother and sister team (Arushi, now 13 years old; Artash, now 16 years old) have an insatiable curiosity about the world around them, researching everything from the impacts of climate change to—what else?—the Universe.

In 2014, the pair won the NASA Space Apps Toronto Award for their "Mars Rover: CuriosityBot" and were among the top five NASA Space Apps winners globally.

Once again, they won the same award in 2017, 2018, and 2019, as well as the 2017 Canadian Space Agency's Space Apps Challenge for their project "Yes I Can," which used Canada's own RadarSat-2 satellite data to recreate the #Canada150 logo. For that, they were invited to present their project to newly named Canadian astronauts, Jennifer Sidey-Gibbons and Joshua Kutryk.

Most excitingly, the pair were global winners of the 2020 NASA SpaceApps COVID-19 Challenge and were even invited to watch a rocket launch.

They have given numerous talks, including at several Toronto Centre events as well as at the RASC General Assembly.

In October, Arushi gave a presentation at the Toronto Centre on her photometric observations on the Didymos asteroid system, where NASA's DART spacecraft slammed into its smaller companion, Dimorphos.

And, most recently, she won the Best Project Award (Innovation) along with the Excellence in Astronomy Award from the RASC, a gold medal, the Top Category Award in Curiosity and Ingenuity, and the Youth Can Award at the 2022 Canada-Wide Science Fair (CWSF) for her research paper "Strengthening Planetary Defense: Detecting Unknown Asteroids using Open Data, Math, and Python," which was also published in the February 2023 issue of the *Journal of The Royal Astronomical Society of Canada*.

This brother and sister team exemplifies what it is that we look for—and hope to inspire—as a Society: youth, diversity, and passion.

Service Awards

Chris Young, Quinn Smith, Silvia Graca, John Marchese, Emma Macphee, Pierre Schierle

Chris Yung, of the RASC Halifax Centre, in recognition for his long and steadfast service to the RASC. This includes his serving as Centre Secretary for 5 years, contributing meeting reports, providing public outreach talks, helping organize the Centre's star party, assisting with Centre BBQs, and generally providing support and counsel on a plethora of Centre activities.

Chris Young is one of those stalwart members who do not seek the limelight but is always ready to jump in to lend a hand without being asked. He has a level head and a calming manner, always helpful in problem-solving and providing guidance. Countless volunteers have credited Chris with keeping them "sane" during stressful episodes such as running GAs and other complex events—one individual called Chris his "guardian angel."

One episode is telling: when a former elderly Centre President became too sick to drive himself to meetings, Chris arranged to pick him up, bring him to meetings, and take him home afterward—no one asked Chris to do that, he just saw the need and quietly took care of it. Later, before that gentleman's death, he requested to look once more at the dark night sky from the Centre's Saint Croix Observatory, and Chris took care of that as well. Chris carefully managed the disposition of the eventual donation of astronomical equipment to the Centre.

Quinn Smith, of the RASC Halifax Centre, in recognition for his long and steadfast service to the RASC. This includes his serving as Centre newsletter Editor for 9 years, Chair of the RASC Halifax IYA 2009 Committee, co-chair of the Dark Sky Committee for 12 years, Registrar of the Centre's star party for four years, co-chair or chair of the star party for two years, Chair of the 2015 RASC GA in Halifax, providing public outreach talks, presenter at the Halifax Planetarium, and participating in Exhibition outreach opportunities.

Quinn Smith is a passionate amateur astronomer whose hard work has contributed much to the success of the RASC Halifax Centre. As a small tech business owner, he has superb organizational and managerial skills, along with an engaging personality in representational matters with outside organizations such as Parks Canada, local universities, and exhibitions.

Silvia Graca joined the Winnipeg Centre in 2008 and has been an active member and volunteer since that time.

From 2010 to 2022, Silvia chaired the Spruce Woods Star Party (SWSP) committee and was the driving force behind a small cadre of volunteers running the event. Beginning as a simple camping and observing weekend for members and their families, SWSP has grown under Silvia's leadership to include local and guest speakers, public outreach events, evening banquets, and many other highlights that make it the Winnipeg Centre's flagship member event.

Silvia also was instrumental along with other Winnipeg Centre members in the establishment of Spruce Woods Provincial Park as a certified Dark-Sky site. While many others had a role in the creation of the Dark-Sky Preserve at Spruce Woods, it was Silvia's vision to make a celebratory commemoration event of it all. In addition to her SWSP duties, Silvia has been active in astronomy outreach programs at Oak Hammock Marsh and the Telescopes and Teepees events that have spread across the prairies.

She is also an avid visual observer and astro-sketcher, producing wonderful pencil, pastel, and even watercolour images of the Sun, Moon, planets, and deep sky objects as seen through her telescope. Silvia organized the Winnipeg Centre's current astro-sketching group and is active in the national AstroSketchers group as well. Her art has appeared in the RASC *Journal*, *SkyNews*, and our Centre's local newsletter, *Winnicentrics*, and her sketch of Comet Wirtanen won the Special Award for sketching as part of the Imagining the Universe event celebrating the RASC's 150th anniversary. Her sketching inspires others to spend more time at the eyepiece and fosters observers with a desire to search for ever elusive details and encourages the somewhat lost skill of recording and journalling observing sessions.

Silvia is a friendly and welcoming presence in the Winnipeg Centre and is very deserving of the Society's Service Award.

John Marchese started out as a Council member of the original Mississauga Astronomical Society, formed in 2003. Shortly after the Society became a Centre of the RASC in May 2006, John joined the Mississauga Centre Council and became Membership Secretary, a position he has held for the past 17 years, although he stepped down from Council in 2021. During this time, he has diligently and enthusiastically fulfilled his role and proven himself to be an important and valued member of the Centre.

John is constantly updating the membership list, sending polite and respectful reminders to members whose renewals have lapsed, and presenting membership reports at Council meetings when invited.

John set up and oversees the Centre e-mailbox and sends out notices and announcements to members before meetings. A few years ago, he took the initiative to draft a welcome letter, with Mississauga Centre Council, to new members. He ensures that members receive astronomical name badges. While no longer on Council, he continues to regularly discuss membership numbers and strategies to recruit and hold on to members for the Centre. He regularly submits the names of new members every two months for inclusion in the Centre's newsletter. For years, he has stood at the welcome table at meetings and goes out of his way to engage new members. In fact, John is the face of the Mississauga Centre because he is the one who members see first when attending meetings (when meeting in person).

John is not only an extremely pleasant person, but he has an outstanding memory of members' names and lives, indicating his unique ability to connect with the membership. In addition to the time he spends weekly on behalf of the Centre, John has for years organized the Mississauga Centre Starfest contingent. He keeps a running tally of potential attendees to Starfest, and gives a talk and encouragement at meetings for members to attend Starfest with maps, directions, etc. As a result, the Mississauga Centre has one of the largest attendances of any club at Starfest. He has also acted as the chief barbecuer at our annual picnic. In addition, John co-led a highly successful Mississauga Centre trip to SNOLab, which involved careful co-ordination and organization.

Emma Macphee has been a member of RASC N.B. since November 2001, shortly after it was established originally as RASC Moncton Centre. Since joining, she has been an important, dedicated, hard-working and integral part of the centre.

She has been a council member since 2003, holding numerous positions on the council:

Secretary 2003–2006 – Newsletter Editor 2007 – Treasurer 2007–2010 – Treasurer & general committee member for the N.B. Centre GA/AGM in 2010 – Councillor 2011 – 2VP in 2012 – Treasurer 2012 interim – Treasurer 2013 to present – National Observing committee member currently – RASC N.B. Inc. Observing Chair at present – Secretary – Treasurer 2020 to present – Frequent speaker at meetings – Outreach: about 100 events since 2016 (mostly courses for seniors; Guides, public observing at Moncton HS observing, Mad Science summer camp) – Prior to 2016, participated in numerous of the observing events held by RASC N.B. – annually–star parties, special events – Earned certificates for the Explore the Universe, Messier, and Finest NGC programs, now working on the Double Star & Lunar Program certificates

Emma has contributed in many ways to the growth and well-being of our Centre. She has been supportive of and involved in centre and member initiatives, projects, and events. She was part of the committee for the application for charitable status from 2019–2022. Emma has helped mentor new members in their observing as well as recruiting new members to the centre. She has also been involved in planning for the future of RASC N.B. Inc. Over the years, Emma has demonstrated her commitment and dedication to RASC N.B. in small, quiet, unsung ways. Supporting new members in their efforts, offering ideas for future plans, events, problem-solving, observing, etc…

She has contributed much to RASC N.B. whose members are proud to nominate her for the well-deserved RASC Service Award.

Pierre Shierle is a stalwart member of the RASC Regina Centre. His daughter, Katelyn, joined the Society in 2012, and a year later, Pierre followed her lead. Pierre quickly became involved in Centre outreach activities and learned astronomy at a rapid pace by engaging fellow members with thoughtful questions. After much research, Pierre purchased a 15-inch Obsession telescope, which he and Katelyn frequently used to work on their observing certificates.

Pierre is always quick to lend a helping hand and started assisting the Centre executive. He became a Centre Councillor in 2014 and took on the duty of managing the Centre's mailing lists. By the fall of 2018, Pierre was the Centre President and started spending more time solidifying the foundation of the Centre in the areas of membership, finances, team-building and documentation. Pierre spent countless hours every week working on something to benefit the Centre.

During his last year as Centre president in 2021, Pierre started identifying, troubleshooting and documenting issues that appeared when the new Driven system was implemented. He was spending 20-40 hours a week just addressing issues that were showing up and causing Centres grief. Through patience, persistence, and attention to detail, Pierre was able to help resolve a lot of issues for the betterment of the entire RASC organization. This was no small feat in itself, which he took on in addition to the other local duties he was working on.

Pierre completed the Messier Certificate Program in 2017, after a two-year effort in which he sketched every object and created a very beautiful observing log of it all. Through his observing learning journey, he took note of shortfalls that exist for the real newcomers to astronomy and developed the Regina Centre's Beginners Observing List. This is a very well-documented set of charts and list of 12 objects, that someone who knows absolutely nothing about astronomy can pick up the list and get started with the very basics. It covers topics that seasoned observers typically gloss over when trying to teach a new person from scratch. It's also great for youth to help them get started as well.

Pierre is a regular volunteer for Centre outreach events, most often accompanied by Katelyn—they make a great team. He always finds a way to re-arrange his schedule to assist with the public events and will often do outreach events on his own. He really enjoys sharing his passions with others and has become a mentor within the Regina Centre as a result. He always treats people with kindness and welcomes them into the hobby whenever he can. He truly is an ambassador for the RASC and an advocate for astronomy and the allied sciences.

The Saskatchewan Summer Star Party in Cypress Hills is one of Pierre's favourite summer camping destinations. He is often one of the first attendees to arrive and the last to leave. He often sets up his telescope well before the event and does public outreach to the general public while waiting for the SSSP to officially begin. His willingness to help quickly led him to volunteer as a member of the planning committee. He spends many hours ensuring the Star Party is ready for when guests arrive and takes care of them as Meadows Coordinator to ensure the event runs as smoothly as possible.

For his hard work and continuing dedication to both the RASC Regina Centre and the RASC Nationally, Pierre is highly deserving of the Society's Service Award.

President's Award

Judy Black, Halifax Centre

Judy Black has been working tirelessly as Chair of the National Council to turn it into a functioning entity, focussing on communication, cooperation, and transparency. She's been on the phone with the President just about every day working on this, running productive National Council meetings and mentoring the process online through the chat groups and email. We've now reached a point where we are seeing results. Therefore, I have nominated Judy for the President's Award for 2023 to recognize this important contribution to the Society.

Charles Ennis

President, Royal Astronomical Society of Canada

Plaskett Award

Dr. Deborah Lokhorst

Plaskett Award CASCA is pleased to announce Dr. Deborah Lokhorst as the recipient of the 2023 J.S. Plaskett Medal for the most outstanding doctoral thesis in astronomy or astrophysics. Dr. Lokhorst received her Ph.D. in 2022 under the supervision of Dr. Roberto Abraham at the University of Toronto, and she is now a Herzberg Instrument Science Fellow at NRC Herzberg Astronomy & Astrophysics Research Centre. Her thesis titled "Ultra-Narrowband Imaging with the Dragonfly Telephoto Array: Toward the Cosmic Web" is a tour-de-force combining theory, observation, and instrumentation. Dr. Lokhorst played a central role in the construction and scientific exploitation of the Dragonfly Telephoto Array, opening a new window on the "low surface brightness Universe." Her thesis work began with an analysis of hydrodynamical simulations to understand the observational limits needed to directly detect "invisible" gas in the circumgalactic medium (CGM) around nearby galaxies. She then designed, machined, and assembled the prototype of a new component of the Dragonfly Telephoto Array, the "Filter-Tilter," to allow the required limits to be achieved. She finally obtained the first scientific observations taken by a pathfinder Dragonfly narrowband imager, discovering a giant ionized gas cloud in the CGM of the starburst galaxy M82.

CASCA is delighted to recognize Dr. Lokhorst's achievements with this award.

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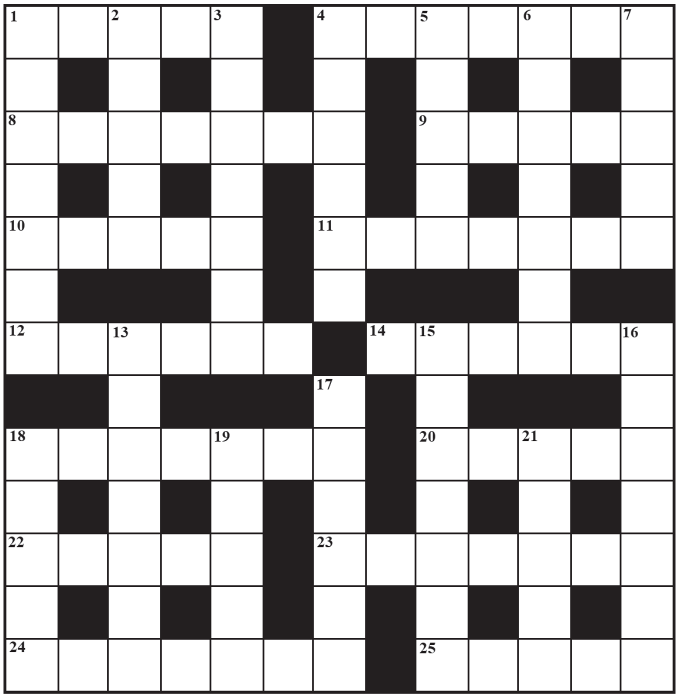
La CASCA a le plaisir d'annoncer que Dr Deborah Lokhorst est la lauréate de la médaille J.S. Plaskett 2023 pour la thèse de doctorat la plus remarquable en astronomie ou en astrophysique. Dr Lokhorst a obtenu son doctorat en 2022 sous la direction de Roberto Abraham à l'Université de Toronto, et elle est maintenant chercheure postdoctorale en instrumentation au Centre de recherche Herzberg en astronomie et en astrophysique. Sa thèse intitulée "Ultra-Narrowband Imaging with the Dragonfly Telephoto Array: Toward the Cosmic Web" est un tour de force combinant théorie, observation et instrumentation. Dr Lokhorst a joué un rôle central dans la construction et l'exploitation scientifique de Dragonfly, ouvrant une nouvelle fenêtre sur l'univers à faible brillance de surface. Sa thèse a débuté par une analyse de simulations hydrodynamiques afin de comprendre les limites observationelles nécessaires pour détecter directement le gaz «invisible » dans le milieu circumgalactique autour des galaxies proches. Elle a ensuite conçu, usiné et assemblé le prototype d'un nouveau composant de Dragonfly, le « Filter-Tilter », pour permettre d'atteindre les limites requises. Enfin, elle a obtenu les premières observations scientifiques réalisées par un prototype de base d'un imageur à bande étroite pour Dragonfly, découvrant un nuage de gaz ionisé géant dans le milieu circumgalactique de la galaxie à sursaut de formation d'étoiles M82.

La CASCA est ravie de souligner les réalisations de Dr Lokhorst en lui décernant ce prix.

Astrocryptic

by Curt Nason



ACROSS

1. Sam I am without a way back around Saturn (5)
4. It ain't a spinning satellite, or is it? (7)
8. Wide field scopes used by wealthiest observers (7)
9. Pointer offered through the camera Kohoutek used (5)
10. McLure-Griffith could nominally benefit from VLTI upgrade (5)
11. In Uranus, habaneros unofficially made the centaur's arrowhead (7)
12. Aquarius briefly collects unemployment insurance and a stellar eagle (6)
14. Sheepish remark the German film maker made (6)
18. A blue oddity in northeast among DSOs (7)
20. Accretion disc shaped like a bull, I hear (5)
22. Salvadore's comeback held one tale of Achilles (5)
23. Poetically, the sky above even has its changes (7)
24. Cash needed to load SLR differently for astroimaging (7)
25. Southern star trails taken over that rock for years round (5)

DOWN

1. Space station and a moon orbit Uranus (7)
2. Too manly to be a source of dark matter (5)
3. I find myself in odd places when studying relativity (7)
4. Atlas and Prometheus spawned by Iapetus (6)
5. Setback in which I'm involved for ages and eons (5)
6. Fullum's first visit to endless invasion site (7)
7. Paul croons before a star in Phoenix (5)
13. I lumber around Uranus (7)
15. A star twinkles at each little asteroid (7)
16. Seven sisters turn against one who defies (7)
17. The mother of rivers flows around Saturn (6)
18. Crooner Paul's sitter orbiting Neptune (5)
19. Tattooed lady rotates daily beyond Mars (5)
21. Peewee makes short stop east after the Astronomer Royal (5)

Answers to previous puzzle

Across: **1** CBC (abbrev.); **3** FOMALHAUT (anag); **8** PLAGE (2 def); **9** MARTIAN (Mar(t)ian); **10** LEAVITT (an(AV)ag); **11** ELARA (el+Ara); **12** AURIGA (Au+rig+a); **14** SCHEAT (S+cheat; β Peg); **18** LIGHT (2 def); **20** TIP-TILT (2 def); **22** TALITHA (2 def, hom); **23** EDWIN (hid); **24** ROSENFELD (rose+N+anag); **25** NEA (hid; near-Earth asteroid)

Down: **1** CAPELLA (anag); **2** CHARA (2 def); **3** FLEMING (F+anag); **4** MCMATH (abb+math); **5** LYRAE (anag); 6 ALIDADE (Ali+dad+E); **7** TANIA (2 def); **13** REGULUS (anag); **15** CEPHEID (anag); **16** TITANIA (anag); **17** ETHANE (methane-m); **18** LATER (anag-r); **19** TITAN (tit+a+N); **21** IOWAN (2 def)

Great Images

by Basudeb Chakrabarti

This beautiful image of the Belt of Venus, taken by Basudeb Chakrabarti and Soumyadeep Mukherjee, shows the post-sunset show in the eastern sky from Sadhutar, Nepal, above Mount Everest. Along with Everest are two other tall peaks, Lhotse (fourth highest mountain) and Makalu (fifth highest mountain). The pair used a Nikon D5600, Sigma 50-mm Art lens, and a Digitek GOCam.

Journal

This is a spectacular image of Messier 94, a spiral galaxy located in Canes Venatici, taken by Ron Brecher. from his SkyShed in Guelph, Ontario. "It's about 16 million light-years from us and has two rings," he says. "The inner ring structure is about 5,400 light-years wide, and the outer ring is about 45,000 light-years across. The outer ring contains more than 20% of the galaxy's mass." He used a Paramount MX mount with N.I.N.A., TheSkyX and PHD2. All pre-processing and processing was done using PixInsight. For luminance, he used a Sky-Watcher Esprit 150 ƒ/7 refractor and QHY600M camera with Optolong UV/IR filter. For chrominance, he used a Takahashi FSQ-106 ED IV ƒ/5 and QHY367C Pro one-shot colour camera with Optolong UV/IR filter. Total integration was 38 hours and 45 minutes.