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Journal

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PROMOTING ASTRONOMY IN CANADA

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Inside this issue:

The Elephant's Trunk

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Shawn Nielson imaged the Elephant's Trunk Nebula from Kitchener, Ontario. He used a Starfield Optics 8″ astrograph, a Starizona Nexus reducer/corrector at ƒ/3, a QHY268M CMOS camera together with Optolong 3nm Ha, OIII, SII filters. He acquired images using NINA 2.0 and processed in PixInsight for a total of 5 hours.

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

by Robyn Foret, Calgary Centre
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This year's Annual General Assembly brought to an end the term of Dr. Douglas Hube as our Honorary President.

Dr. Hube joined the RASC in 1960 as a student and went on to study astronomy at the University of Toronto, where he completed his Ph.D., and a year later, joined the faculty of the University of Alberta. He is well known for his exceptional teaching, research, and outreach activities. He received an RASC Service Award in 1982 and served as Society President from 1994 to 1996. Ever active in RASC activities, we offer our sincere thanks for 62 years of service to the Society, and particularly for these past four years as our Honorary President.

We were also very pleased to introduce Dr. Sara Seager as our new Honorary President at the 2022 AGM. Dr. Seager joined the RASC as a student too, and in a guest editorial for the 2015 RASC Observer's Handbook, she recalls her first experience viewing the Moon through a telescope at an RASC event. Joining the Toronto Centre as a teenager, she considers the bi-monthly Friday night meetings of the Centre at that time a highlight of her high school and undergraduate years. She went on to Harvard University for Graduate studies, coincidental to the publishing of the first reports of exoplanets, which led to her at-the-time controversial work to develop predictive models of the atmospheres of the exoplanets. She earned her Ph.D. at Harvard in 1999, was a long-term member of the Institute for Advanced Study in Princeton, New Jersey, and a senior researcher at the Carnegie Institution of Washington before joining MIT in 2007. As a side note, if you're not familiar with the Institute for Advanced Study, it's one of the world's leading centres for curiosity-driven research whose past and present Faculty and Members include 35 Nobel Laureates, 42 of the 60 Fields Medalists, 22 of the 25 Abel Prize Laureates, and many MacArthur Fellows and Wolf Prize winners. Albert Einstein was one of the Institute's first Professors and he remained at the Institute until his death in 1955.

Dr. Seager is one of those MacArthur Fellows noted and other accolades include membership in the U.S. National Academy of Sciences, the Sackler Prize in Physical Science, the Magellanic Premium Medal, and she is an Officer of the Order of Canada.

At MIT, Dr. Seager is a Professor of Physics, Professor of Planetary Science, and a Professor of Aeronautics and Astronautics. She also holds the Class of 1941 Professor Chair.

We are humbled and honoured to have Dr. Seager as our Honorary President, and I hope that both Dr. Hube and Dr. Seager continue to inspire our RASC youth; they are both incredible examples of how passion for STEM can lead to extraordinary things.

Isaac Newton said, "If I have seen further, it is by standing on the shoulders of giants." Here in the RASC, the giants are among us, and I am proud to be a part of such an esteemed organization, and I hope that you are, too.

P.S. as this is my last President's Corner, I must say that it has been an honour serving you as your Society President these past two years.

Take good care of you and yours! ✶

News Notes / En manchette

Compiled by Jay Anderson

New bells for CHIME

In the quest to identify the origins of one of astronomy's bigger mysteries—fast radio bursts or FRBs—Canada's world-renowned telescope, the Canadian Hydrogen Intensity Mapping Experiment (CHIME), is getting backup.

Supported by approximately $10 million in grants from the Gordon and Betty Moore Foundation, the CHIME/FRB Outriggers project has now secured funding to complete the construction of three new radio telescopes to work in conjunction with the main CHIME instrument, located in British Columbia's Okanagan Valley.

"It has been a pleasure to work with the talented team developing the outriggers for CHIME," said Robert Kirshner, Ph.D., Chief Program Officer for Science at the Gordon and Betty Moore Foundation. "Despite the burdens of COVID, interruptions in the supply of steel for the antennas, and competition with bitcoin miners for the specialized computer chips that power their computational wizardry, the CHIME team is headed toward a spectacular improvement in the scientific yield of CHIME's copious FRB discoveries."

Figure 1 — The CHIME radio-telescope at Penticton. Image: CHIME

The current CHIME instrument consists of four 100×20 metre antennas, each in the shape of a parabolic half-cylinder lying flat on the ground. Suspended above each cylinder are 1024 dual-polarization radio receivers that detect frequencies in the 400–800 MHz range emitted by hydrogen. The telescope array's main purpose is to measure the expansion rate of the Universe, but its most noticeable achievement so far is to detect FRBs at a rate far higher than any other telescope. In its first year of operation, CHIME detected over 500 FRBs. The instrument has no moving parts and so relies on the rotation of the Earth to allow it to sweep half of the sky each day.

FRBs are bright, millisecond-wide "flashes" in the radio spectrum, originating at cosmological distances. As they make their few-billion-year journey to earth, FRBs carry the imprint of the material lying between galaxies and stars, making them a significant probe to study these environments. While the current scientific consensus is that FRBs have natural origins, they represent an exciting astronomical phenomenon. Their high degree of spectro-temporal structure and transient nature make them an ideal proving ground for the robust signal processing systems in CHIME.

With the ability to detect 10–100 times more fast radio bursts than all other telescopes combined, CHIME has had a radical impact on FRB science. The telescope has allowed scientists to observe the vanishingly brief bursts with exquisite time resolution. CHIME's limitation, however, has been its inability to identify with any precision where the FRBs were coming from. The outriggers will enable this radical leap.

"The CHIME telescope can currently locate the position of a fast radio burst to a patch of sky equivalent to the size of the full Moon. With the addition of the three new outrigger telescopes, this patch of sky can be reduced to the size of a quarter held at roughly 40 km," explained Patrick Boyle, Senior Project Manager for the CHIME/FRB Outriggers project and Senior Academic Associate in the Department of Physics at McGill University.

By pinpointing FRBs, the new telescopes will allow scientists to zoom in on the environments within galaxies from which the bursts originate and, in so doing, narrow down the possible explanations for their existence.

"The CHIME/Outrigger Fast Radio Burst team is poised to shed even more light on one of the Universe's most exciting recent discoveries: the fleeting pulses known as fast radio bursts (FRBs)," said lead CHIME/FRB researcher Prof. Victoria Kaspi, Director of the McGill Space Institute and Professor of Physics at McGill University. "The CHIME outrigger telescopes will help us to both understand the origins of FRBs and realize their potential as cosmic probes."

The outrigger telescopes are smaller versions of the original set to be built in three locations across North America. One of the outrigger sites is in Canada:

- Near Princeton, British Columbia, on land kindly leased to CHIME by HML Mining Ltd., where construction of the new telescope's reflector has already been completed

The other two are in the United States and result from partnerships with existing radio astronomy observatories:

- The Green Bank Observatory in West Virginia, where it sits in the middle of the National Radio Quiet Zone (NRQZ).
- The Hat Creek Radio Observatory in California, where the CHIME/FRB project has partnered with the SETI Institute.

"Green Bank Observatory's distance from the other CHIME locations, being within the NRQZ and the pre-existing infrastructure available on our campus, make this the perfect site for a new CHIME Outrigger. The instrument will benefit from the protections of radio frequency interference that the NRQZ provides. It is good to see our extensive 2,700 acre [1093 hectare] campus being used in new ways, and it is exciting to see this impressive instrument under construction," said Andrew Seymour, a Green Bank Observatory scientist working with the CHIME team on the project.

"We are thrilled to welcome the world-class CHIME team to the Hat Creek Radio Observatory," said Andrew Siemion, Bernard M. Oliver Chair for SETI at the SETI Institute. "Hosting a CHIME outrigger represents a phenomenal and complementary addition to the HCRO's science mission."

Representing an amazing convergence of scientists across North America, the CHIME/FRB Outriggers project is a collaboration between several Canadian and international institutes, including McGill University, the University of British Columbia, the University of Toronto, West Virginia University, and the Massachusetts Institute of Technology. Also partnering on the project is the Perimeter Institute for Theoretical Physics, the National Research Council of Canada, the National Radio Astronomy Observatory, and the Green Bank Observatory. The outrigger project has also received funding by the National Science Foundation (NSF) for the electronics as well as salaries for faculty, postdocs, and graduate students located in the United States.

One star, loaded

In our neighbourhood of the Milky Way is a relatively bright star, and in it, astronomers have been able to identify the widest range of elements yet in a star beyond our Solar System.

The study, led by University of Michigan astronomer Ian Roederer, has identified 65 elements in the star, HD 222925. Forty-two of the elements identified are heavy elements that are found along the lower half of the periodic table of elements.

"To the best of my knowledge, that's a record for any object beyond our Solar System. And what makes this star so unique is that it has a very high relative proportion of the elements listed along the bottom two-thirds of the periodic table. We even detected gold," Roederer said. "That's really the thing we're trying to study: the physics in understanding how, where, and when those elements were made."

HD 222925 is a 9th-magnitude horizontal-branch star—that is, a star burning helium at its core and hydrogen in a shell around the core—lying at a distance of nearly 1500 light-years in the constellation Tucana. HD 222925's classification comes from its position on the Hertzsprung-Russell diagram, a graph of stellar luminosity versus temperature. For comparison, our Sun lies at a considerably cooler (lower) location on the H-R diagram and all the elements up to atomic number 90 have been identified in its atmosphere.

Figure 2 — It isn't much to look at, but here's HD 222925. Image: STScI Digitized Sky Survey

Identifying the heavy elements in a single star will help astronomers understand what's called the "rapid neutron capture process," one of the major ways by which heavy elements in the Universe were created. The process, also called the "r-process," begins with the presence of elements lighter than iron. Then, rapidly—on the order of a second—neutrons released in a very hot event are added to the nuclei of these lighter elements, creating heavier elements such as selenium, silver, tellurium, platinum, gold, and thorium—the kind found in HD 222925 and all of which are rarely detected in stars. R-process events are responsible for the creation of about half of the heavy elements in the Universe.

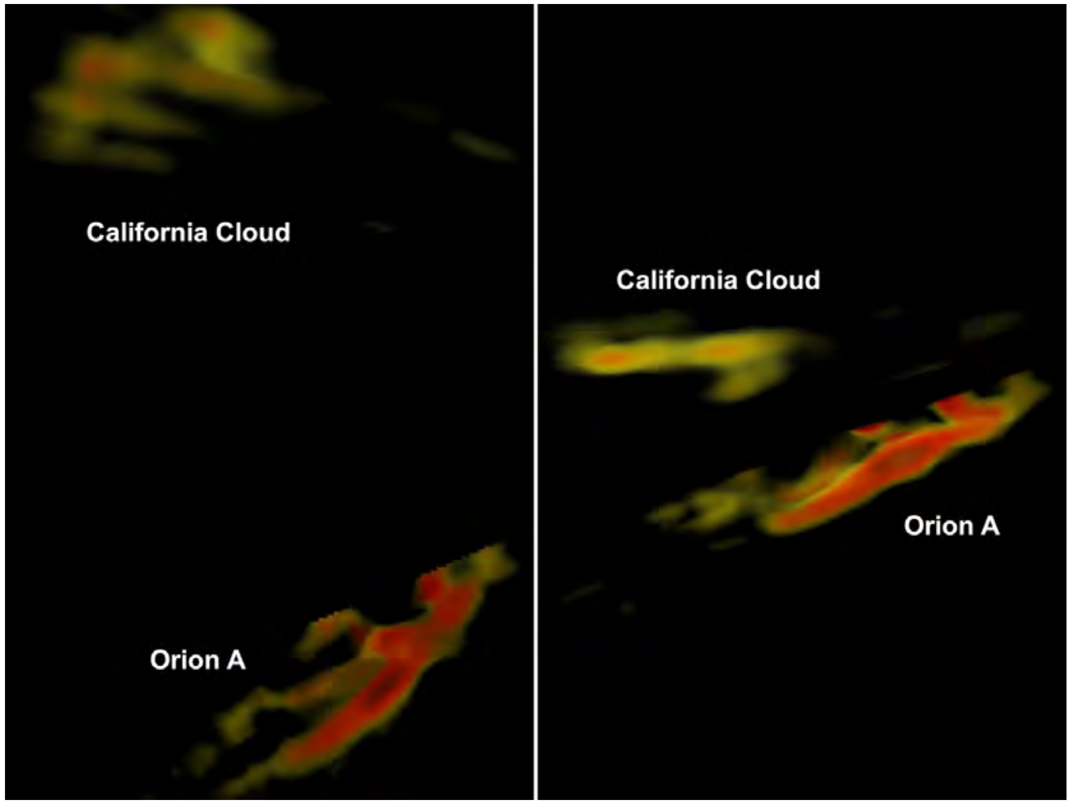


Figure 3 — The shape of the California and Orion A Clouds from two different perspectives at a spatial resolution of 15 light-years. The colours indicate density, with red colours representing higher values. The images are based on the 3-D reconstruction by Sara Rezaei Khoshbakht and Jouni Kainulainen, MPIA.

"You need lots of neutrons that are free and a very high energy set of conditions to liberate them and add them to the nuclei of atoms," Roederer said. "There aren't very many environments in which that can happen—two, maybe."

One of these environments has been confirmed: the merging of neutron stars. Neutron stars are the collapsed cores of supergiant stars, and are the smallest and densest known celestial objects. The collision of neutron star pairs causes gravitational waves, and in 2017, astronomers first detected gravitational waves from merging neutron stars. Another way the r-process might occur is after the explosive death of massive stars.

"That's an important step forward: recognizing where the r-process can occur. But it's a much bigger step to say, 'What did that event actually do? What was produced there?'" Roederer said. "That's where our study comes in."

The elements Roederer and his team identified in HD 222925 were produced in either massive supernovae or a merger of neutron stars very early in the Universe. The material was ejected and thrown back into space, where it later reformed into the star.

This star can then be used as a proxy for what one of those events would have produced. Any model developed in the future that demonstrates how the r-process or nature produces elements on the bottom two-thirds of the periodic table must have the same signature as HD 222925, Roederer says.

Crucially, the astronomers used an instrument on the *Hubble Space Telescope* that can collect ultraviolet spectra. This instrument was key in allowing the astronomers to collect light in the ultraviolet part of the light spectrum—light that is faint, coming from a cool star such as HD 222925.

The astronomers also used one of the Magellan telescopes at Las Campanas Observatory in Chile to collect light from HD 222925 in the optical part of the spectrum. These spectra encode the "chemical fingerprint" of elements within stars, allowing researchers to identify both the presence and approximate quantity of each atomic species.

Anna Frebel, co-author of the study and professor of physics at the Massachusetts Institute of Technology, helped with the overall interpretation of the HD 222925's element abundance pattern and how it informs our understanding of the origin of the elements in the cosmos. "We now know the detailed element-by-element output of some r-process event that happened early in the Universe," Frebel said. "Any model that tries to understand what's going on with the r-process has to be able to reproduce that."

Many of the study co-authors are part of a group called the R-Process Alliance, a group of astrophysicists dedicated to solving the big questions of the r-process. This project marks one of the team's key goals: identifying which elements, and in what amounts, were produced in the r-process in an unprecedented level of detail.

Composed in part with material provided by the University of Michigan.

An extra dimension for molecular clouds

Using tens of thousands of stars observed by the *Gaia* space probe, astronomers from the Max Planck Institute for Astronomy (MPIA) and the Chalmers University of Technology in Gothenburg, Sweden, have revealed the 3-D shapes of two large star-forming molecular clouds, the California Cloud and the Orion A Cloud (the southwestern part of the California Cloud is the well-known California Nebula). In conventional 2-D images, they appear similarly structured, containing filaments of dust and gas with seemingly comparable densities. In 3-D, however, they look quite distinct. In fact, their densities are much more different than their images projected on the plane of the sky would suggest. This result solves a long-standing mystery of why these two clouds form stars at different rates.

Cosmic clouds of gas and dust are the birthplaces of stars. More specifically, stars form in the densest pockets of such material. In these pockets, temperatures drop to near absolute zero, and the densely packed gas collapses under its own weight, eventually forming a star. "Density, the amount of matter compressed into a given volume, is one of the crucial properties that determine star formation efficiency," says Sara Rezaei Khoshbakht. She is an astronomer at MPIA in Heidelberg, Germany, and is the main author of the report.

In a pilot study portrayed in this article, Khoshbakht and co-author Jouni Kainulainen of Chalmers University have applied a method that allows them to reconstruct 3-D morphologies of molecular clouds in the two giant star-forming clouds. Usually, measuring the density within clouds is a difficult project. "Everything we see when we observe objects in space is their two-dimensional projection on an imaginary celestial sphere," explains Jouni Kainulainen. He is an expert on interpreting the influence of cosmic matter on stellar light and calculating densities from such data. Kainulainen adds, "Conventional observations lack the necessary depth. Therefore, the only density we usually can infer from such data is the so-called column density."

The column density is the mass added along a line of sight divided by the projected cross-section. Hence, those column densities do not necessarily reflect the actual densities of molecular clouds, which is problematic when relating cloud properties to star-formation activity. Indeed, infrared images of the two clouds that show the thermal dust emission apparently share similar structures and densities. However, their vastly different star-forming rates have been puzzling astronomers for many years.

Instead, the new 3-D reconstruction now shows that those two clouds are not that alike after all. Despite the filamentary appearance the 2-D images portray, the California Cloud is a flat and nearly 500-light-years-long sheet of material with a large bubble that extends below. One cannot attribute a single distance to the California Cloud, which has significant repercussions for interpreting its properties. From our perspective on Earth, it is oriented almost edge-on, which only simulates a filamentary structure. As a result, the sheet's actual density is much lower than the column density suggests, explaining the discrepancy between the previous density estimates and the cloud's star formation rate.

And what does the Orion A Cloud look like in 3-D? The team confirmed its dense filamentary structure seen in the 2-D images. However, its actual morphology also differs from what we see in 2-D. Orion A is rather complex, with additional condensations along the prominent ridge of gas and dust. On average, Orion A is much denser than the California Cloud, explaining its more pronounced star-forming activity.

Khoshbakht developed the 3-D reconstruction method by analyzing the alteration of stellar light as it passed through those clouds of gas and dust as measured by the *Gaia* space probe and other telescopes. *Gaia* is a European Space Agency project whose primary purpose is to precisely measure the distances to over a billion stars in the Milky Way. Those distances are crucial for the 3-D reconstruction method.

"We analyzed and cross-correlated the light from 160,000 and 60,000 stars for the California and Orion A Clouds, respectively," says Khoshbakht. The two astronomers reconstructed the cloud morphologies and densities at a resolution of only 15 light-years. "This is not the only approach astronomers employ to derive spatial cloud structures," Khosbakht adds "But ours produces robust and reliable results without numerical artefacts."

This study proves its potential to improve star formation research in the Milky Way by adding a third dimension. "I think one important outcome of this work is that it challenges studies that rely solely on column density thresholds to derive star-formation properties and to compare them with one another," Khoshbakht concludes.

However, this work is only the first step of what the astronomers want to achieve. Sara Rezaei Khoshbakht continues to pursue a project that ultimately will produce the spatial distribution of dust in the entire Milky Way and uncover its connection to star formation.

A 3-D video of the structure of the California Cloud can be found at www.youtube.com/watch?v=lZJNEf5roe8&t=9s; the same for the Orion Cloud is at www.youtube.com/watch?v=f4paK6XCbXs&t=2s.

Compiled with material provided by the Max Planck Institute for Astronomy

Mars dust emulates Earth's deserts

Travellers to the American Southwest or the Mexican deserts may have noticed the extreme dustiness of the atmosphere in summer months and the high frequency of dust devils in the heat of the afternoon. In addition, the landscape is occasionally visited by small dust storms generated by winds derived from convective clouds. Now a team of researchers has identified the same events on Mars and investigated their role in the atmosphere.

Figure 4 — On 2016 March 31, the long-lasting rover Opportunity caught this view of a large dust devil winding its way across the Martian landscape. Image: NASA / JPL-Caltech / Cornell / Don Davis

The researchers, associated with a host of institutions in Spain, France, Finland, and the USA, have proposed that frequent dust devils and occasional strong wind gusts, combined with upslope winds, are responsible for much of the red haziness in the Martian atmosphere.

Scientists have known for many years that Mars looks red not only because of the dust that coats its surface, but because much of that dust is borne aloft in the planet's atmosphere. What has remained a mystery, until now, are the factors responsible for keeping the dust aloft. While observations from Earth have shown that Mars experiences large, periodic dust storms that carry enormous amounts of dust into the atmosphere, present study of the storms has shown that they are not frequent enough to explain the persistence of dust in the atmosphere. To find its true cause, the researchers used the data from the Perseverance rover.

Perseverance carries the Mars Environmental Dynamics Analyzer (MEDA), which collects a suite of weather observations—temperature, wind, humidity, and pressure—along with less conventional instruments such as a thermal infrared sensor, and radiation and dust sensors. In addition to MEDA, there are cameras to capture images of the surroundings and a microphone to record the sounds of the wind.

Convection—the ascent of warm air generated by surface heating—peaks during the afternoon on Mars when surface temperatures are highest. On Earth, these convective cells would produce clouds, including thunderstorms, but on Mars, the cloudless convection only carries surface air upward, to be replaced by compensating downdrafts. These downdrafts bring higher winds speeds to the surface from aloft, which are strongest when the convective cells are aligned to generate linear gust fronts, much as on Earth.

The gusts produced by these convective downdrafts are capable of forming local, short-lived gust fronts that pick up and carry the surface dust into the lower atmosphere. Dust particles are initially difficult to dislodge from the surface, but once a few grains are lifted, the subsequent impact as they fall back to the surface is capable of loosening newer particles and so the dustiness tends to increase during the lifetime of the gust. Because local winds tend to blow upslope, the dust from the gust-generating convective cells is carried upward into the atmosphere as the air rises along the terrain, carrying particles aloft.

Dust devils are common on Mars—much more than gust fronts—so there is a second mechanism that raises dust on a much smaller but much more frequent basis. Perseverance found that at least one dust devil was generated in the vicinity of and even overtop the rover every day.

The research team found that wind speeds must reach at least 15 m/s to begin to raise dust into the atmosphere. The researchers suggest that, taken together, the wind events provide a reasonable explanation for the persistence of dust in the atmosphere. ✶

Research Articles / Article de reserche

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

Gilbert St-Onge et al.
Gilberts311@gmail.com

G. St-Onge[1], D. Bergeron[2], D. St-Gelais[3], J. G. Moreau[4], R. Gauvin[5], J. B. Desrosiers[6], C. Dupriez[7], R. Cazilhac[8], A. Amsaleg[9], M. Hanson[10].

Abstract

Most of the time observers stick to the variable aspects of the main nebula NGC 2261 to the north side of the R Monoceros "Herbig Ae/Be star" (Finkenzeller & Mundt 1984), the counterpart nebula to the south is almost never detected. Since 2019, we have been monitoring the NGC 2261 nebula more closely. Our work has determined that a section south of the main nebula, associated with the young star R Monoceros, has been missing since ~2015. Our monitoring of this nebula aims to try to re-detect this source and to document its apparent evolution, if possible. This present document focuses further on our work to determine if it is possible to detect traces of this structure in the sky where an elongated nebula of variable luminosity was previously observed, which is in the south component of nebula NGC 2261. The coordinates of the star R Monoceros (J2000), RA 06h 39m 09.95s and Dec 8° 44′ 09.7″ (DSS).

Résumé

Généralement les observateurs s'en tiennent aux aspects variables de la nébuleuse principale au nord de l'étoile R Monoceros "Herbig Ae/Be star" (Finkenzeller & Mundt 1984), la contre-parti au sud est plus rarement détectée. Elle demande des images qui ont un signale plus importants, les images plus anciennes (argentiques), elles ont rarement un signal suffisant pour dévoiler cette structure en jet du cotée sud.

Depuis 2019, nous effectuons un suivit plus serrée de la nébuleuse NGC 2261. Nos travaux ont permis de déterminer qu'une section au sud de la nébuleuse principale, associée à l'étoile jeune R Monoceros (R de la Licorne), a disparu depuis ~ 2015. Notre suivi de cette nébuleuse a pour but de tenter de redétecter cette source et d'en documenter son évolution apparente si possible. Ce 3iem dossier ce concentre aussi sur nos travaux qui tente de déterminer s'il est possible de détecter des traces de cette structure sur le ciel là ou s'observait parfois cette structure longiforme d'intensité lumineuse variable, qui est dans la composante sud de la nébuleuse NGC2261. Les coordonnées de l'étoile R Monoceros (J2000), AD 06h 39m 09,95 et DC 8 44′ 09,7″ (DSS)

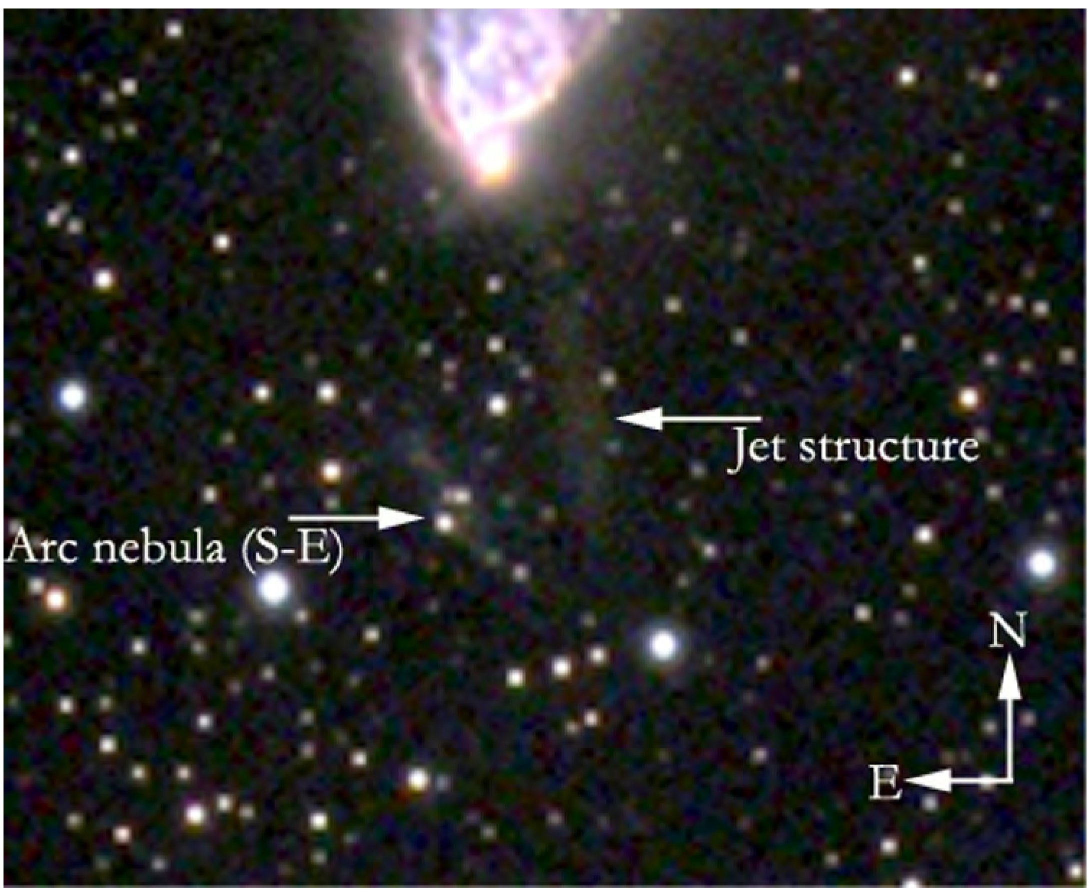
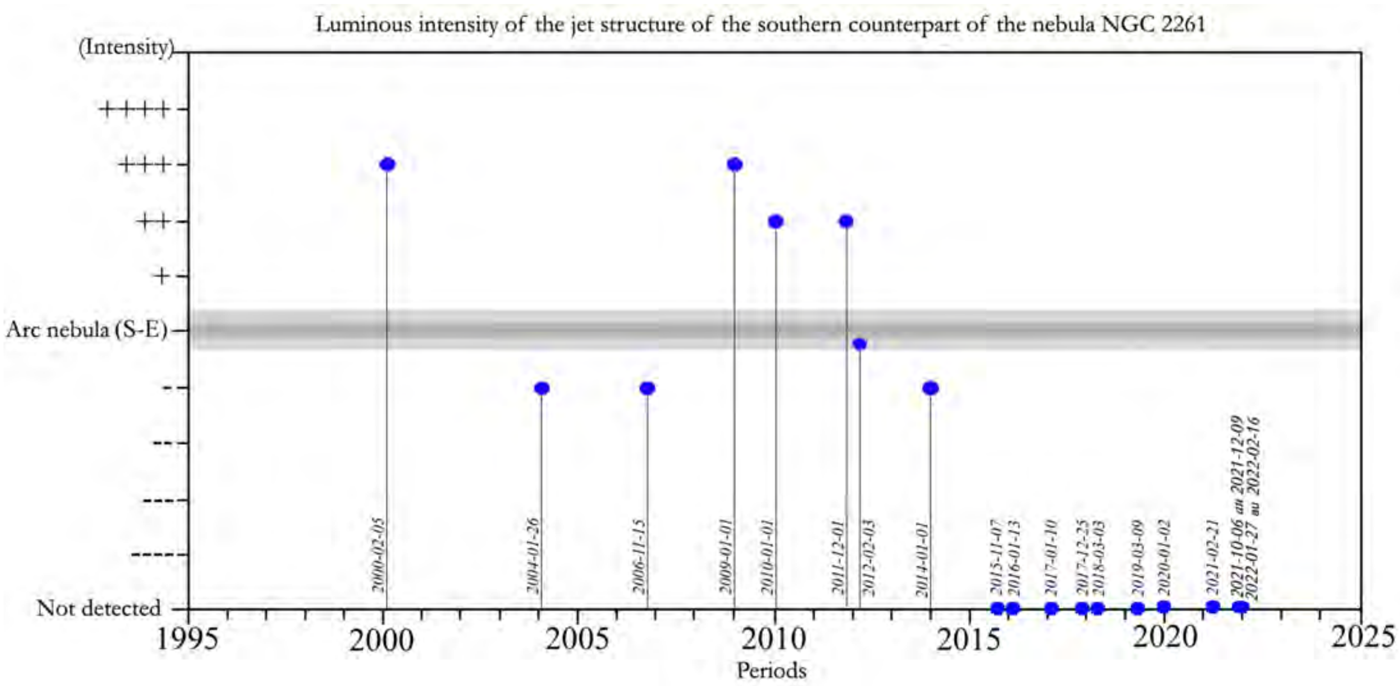


Figure 1 – NGC 2261, by Christian Dupriez 2014. The arrow on the right points to the jet-like structure, which is studied in this dossier The left arrow points to the small arching nebula southeast of the jet-like structure. This nebula serves as a reference for the intensity estimates of the jet-like structure. (See Graph 1).

*Two documents summarize our most recent follow-ups, one from 2020 and the other in 2021: astrosurf.com/cdadfs/CDADFS2/recherches/N2261_2020_V243.pdf and astrosurf.com/cdadfs/CDADFS2/recherches/NGC2261_2021.pdf



Graph 1 — This graph contains all periods during which the area containing the jet-like structure in the southern counterpart of NGC 2261 has been observed. On the vertical axis, each measurement point (blue) indicates the intensity attributed to this jet-like structure.

Introduction and History

This luminous jet structure of the southern counterpart of the nebula could be detected in good quality amateur CCD imaging. It is part of the southern counterpart of the nebula NGC 2261 identified by Walsh & Malin (1985). The oldest CCD images of our group that highlight this structure date from the years 2000, 2009, 2011, and 2012.

It is some images of 2019 by J. G. Moreau that revealed to us the disappearance of this jet-like structure to the south of the main nebula. This justified a follow-up to firstly determine when this jet-like structure disappeared, and secondly, to observe in the near future its reappearance and new apparent morphology in visible light, if possible.

A3) Our results in Graph 1 indicate that this luminous jet-like structure to the south would have disappeared from our images around 2015 and that, since then, it is no longer detectable with amateur instruments, whether in visible light, luminance, or in hydrogen-alpha emission at ~656.3 nm. This graph contains all detection periods that have been accessed of the jet-like structure in the southern counterpart of NGC 2261. On the vertical axis, each measurement point (blue) indicates the intensity attributed to this jet-like structure.

The horizontal and central (darker) line corresponds to the reference point of the intensity. This is the intensity of the

Figure 2 — by Réal Gauvin. We see no trace of the jet-like structure to the south, but we can very well detect the small nearby curved nebula to the SE.

Figure 3 — by Robert Cazilhac. We can see the small, curved nebula nearby to the SE, but there is no trace of the jet-like structure to the south.

Figure 4 — by Jean Guy Moreau. We can see the small, curved nebula nearby to the SE, but there is no trace of the jet-like structure to the south.

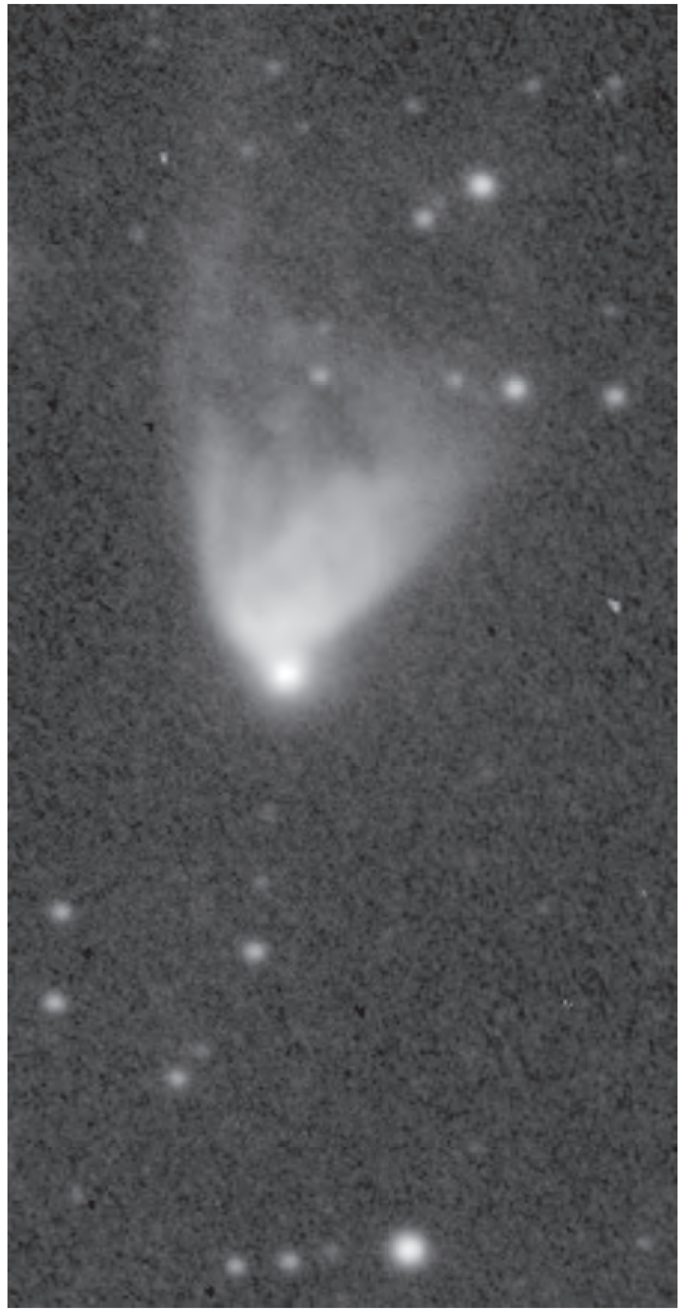


**Figure 5 — By Denis Bergeron. With the Moon in the sky, we can detect some traces of the curved nebula, but no trace of the jet-like structure to the south.*

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

It seems clear on this graph that this jet-like structure varies in intensity over time independently of the small, curved nebula

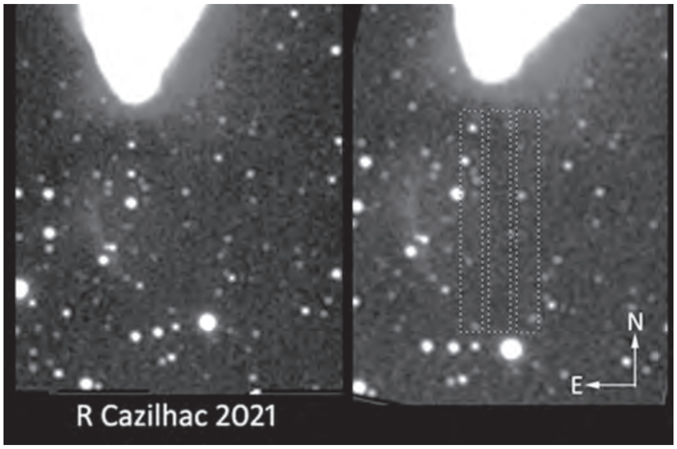


Figure 6 — Three nearby regions to the south, where the jet-like structure can be observed, in which the number of detectable stars has been estimated.

to the SE and that, for several years, it is no longer detectable on our images. This disappearance was happened over a short period, so we can assume that it is a filiform structure, which is a reflection nebula illuminated by the young star R Monoceros, whose light was hidden by circumstellar material very close to the star in the same plane. At this distance, the great rapidity at which this disappearance occurred cannot imply a high-velocity ionized-matter jet of the (HH) Herbig-Haro type.

B3) Our images of the period 2021-2022, show no luminous trace of this jet-like structure to the south! We have 6 observation periods: Réal Gauvin, 2021-10-06, 2021-11-10, and 2021-12-05; Robert Cazilhac on 2021-12-09; Jean Guy Moreau on 2022-01-17 and Denis Bergeron on 2022-02-17.

C3) Can we detect in the sky some traces of the elongated structure to the south? Even if the jet-like structure is not detected, can we see darker traces of it in the sky, where it should be, at the south of the main nebula? The procedure is to check if there are fewer stars or less signal at its usual position.

In Figure 6, we can see in the left image, the region where the jet structure is usually observed, that it seems a little darker than its surrounding area and that there are very fewer stars in this area of the sky!

The number of stars in this region has been estimated relative to the surrounding regions. Considering that if there is a denser nebula at this location, the foreground stars should be dominant and the others, more in the background, must have brightness more affected and therefore be fewer in number and less intense (See Figure 6).

Figure 6 — Our results; Right picture: The dotted rectangles are the area and regions used to estimate the number of stars.

Note: The image has been rotated to orient the three measurement regions vertically in this representation.

Figures 7–8 — This gorgeous image of NGC 2261 by Mark Hanson is from the 2018 period.

* Region on the left (East) ≈ 8 stars are observed.
* Central region (Jet-like structure) ≈ 1 star
* Region on the right (West) ≈ 3 stars

Does the nebula material obstruct by extinction the light from background stars?

Figure 7 presents the image of NGC 2261 as published by Mark Hanson on his site. In this image we can clearly see the large band that does not contain stars where we could at times, prior to 2015, see a thread-like luminous nebula in the form

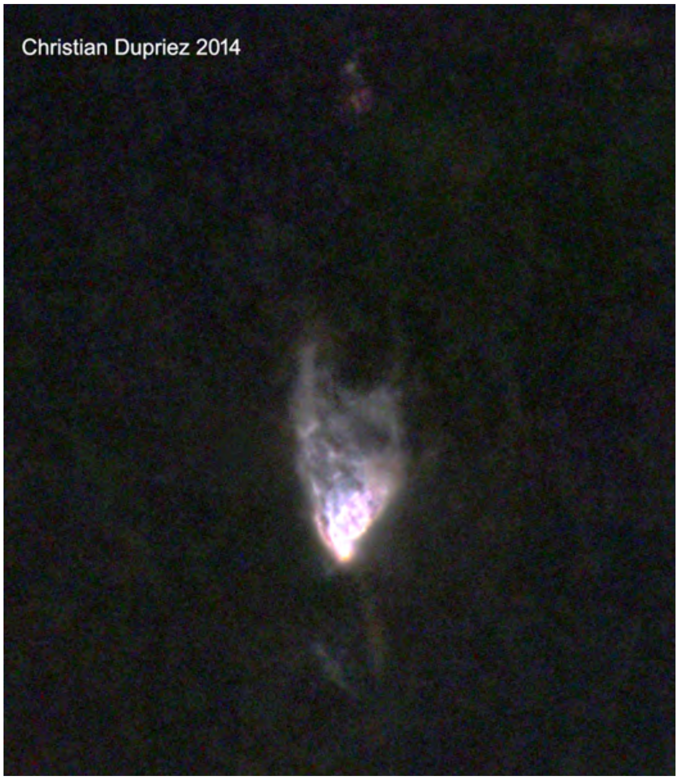


Figure 9

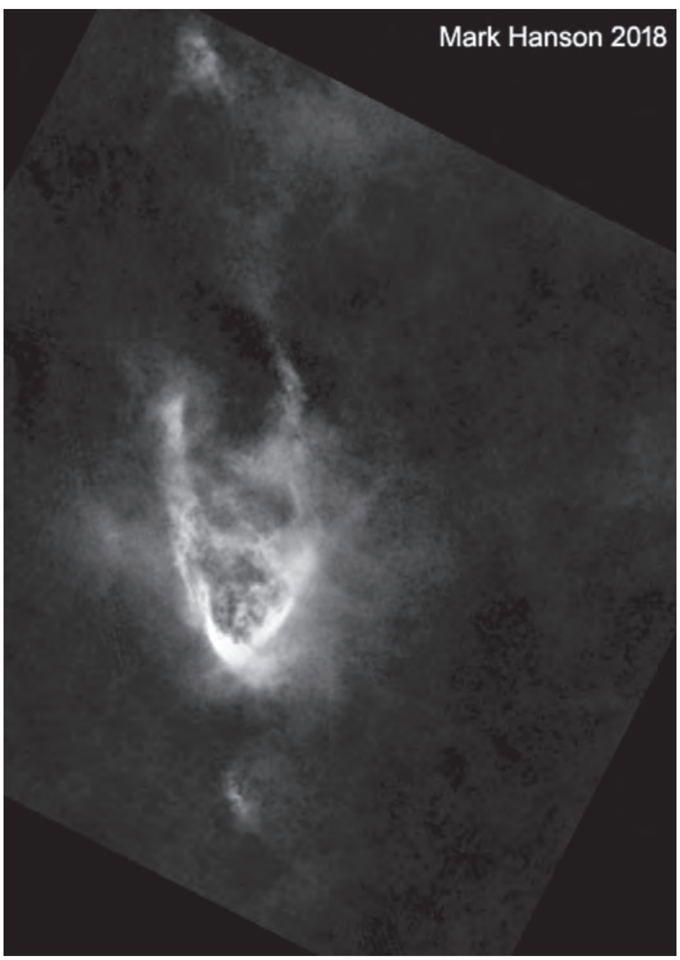


Figure 10

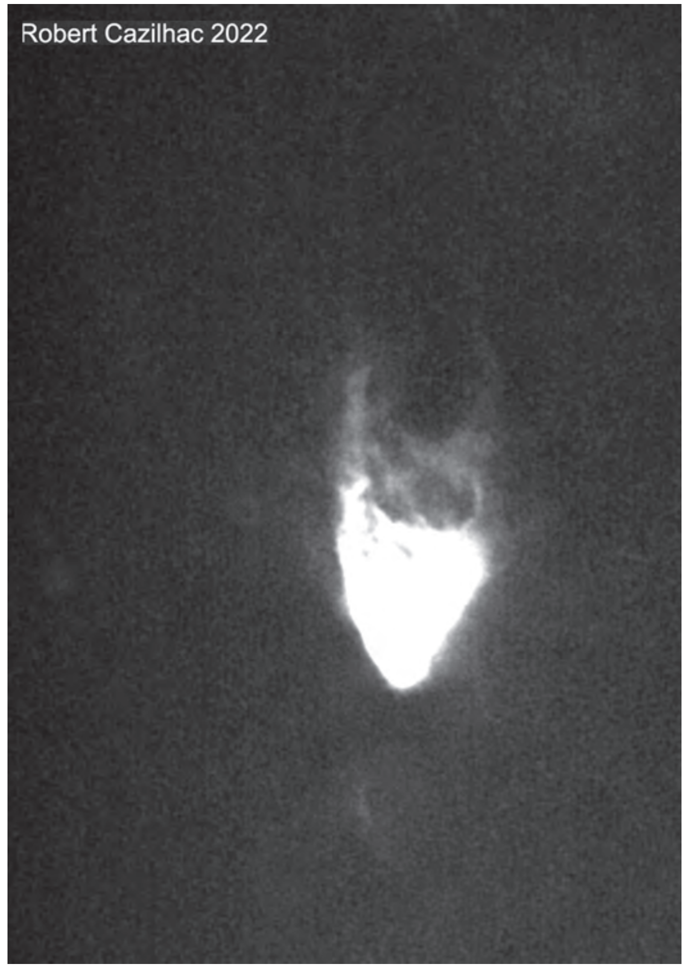


Figure 11

of a jet. We see some pale and diffuse cloudiness toward the south of the main nebula. We also detect a change of intensity and appearance of this diffuse cloudiness at the site where the luminous jet-like structure could previously be detected.

www.hansonastronomy.com/hubble-veriable-nebula

Figure 8 is the same image by Mark Hanson; it has undergone a contrast enhancement to allow this region to be even more highlighted in the sky where the luminous jet-like structure was previously detected. The arrow at the bottom on the right indicates the expected angle of the structure in the image.

Conclusion

Historically, there doesn't seem to be much literature or documentation about this jet-like structure in the nebula south of NGC 2261. Archival observations often lack the optical depth necessary to reveal this fine structure. This contributes to the level of interest in such a follow-up.

For the period covered by this dossier, i.e. 2021/2022, we can conclude that this jet-like structure of the southern component of the nebula NGC 2261 remains undetectable in our images. So, since 2015, this luminous filiform structure has disappeared! As shown in Figures 9 to 11. We removed the stars from these images to leave all the room for the surrounding bright nebulosity of NGC 2261, which we amplified. Figure 9 from 2014 clearly shows the presence of this jet-like structure, on the other two images from 2018 and 2022, it is absent.

On the other hand, we think it is possible to detect it indirectly in the sky, as we demonstrated in the last section (C3), and in Figures 6 to 8. We can infer that this jet-like structure undergoes luminous variations of the same type as the main reflection nebula to the north of the star R Monoceros. *Thank you Reviser and translation—Gerald MacKenzie and Dominique, as well as Karim Jaffer (RASC Montréal Centre)* ✶

*References and images used for this project

La nébuleuse variable de (Hubble) NGC 2261
La nébuleuse en jet au sud est disparue sur nos images de 2020!
Une mise à jour
G. St-Onge, D. Bergeron, D. St-Gelais, J. G. Moreau
N2261_2020_V33b.pdf (faaq.org)
Fédération des astronomes amateurs du Québec (faaq.org) /Observation du ciel/Rapports de projet de recherche

La bonne interprétation des cartes de polarisation des étoiles jeunes
Par Pierre Bastien
Observatoire du mont Mégantic et du Département de physique de l'Université de Montréal
Un texte présenté dans la revue La Recherche Astronomique de décembre 1990
http://astrosurf.com//stog/archives/xpolarisation/polaris.htm

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

L'étoile R Monoceros ET NGC 2261, Par Gilbert St-Onge, 2008
www.astrosurf.com//stog/xtravaux_recherches_2/n2261/ngc2261_v2008.pdf

#1 L'étoile jeune R Monoceros et NGC 2261 nous dévoilent un jet
Par G. St-Onge
http://astrosurf.com//stog/xtravaux_recherches_2/ngc2261/2261osj.htm

(L. M. Close et al. 1997) sur le web à: Adaptive Optics Infrared Imaging Polarimetry and Optical HST Imaging of Hubble's Variable Nebula (R Monocerotis/NGC 2261): A Close Look at a Very Young Active Herbig Ae/Be Star
www.journals.uchicago.edu/ApJ/journal/is sues/ApJ/v489n1/36055/36055.html

À la portée de tous NGC 2261 et HH-39 par des amateurs québécois
Dans le magazine *Astronomie-Québec* · Juillet/août 2014
Par G. St-Onge
astrosurf.com/cdadfs/CDADFS2/recherches/NGC2261%20et%20HH39-v2C.pdf
et
http://astronomie.quebec/magazine.php

Une nébuleuse qui n'a pas peur des changements
NGC 2261
Par Gilbert St-Onge
Merci à Pierre Bastien, réviseur du document :
Dr. Pierre Bastien, département de physique, U. Montréal, OMM, CRAQ
Astronomie-Québec · Janvier / février 2013 p.26
http://astronomie.quebec/magazine.php

La Lumière Cachée par G. St-Onge →
Magazine Astronomie-Québec · Mars/avril 2014 → p.34
http://astronomie.quebec/magazine.php

Variations autour de NGC 2261, *par Carine Souplet, Astronomie-Magazine france* P.33 No 183 novembre 2015

*Carte de polarisation N2261
(Image 4.1) Une carte de polarisation de NGC 2261 en filtre « V » de S.M. Scarrott, P.W. Draper, R.F. Warren-Smith 1988.

M. J. Jiménez-Donaire et al, Herschel observations of the circumstellar environments of the Be stars R Mon and PSD27, *A&A 605*, A62 (2017).
Herschel observations of the circumstellar environments of the Herbig Be stars R Mon and PDS 27 – NASA/ADS (harvard.edu)

Göran Sandell et al, The Molecular Outflow from R Mon, *APJ, 889:138* (9pp), 2020 February

Sloan Digital Sky Survey (SDSS)
V* R Mon (u-strasbg.fr)
simbad.u-strasbg.fr/simbad/sim-id?Ident=%40907222&Name=V*%20R%20Mon&submit=submit
Et – www.astrobin.com/126445/?q=
Credit: SDSS/Giuseppe Donatiello, 2014-10-07.

Merci à Mark Hanson de nous permettre d'utiliser sa magnifique image de N2261 dans ce dossier.
Mark Hanson, Hubble's Variable Nebula—NGC 2261, 2018—©hansonastronomy.com
LRGB Hα 300,180,180,180,450 Taken with a PlaneWave 24″ CDK from Animas, New Mexico.
www.hansonastronomy.com/hubble-veriable-nebula

G. St-Onge[1] (CDADFS/ RASC/ SAM, Québec)
Le suivi de NGC2261 depuis 1990 et bien d'autres choses… Sites Web: www.astrosurf.com/cdadfs/cdadfs1.htm
et http://astrosurf.com//stog/saisons_ciel/

D. Bergeron[2] (Val-des-Bois, Québec)
Il a une chaine sur Youtube avec plusieurs tutoriels sur plein de sujets en astro et un site web que vous pouvez consulter à cette adresse: http://www.astrosurf.com/d_bergeron/
D. St-Gelais[3] (Mexique)
Réside à Querétaro Estadio de Querétaro, Mexico. • (Exoplanètes Transit Database). • Projet GRANDMA recherche de KiloNova. • Mesures du transit de l'exoplanète, membre de la liste de diffusion d'Alexandre Santerne depuis la fin 2019. • Photométrie pour AAVSO, étoile variable.

J. G. Moreau[4] (Du Québec)
Jean Guy Moreau, de formation je suis un technicien en chimie industrielle. Il a été technicien en travaux pratiques pendant 25 ans.

L'astrophotographie permet un certain contact avec ce mystérieux Univers d'une incompréhensible beauté, qui ne cesse de m'émerveiller.

Réal Gauvin[5] (Drummondville, Québec)
De la banlieue proche de Drummondville, il se spécialise surtout dans la photo de nébuleuses planétaires au filtre H-alpha et [oxygène III]. Son site d'hébergement d'astrophotos : https://telescopius.com/profile/herge61

Jean-Bruno Desrosiers[6] (OMSJ, du Québec)
Observatoire du Mont St-Joseph, http://omsj.info | AAVSO: DJED
Télescope C14, Caméra Atrik 414ex
Filtres NarrowBand et en RVB

Christian Dupriez[7] (France)
Région Lilloise dans le Nord de la France
Astrophotographie en Région Lilloise
www.astrosurf.com/chd/index.htm

Robert Cazilhac[8] (France)
Lugny 02140 France
Traitement avec IRIS
www.astrosurf.com/pixiel/1ertestZWONGC2261.htm

Alain Amsaleg[9] (France)
France,
Merci de ta contribution

Mark Hanson[10] (New Mexico)
Hubble's Variable Nebula—NGC 2261, 2018—©hansonastronomy.com
LRGB Hα 300,180,180,180,450 Taken with a PlaneWave 24″ CDK from Animas, New Mexico.
www.hansonastronomy.com/hubble-veriable-nebula

** Provenance des images utilisées pour ce projet :*

J. G. Moreau (Qc.), D. Bergeron (Qc), D. St-Gelais (Mexique), Réal Gauvin (Qc), Jean-Bruno Desrosiers (Qc), Christian Dupriez (France), Robert Cazilhac (France), Alain Amsaleg (France), Mark Hanson (New Mexico), Sloan Digital Sky Survey (SDSS).

Image detail

Réal Gauvin (2021-10-06)
Voici un empilement de 4 images de NGC 2261 avec des poses unitaires de 10 minutes
Image finale calibrée avec flats, darks et bias.
Images prisent hier soir; 6 octobre 2021 vers 4h30 du matin.
Télescope 10″ RC à 2032 mm de focale
Caméra Atik 460ex
Filtre anti-pollution lumineuse Astronomik
Bin2

Réal Gauvin (2021-11-10)
Voici une image empilée de NGC 2261 prise dans la nuit du 10 au 11 novembre 2021.
23 images calibrées avec dark, flat et bias de 10 minutes chacune en bin2
Télescope 10″ Ritchey-Chrétien *f*/8.
Caméra monochrome Atik 460ex
Filtre Astronomik anti-pollution

Réal Gauvin (~2021-12-05)
(Début décembre 2021) La semaine dernière, j'ai complété la photo avec mes filtres Hα, G et B
La couche Hα est constituée de 29 images empilées et calibrées de 5 minutes bin2 chacune.
Télescope iOptron trusstube 10″ Ritchey-Chretien
Caméra Atik 460ex monochrome avec pixels de 4.54 microns en bin1
Filtres Astronomik Hα de 6 nm

Robert Cazilhac (2021 12 09)
Voici 2 images prises en milieu de nuit le 09 Décembre 2021
Meade12″ /D10 (F:3000 mm) ASI 1600 MMC sans filtre
Seeing 5/10
Seulement 500 poses de 5s
(Passage en bin 2x2 au traitement)
Je joins donc 2 images avec des seuils de visualisation différents
...pour les détails dans la nébuleuse et les nébulosités externes!!

Jean Guy Moreau (2022 01 17)
CMOS couleurs
Instrument 14 po /3,3 avec correcteur/réducteur Keller 0,73X.
Exposition de 155 minutes avec camera QHY268C, pixels de 3.76 microns, matrice Bayer RGGB.
C'est un crop de l'image, je vois le bas des étoiles bordées de rouge à cause de la dispersion atmosphérique, car la nébuleuse était très basse à l'Est.

Denis Bergeron (2022 02 16)
Mon telescope est une Planewave CDK 30 cm F8 FL: 2555 mm avec une camera SBIG STL11000M avec filtre Luminance.

Mark Hanson
Mark Hanson, Hubble's Variable Nebula—NGC 2261, 2018—©hansonastronomy.com
LRGB Hα 300,180,180,180,450 Taken with a PlaneWave 24″ CDK from Animas, New Mexico.
www.hansonastronomy.com/hubble-veriable-nebula

Great Images

Her are two images from our Astroimaging certificate winners.

Figure 1 — Gibbous Moon: Scott Barrie. "This photograph was taken from our back yard in Ariss, Ontario. I enjoy photographing the moon during different phases, but I particularly like the detail that is possible to capture close to the terminator in the Gibbous phase. In this image the Moon, which is approximately 70% illuminated, is over Guelph to the south of my location, but both transparency and seeing seemed particularly good."

Date: 2015 November 20, with a Nikon D810 camera and a Nikon 200-400mm f4.0 lens, at 400mm, 1/200 second at ƒ/6.8, and ISO 500.

Figure 2 — Star Trails: Kersti Meema. From Ross Lake, Haliburton, Ontario, star trails show the path of stars across the night sky over time. "The central star that looks almost stationary is Polaris, towards which the axis of the Earth points. I was encouraged by RASC members to try StarStax to make star trails, rather than use old-fashioned film (which I tried with my old Nikon camera somewhat successfully), or just using a long exposure with my DSLR. I was amazed at the facility with which the program worked. For this composite, I removed the images that had the red lights of airplanes streaking across the image. I think this resulted in some areas of the image not having complete star trails." Details: 10:55 p.m., on 2016 July 11 to 1:03 a.m., August 12, with a Canon EOS REBEL T5i at ƒ/4, with 30-sec exposures at ISO 1600, focal length 17mm. 233 images Stacked in StarStax.

Featured Articles / Articles de fond

Rudolph Dorner (1948–2022)

R.A. Rosenfeld[1], FRASC, Dr. Michael Szpir[2], Steve Dodson[3], Peter Pekurar,[2] Alan Ward[3]

> *"Telescopes and binoculars are magic, bringing distant astronomical objects close, or showing things invisible to the naked eye. That magic has never worn off"*
> *—Rudolph Dorner (2019b)*

Abstract

Rudolph Dorner was a remarkable individual, whose Society membership was one of the longest. Throughout those nearly six decades, he was an active observer and a very informed telescope aficionado. His pursuit of astronomy was marked by a personal generosity toward others. His endowment of the RASC's Dorner Telescope Museum is an example of that generosity.

An enterprising life

Rudolph Dorner was a lifelong amateur astronomer, a long-time member of the RASC, and one of its major benefactors (Figure 1). This memoir is centred on his interest in astronomy, an interest that produced lasting friendships, gave rise to adventures celestial and terrestrial, and that led him to envision and endow the RASC's telescope museum. It was wholly typical of the man that his legacy project, the Dorner Telescope Museum (DTM), would benefit others. Rudolph—who could jest that "Rudolph Dorner was an acquired taste"—was certainly memorable, and this account attempts to convey a little of what made him so. Certainly his spirit will live on in the realization of the museum that bears his name.

Rudolph was born in Odenheim, Baden-Württemberg, Germany, in the American Zone (Area 2) several years after the end of the Second World War, but before the creation of the Federal Republic of Germany ("West Germany"). His father, a master tailor, decided his young family would be better off in Canada. The Kitchener area of Ontario seemed a culturally attractive place to settle, and so it was that in 1954 the young Rudolph found himself in Canada. Rudolph was proud of his German heritage, and he retained a useable comprehension of German into his later years.

He enjoyed what he described as a perfectly normal and happy childhood. He maintained a strong bond with his father throughout the years, and he wore his father's watch with fondness after the elder Dorner passed away. Rudolph also retained friendships from his teenage years, and these were very dear to him.

Figure 1 — Rudolph Dorner (1948–2022). Background detail of the Tarantula Nebula in the Large Magellanic Cloud, HST image NASA.

He pursued an honours course in pure mathematics at the University of Waterloo for three years[4], but despite the attraction of the discipline and his talent, his abilities and interests pulled him in other directions. In his younger years, work could mean operating heavy machinery, and earning a master electrician's licence. He would recall those years with fondness—driving big machines and wiring stuff was fun, especially if you got paid for doing it. He was particularly proud of his skills in diagnosing and resolving problems with electrical machinery. He likened it to tuning and playing a musical instrument—the sound told you what wasn't right, and when you had everything running as it should. Tinkering with intent remained a pleasure long after it had ceased being a livelihood. And he maintained his qualifications as an electrician throughout his life.

He became an investor early, typically with startling and cumulative success. To an onlooker, he seemed preternaturally skilled in business, possessing exactly the right combination of sober instinct and ardent scrutiny, married to impeccable timing. It appeared easy, but it was an ease born of experience and hard work. He was bold when he needed to be, and, most importantly, he made his own decisions.

One of his investments found him a partner in a firm of precision machinists in Wellington County, Ontario, which in the mid-1970s was invited to submit a tender to manufacture prism housings for binoculars to be produced by the Canadian division of one of the premier names in German optics. These instruments were to be supplied to the Canadian Armed Forces. As readers of the *Journal* know, making such precision parts to the necessary tolerances was not a task without potential headaches. His partners in the firm were inclined to pass on the opportunity. Not Rudolph, though. He liked the challenge, he liked the opportunity for his firm to be associated with the fabled German name, and he liked the fact that the project involved optics of the highest quality (which *could* be used for astronomy!). He won over his fellow investors. The headaches were more than potential, but his firm succeeded in

Figure 2 — Rudolph Dorner and author Peter Pekurar at refractor shoot-out.

making the parts. One of the binoculars is in the DTM (cat. no. 5.2019516).

In time Rudolph rose to become the chief corporate planner for Babcock & Wilcox (BW), the largest American manufacturer of industrial boilers and nuclear plants. This work involved astronomically large sums, forward thinking, and significant risks. He enjoyed it immensely, and he was good at it. Rudolph was delighted to learn of an astronomical episode in BW's history, namely that in 1935–1937 his firm supplied the primary cell for the 200–inch Hale Telescope at Palomar Observatory (Florence 1994, 263, 296–297). Another astronomical association of his employer was more local. BW was the last owner of Goldie & McCulloch, historically a manufacturer of steam engines in Galt, Ontario. "Goldie" was John Goldie (1822–1896), a respected Society member, whose spectacular paraselene drawing from 1892 survives in our Archives (Goldie 1892). Unfortunately, as the corporate planner for BW, Rudolph had the sad task of closing that historic facility.

Fearing he was becoming much too comfortable where he was, which would lead to eventual retirement long after his best before date[5], he retired from working for others, to work for himself. He valued exercising control over his own circumstances, and, being reasonably confident that Rudolph Dorner working for Rudolph Dorner would give him that control, success would follow. His business-brokerage firm, *Corporate Division*, a one-person operation, enjoyed a success that would occasionally eclipse that of the major charter banks practising the same trade. He brokered a wide variety of businesses (perhaps the most unusual involved the sale of a circus to someone who had always wanted one), skillfully employing narrative as a technique ("stories are important"). Building on his earlier mergers and acquisitions experience, his confidence in Rudolph Dorner was not misplaced. He earned an enviable reputation for negotiating the best possible deals for his clients; and he made yet more friends.

In time, he decided to retire from that line of work, but he did not retire from the business world. Investments continued, and, intriguingly, he ventured into the hospitality sector, becoming a restauranteur, in partnership with the brother of his best friend. The concept was a café with no prices listed on the fare, and consequently no cashier. Customers paid what they thought was a fair price. The venue was a former service garage in a good urban setting (advantages: location, solid structure, patio doors already *in situ*). If he had a dime for all the times other restaurateurs told him the concept would not fly—too few customers would pay a fair price, many would not pay at all, a service garage could not be brought up to code for a café, his business would not last long enough to leave a memory on the sidewalk—he would have earned another fortune. After more than two decades in business, *City Café* has consistently been in the black, even during the pandemic, and has even expanded modestly. A loyal customer base helped; and the café's employees were not treated as an expendable and infinitely renewable resource. The staff of the former RASC National Office welcomed Rudolph's occasional visits, mostly but not entirely on account of his outgoing presence; he would invariably bring comestibles from *City Café*.

The place of astronomy in an enterprising life

> *"Saturn, when viewed through a good telescope, makes a more remarkable appearance than any of the other planets… its ring is one of the most curious celestial phenomena with which astronomical telescopes have made us acquainted."*
> —Thos. Squire (1818, pp. 16, 246)

> *"Good afternoon…my name is Rudolph Dorner, and I am an amateur astronomer, and I cannot be cured"*
> —Rudolph Dorner (2019a)

For his 11th birthday Rudolph's parents bought him a Japanese-made 60-mm department-store refractor. In the late 1950s and early 1960s, many of those classic long focal-length refractors were of good quality, and some of them were very good indeed (there are several in the DTM, currently being catalogued). He recounts that "One evening I pointed at a dim yellow star, and there in the eyepiece was Saturn, in all its glory. I was hooked for life on astronomy and optics" (Dorner 2019b).

In those days, surplus optical ordnance was in wide circulation across North America and Europe, and readily available to amateurs, often at a fraction of its original cost to the armed forces. Several optical firms arose from that second-hand trade, such as A. Jaegers, and Edmund Scientific in the US. The Canadian WWII surplus optical ordnance—chiefly 6×30 and 7×50 binoculars by Research Enterprises Ltd. (REL), and wide-field, low-powered refractors (gun-sighting telescopes) by REL or Canadian Kodak Co., Ltd.—was robust, the optics were usually good, and they did not cost the Moon (for examples, see DTM cat. nos. 4.2019518, 9.201995, 10.2019824). They were perfect for mechanically adept and optically interested teens to disassemble, (attempt to) reassemble, and to learn from. Rudolph certainly did. In his later years, he recognized that these instruments contained the

Figure 3 — Authors Steve Dodson, Alan Ward, and Peter Pekurar recreating the iconic pose of Percival Lowell (1914), when they were on their 2018 Lowell Observatory expedition. Image reproduced courtesy of Patrick Dodson.

earliest optical-grade glass ever produced in Canada, and as such, deserved a place in the DTM.

Several years after the gift of the 60-mm refractor, Rudolph was able to satisfy his aperture fever with the purchase of an Optical Craftsmen 8-inch Newtonian on an equatorial mount with synchronous drive. This was not an inconsiderable purchase for a teenager in the years before the Moon landing. Instruments were proportionally much more expensive in the 1960s than they are now (the $625 USD list price of that reflector corresponds to about $7,000 in inflation-adjusted Canadian dollars!; Optical Craftsmen 1964, 1). He funded its purchase entirely through his own efforts. The instrument still survives, although not in the DTM.

Rudolph amassed several—well, more than several—collections of telescopes in his long career as an observer. He would obtain the best his resources would allow, and never turned down a superior instrument in good shape if it was offered at a fair price. Refractors were his favourite, which presented views he found the most aesthetically pleasing, but he had time for Maksutovs (Newtonian and Cassegrainian), and traditional Newtonians as well[6]. He would say that 20 instruments made for a good stable of telescopes(!)[7]. It's a good thing he liked generously proportioned houses. He once lived in a converted historic schoolhouse in a remote rural setting, which gave him the luxury of dark skies outside his back door.

He had a thorough knowledge of the night sky. Even though he would pack a good atlas for observing sessions, he was seldom seen to consult it. He had no need to; the locations of objects seemed to be in his very bones. Double stars, deep-sky objects, and planets were of particular interest. He admired the art of astrophotography, but his observing happened exclusively at the eyepiece.

He was impatient to set foot on the observing site but hated the bother of take-down (i.e. the disassembly and packing up of instruments) when the observing had ended. He preferred set-up to be as easy and quick as possible, which lead him to prefer robust alt-azimuth mounts (with superb motion) over driven equatorials. Some nights were spent in refining the art of observing with a minimal complement of high-quality equipment. You could travel lightly, and see a hell of a lot, if you were willing to push yourself and your minimal instrument of choice to the limit. The trick was not to waste time bemoaning the larger aperture you could have lugged out, but to take the time to see, *really* see, what the smaller instrument had to offer (i.e. the limits of the instrument weren't limits to viewing, but a reframing). The effort might even make you a better observer. One of the authors (RAR) owes his introduction to the delights (and challenges) of observing with superb 60-mm apochromats to Rudolph's example.

Rudolph was a gregarious observer, but preferred small observing parties of just a few experienced friends. He was a good observing companion to all of us. He was especially fond of equipment "shoot-outs." For those unfamiliar with the practice, these were intended to be even-handed comparisons of instruments with the same or similar apertures through critical observational tests under the night sky. Sounds scientific? It was really all about aesthetics, and the total experience of the instruments in use[8]. Over the years, Rudolph took part in countless shoot-outs with all manner of telescopes and binoculars. It was an endless source of amusement for him and his companions (Figure 2). Rudolph had planned another shoot-out in the near future. And though this one will have to happen without him, his spirit of finding joy in the "best view of the night sky" will always remain with his observing companions.

His practice of astronomy was a generous one, and this is not a mere platitude for a memorial. He really was generous. A few examples must suffice. Rudolph would routinely buy Vixen binoculars, and freely distribute them to those new to observing, especially students on a budget, or those he deemed needed an optical upgrade. One student, who was a committed observer and part of the die-hard group of visual astronomers of the Kitchener-Waterloo Centre, was moving to another

Figure 4 — Mount built by Peter Pekurar for Rudolph Dorner's Intes-Micro ALTER MN 76 (178-mm Maksutov-Newtonian).

Figure 5 — Rudolph Dorner and Alan Ward with the award-winning 6-inch ƒ/10 apochromatic refractor built for Rudolph by Alan.

province, but not before receiving a Takahashi mount from Rudolph. On another occasion, when he learned that a friend was without a telescope because of personal circumstances, he simply gave him one of his own (and it should be said that the instrument was one that possessed real significance to Rudolph).

His generosity wasn't confined to gifts of equipment; he was also generous with opportunities. One of us (SD), after celebrating the excellent 2003 perihelion opposition of Mars, harboured a wish to observe the next perihelion (2018) with the historic instrument most associated with the last century's Martian fascination, the 24-inch Alvan Clark & Sons Great Refractor (1896) at Lowell Observatory. Over the following decade and a half, the means to turn that dream to reality never materialized. In early July 2018, when this co-author was driving eastward from Sudbury to Champlain Provincial Park with his son for the "Gateway to the Universe" Star Party, the son received a text that another one of us (AW) urgently wanted to convey a message. The message was a question: "Would I be interested in going to Lowell Observatory next week, all expenses paid?" There could only be one answer to that question! Rudolph had arranged for himself and two others to observe Mars with the famous instrument. Unfortunately, Rudolph had a bad bicycle accident, resulting in multiple fractures of his left shoulder and upper arm. Even after excellent medical care he was in constant pain, and could no longer take the trip to Lowell Observatory. His natural impulse was to turn to generosity, and so offer his spot on the trip to a friend (SD). A week's vacation was enjoyed by three of the authors (PP, AW, & SD), spending several days at the Lowell Observatory's evocative hilltop campus, and several hours in the amazing facility observing with the wonderful Clark Telescope (Figure 3). It was a dream come true![9]

The generous opportunities were not confined to realizing dreams of travel for astronomers—they also extended to creating the conditions for telescope makers to extend their craft. Two of us (PP & SD) developed innovative mounts as commissions from Rudolph, with his creative input (Figure 4), and one of us (AW) was emboldened by a proposal from him to create two identical 150-mm ƒ/10 apochromatic refractors, one of which won important awards at the 2017 and 2018 Stellafane Conventions (Figure 5)[10]. The price of high-quality exotic glass blanks for making apochromats in this size is not trivial. Nor are the costs for the elegantly turned CNC OTAs, and massive alt-az mounts. Rudolph offered to fund the acquisition of the materials, in return for ownership of the better of the two instruments!

Several years ago, Rudolph contracted cancer, and was brilliantly kept alive by his wife Patricia (a physician) long beyond the initial prognosis. (Their relationship was a marvellously successful partnership)[11]. The fact of mortality was the impetus to look for a legacy project. Rudolph came up with the inspired concept of a museum to tell the story of the telescope in Canada, an institution that would use the power of narrative ("stories are important"), and the power of tactile experience (people observing through artifacts) as instruments of discovery[12]. As the story of the telescope in Canada was in part an RASC story, he chose the Society to implement his vision. He would provide the funding, if the RASC could provide the expertise and physical space to transform the idea

Continues on page 142

Pen & Pixel

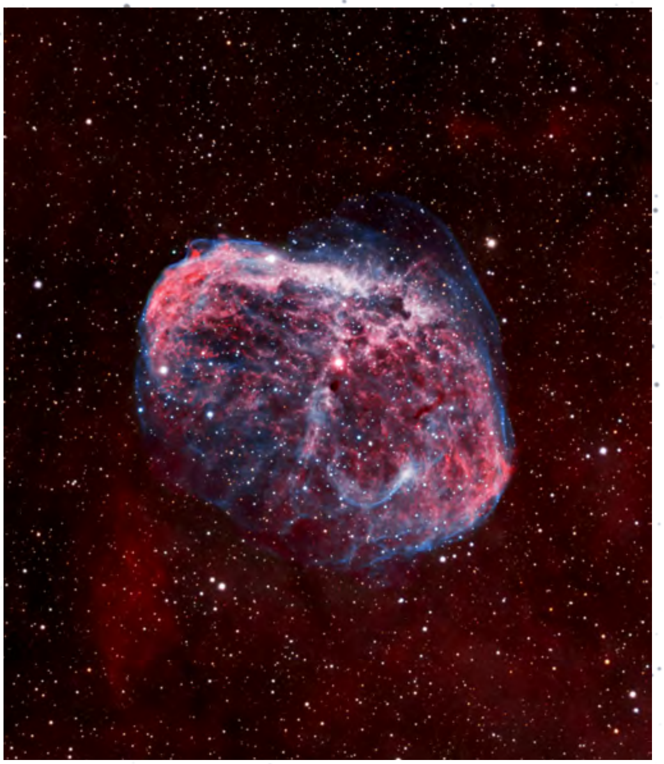


Figure 1 — The Crescent Nebula is a favourite target of many amateur astronomers and Steve Leonard is no different. He used an AstroTech AT115EDT 4.5″ triplet refractor at ƒ/5.6, on an HEQ5 mount, along with NINA, an ASI 1600MM Pro camera, and Chroma 3 nm Hα and OIII filters. The final image was processed in Pixinsight and Topaz AI. Steve shot the image from the suburbs of Toronto (Bortle 8/9) for a total of 7 hours using an Hα filter, and 8 hours using an OIII filter.

Figure 2 — Andrea Girones calls this shot, "The eye of the Scorpion and the Blood Red moon." Andrea took the image during the May 15–16 total lunar eclipse, with the goal of capturing some of the nebulosity in the Rho Ophiuchi region. But, she says, "I made a few mistakes with my targeting and I had the wrong area of space for a bit. I finally was able to find where I needed to be manually having left my very important notes at home, and by then the clouds were starting to roll in!" She used an ASI2600MC connected to a manual Nikon 50mm ƒ/1.8 lens stopped down to ƒ/4. The image is a total of 5x60s subs and 1.5s exposure of the moon blended in. She tracked using an iOptron CEM26 equatorial mount. The final images were stacked in Pixinsight and processed in Photoshop.

Figure 3 — The Wizard Nebula lies roughly 7,200 light-years from Earth and is a gaseous region surrounding the open star cluster, NGC 7380. Katelyn Beecroft imaged this using her Sky-Watcher Evostar 72ED with a Starfield 1.0 Flattener and an ASI 533MC Pro at gain 100. She used an HEQ5 mount and a ZWO 30mm ƒ/4 and an ASI120mm mini guide-cam. Total integration time was 135 x 240s subs.

Figure 4 — This stunning image of Messier 81 and Messier 82 along with quite a bit of integrated flux nebulosity was taken by Shelley Jackson from Sarnia, Ontario (Bortle 7). She used an Askar 200mm FL astrograph lens, a 30-mm guide scope and a ZWO 120 mono mini guide-cam together with a ZWO ASI294MC Pro OSC CMOS cam cooled to –10 °C on a Sky-Watcher AZ EQ 5 Pro mount. The final image was stacked and processed with PixInsight for a total of 274 × 120 sec subs.

Continued from 139

from potentiality to actuality. And hence the RASC's Dorner Telescope Museum was born. This act of generosity would benefit the RASC, the wider astronomical community, and enrich the cultural landscape of scientific heritage in Canada. It is now up to us to see that it does. ✶

Note: the principal source material for the material recounted above is Rudolph's reminiscences told to us over the years. This is thus an oral history, with the strengths, and weaknesses of that genre.

Acknowledgements

We wish to thank Clark Muir for reading a draft of this biographical memoir, Jim Goetz for information on Rudolph's long membership in the RASC, Patrick Dodson for digital expertise, and the anonymous reader for suggestions leading to greater clarity. This research has made use of NASA's Astrophysics Data System. The authors alone take responsibility for any errors remaining.

References

Manuscripts, Books, Articles and Websites

Anon. (1817). *Catalogue des livres de feu M. Charles Messier, doyen des astronomes...* Paris: Tilliard Frères

Broughton, R.P. (1994). *Looking Up: a History of the Royal Astronomical Society of Canada*. Toronto–Oxford: Dundurn Press

Dorner, R. (2019a). Dorner Telescope Museum: Part I. 2019 RASC General Assembly, York University, Toronto, 2019 June 15

Dorner, R. (2019b). Dorner Telescope Museum Founder's Statement. Unpublished manuscript, Dorner Telescope Museum, Toronto

Dorner, R. (2022). "Rudolph Dorner is dead." *The Record* (March 14)

Dufner, B. (2002). *Den Himmel fest im Blick. Eine wissenschaftliche Biografie* über *den Astro-Optiker Bernhard Schmidt*, *Studien zur modernen Geschichte B. 56*. Stuttgart: Franz Steiner Verlag

Florence, R. (1994). *The Perfect Machine: Building the Palomar Telescope*. New York: HarperCollins

Goldie, John (1892). Paraselene 1892. RASC Archives

(*www.rasc.ca/paraselene-1892*, *consulted 2022 April 11*)

Helfricht, J., & Koge, S. (1990). *Chr. Gärtner und J.G. Palitzsch—Bauern-astronomen aus Tolkewitz und Prohlis bei Dresden*. Veröffentlichungen der Sternwarte Pulsnitz 25. Pulsnitz: Sternwarte Pulsnitz

Hill, V. (2022). "Lifetimes: Rudy Dorner was a Fierce Advocate for His Clients." *The Record* (April 11)

(*www.therecord.com/life/2022/04/11/lifetimes-rudy-dorner-was-a-fierce-advocate-for-his-clients.html?li_source=LI&li_medium=rec_web_ymbii*, *consulted 2022 April 14*)

Jedicke, P., & R. (2003). Asteroid (14989) Tutte. Asteroids with a Canadian Connection

(*www.rasc.ca/asteroid/14989*, *consulted 2022 April 13*)

McNaught, R.W. (2017). *A Journal of Telescopic Observations by William Rutter Dawes for the Years 1834-1843...* Morrisville, NC: Lulu

Optical Craftsmen (1964). *Price List* (1964 April 15)

Squire, T. (1818). *A Popular Grammar of the Elements of Astronomy...* London: J. Souter

Endnotes

1 RASC Archivist & Director of the Dorner Telescope Museum. Email for correspondence: r.rosenfeld@rasc.ca.

2 Kitchener-Waterloo Centre.

3 Sudbury Centre.

4 This was early on at the start of the mathematician Bill Tutte's tenure at Waterloo. Of course, Rudolph couldn't have known at the time that Tutte was one of the Bletchley Park wizards. It was an act of cosmic negligence that the lead author of this paper didn't ask Rudolph for his impressions of the faculty when he was a student, in particular Tutte. Around the time Rudolph initiated his long association with the RASC, Tutte was already a member; Broughton 1994, 66; Jedicke & Jedicke 2003.

5 In his own telling, he realized one day that he was becoming "an entitled fundament" (a paraphrase of his actual expression) when he insisted that the person at BW arranging the logistics for one of his business trips book the best of the company's planes for him(!).

6 Although he found the view through Schmidt Cassegrains (SCTs) less than sparkling, he did share an interest—in explosives—with Bernhard Schmidt, the remarkable inventor of the revolutionary Schmidt camera. In Rudolph's case they were in the form of fireworks. He was luckier, or more careful than the young Schmidt, and never lost any limbs to the incendiary art; Dufner 2002, 23–26.

7 Rudolph was following historical precedent without knowing it. Dedicated observers with sizable collections go back at least to the generation of Messier in the 18th century; there is evidence that Messier had upwards of 12 when he died; Anon. 1817, 52–54. Johann Georg Palitzsch (1723–1788), the observer who won the race to recover comet 1P/Halley at its important 1759 apparition, owned 19 telescopes, nearly the number Rudolph recommended(!); Helfricht & Koge 1990, 21.

8 This too was a practice with a precedent. One of us (RAR) was surprised when going through a recently produced facsimile of one of the Rev'd W.R. "Eagle Eye" Dawes's logbooks (1834–1843) to discover that he devoted a great many of the pages to the results of what we would unhesitatingly define as equipment shoot-outs! McNaught 2017. Rudolph would have been amused—perhaps we can replicate these at the DTM!

9 This was the second Lowell Observatory expedition Rudolph had arranged; he had so thoroughly enjoyed the first that he was going to make it happen for others as well.

10 The Stellafane Conventions are the longest-running and premier event for amateur telescope making in the world. At the 2017 convention, Alan Ward's refractor won 1st-Place Compound MC-Optical, and 2nd-Place Special Award in the Master Class Optical & Master Class Mechanical categories. At the 2018 convention, Alan's instrument won 2nd Place Craftsmanship in the Master Class Optical & Mechanical category. Competition for these is fierce. At the 2017 Convention Alan had the refractor in the field with a Tele Vue eyepiece. Al Nagler came by and commented "Nice eyepiece!" It turns out he really liked Alan's work. Another Uncle Al anecdote concerns some of Rudolph's tinkering with intent. Rudolph quite liked the head on the TV Gibraltar mounts but wanted something even beefier(!). So, taking pencil and sketchpad in hand, he scaled it up to megafaunal dimensions, and had two made locally in a machine shop, solely for his own use. He emailed Uncle Al, included a picture, explained what he'd done, and ended with the words "no offense meant." Al Nagler wrote back "None taken!"

11 He was amusingly stoic about his condition, as evidenced by the opening line in his presentation on the DTM at the RASC's 2019 General Assembly: "Good afternoon…my name is Rudolph Dorner, and I am an amateur astronomer, and I cannot be cured," quoted at the head of this section, and by the title of his obituary in the local newspaper, which he wrote for himself: "Rudolph Dorner is Dead;" Dorner 2019a; 2022. His attitude was exemplary.

12 Rudolph well remembered how delighted he was when he had the opportunity at a European institution to examine, touch, and (gingerly) manipulate one of William Herschel's surviving 7-foot reflectors.

The Mackenzie King Diaries; A Total Solar Eclipse and Other Astronomical Notes

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Abstract

Mackenzie King's legacy is a complex, contradictory web between dedicated public service, prejudicial ideals and an active personal practice of spiritualism. Canada's 10th and longest-serving Prime Minister's personal diaries preserve all of this and more. Several King biographies written over many decades deal extensively with these topics.

Long before King was Prime Minister his diaries contain day-to-day entries of a young man and his travels. King was born in 1874 December 17. His first entries start in 1893 and continued through to literally just days before his death on 1950 July 22.

Contained within the King diaries are personal stories and experiences that all of us can relate to even if they are not significant in the big picture of shaping our nation. Here we explore many of the astronomically themed observations and writings of a former Prime Minister. A few are mundane but others are fascinating. They include several lunar and solar eclipses, one totality. Numerous aurora displays are featured including some that were spectacular. Visits to Observatories and other musings are also examined.

All quotes by King are in italics and appear as they were transcribed.

Lunar Eclipses

Among the earlier of King's entries is a simple report of a lunar eclipse witnessed from Muskoka, Ontario. On 1894 Sept 14[1] King writes, *"There was an eclipse of the moon tonight, which was very visible in Muskoka. The shadows on the Lake was remarkable."* This lunar eclipse was a very slight partial.

A year later on 1895 September 3 during a total lunar eclipse again in the Muskoka's, King writes:

"After rowing in we then watched with intense interest a total eclipse of the moon, which was very visible from the verandah here. A very interesting point was to watch the immergence of the stars from the darkness as the light of the moon became hidden."

King's notes indicate that this was more than a casual observation of the event.

Another partial lunar eclipse is mentioned by King in his diary form 1898 January 7. His short passage, *"There was a partial eclipse of the moon tonight. George[2] and I agreed it was a good or ill Omen to our words"*. This entry highlights his spiritualist tendencies are at play. The above examples are brief passages but establish the theme for astronomical observations found in his diary throughout his entire life.

Other lunar eclipses King witnessed on 1907 July 24 (partial) and 1949 April 12 (total) are again just briefly mentioned. In the former he writes with a suggestion of spiritualism, *"saw eclipse of the moon which I took as a good sign."*

Perhaps the most noteworthy of his lunar eclipse reports is of a total during wartime on 1942 August 25.

His location is in the property known as Moorside[3] near Gatineau, Quebec:

"… afterwards saw eclipse of the moon, as permission to waken the children[4] [Ann & Mary] to show them the eclipse, & then returned to farm & got off messages." Continues… *"The eclipse impressed me deeply, evidencing a perfect order in the universe - design & direction, no chance- law – eternal – important [?] Omen in face of this creating chaos and destruction, killing their fellow men 4 millions - Surely the evil shall perish."*

Here, during the war, we get a glimpse into the torment in King's thoughts that the eclipse evoked. This is in contrast to his action he records, of awaking the children to allow them to see the eclipse.

Solar Eclipses

Mackenzie King travelled extensively even before his active political career. On 1900 May 28, a total solar eclipse was visible from North America into the Atlantic Ocean, Spain, and Africa. King was travelling in Europe by train and watched the partial phase from the city of Dresden, Germany. King details:

"On a public square beside a beautiful little Gothic fountain, I had a view thro a telescope at the sun's eclipse & saw that about 1/3 of its surface was hidden by another body. I noticed too that the day became much darker than is wont, a sort of mist-darkness pervading the light."

Presumably, someone had a telescope set up at a town square to allow public viewing. King records the nature of the subtlety of light changes during the partial phase quite accurately for such a brief and coincidental occasion.

In an extraordinary account, King shares his experience of the total solar eclipse of 1925 January 24:

"This morning as we were passing thro' the state of Connecticut we witnessed the total eclipse of the sun about 9:11 am. It was a deeply impressive event, and one calculated to fill the soul and the world withal. We had the best possible of views from the train window being able to follow the course of the moon across the face of the sun. A very impressive moment was when the last flash of light came like the flare of a comet's tail just before the moon completely obscured the sun & we saw only the wonderful corona, the circle of fringed light around the moon. The stars became visible in the

heavens at the same time, & the earth was quite dark. It was interesting to see the contrast of lights in the shade of oncoming darkness & gloom, & the brightening light after the eclipse. Also to see all along the way people standing in groups, gazing thro' glasses at the sky. What an order! What a divine order! One can only exclaim – What is man that Thou art mindful of him! To think of great celestial & terrestrial bodies moving in an infinity of space in such perfect harmony to an inevitable order of things. How can one do other than believe in God, an infinite Creator.

Chief Justice[5] *& Mrs. Anglin, Bugsley & McGregor & I witnessed this great phenomenon together."*

King was Prime Minister at the time, and he was with the Chief Justice of the Supreme Court of Canada, Francis Anglin (1865–1933). Anglin served on the Supreme Court of Canada from 1909, becoming Chief Justice in 1924 and served there until just days before his death in 1933.

The two men and their travelling companions witnessed totality from a moving train!

King boarded an overnight train that departed Ottawa and headed for New York City. His final destination was Atlantic City, New Jersey. As King describes, totality began at 9:11 a.m. The exact location of the train in Connecticut is not known but practically the entire state enjoyed totality. Maximum length of totality would have been about two minutes.

The eclipse path started west of Lake Superior. Many large urban cities in southern Ontario including London, Kitchener, Toronto, Hamilton, and Niagara Falls were also on the line of totality. It should be noted that the early morning January skies in southern Ontario were overcast. Both the public at large and Canadian scientists were thoroughly engaged. The weather disappointed.

The total eclipse path continued into New York and neighbouring states on the Atlantic coast and into the Atlantic Ocean. The coast through New York City and Connecticut were graced with generally clear skies. Some citizens there even boarded dirigibles to observe the eclipse over the city. The best views of this eclipse anywhere on Earth were to be seen in these areas along the U.S. coastline including King's location.

King gives a graphic account of the magnificent diamond ring effect. The phrase "diamond ring" used to describe this phenomenon today, it is argued might have first been coined during this eclipse. The earliest use of the phrase may be contained in a paper by astronomer Alice Farnsworth "*The eclipse expedition at Windsor, Connecticut, January 24, 1925.*"

King's interesting observation of people "standing in groups gazing thro glasses" is also consistent with existing records from that event. Though it was a Saturday morning, like in Ontario, business in New York City and the surrounding urban areas ground to a halt. People were gathering in clusters to observe the eclipse in the city streets.

Figure 1 — Portrait of a young Mackenzie King 1900 (Bain News Service)

Curious questions remain. What was the reason for the Prime Minister's visit to Atlantic City? Was it for political purposes, or was it for leisure or a bit of both? Why was Chief Justice Francis Anglin with him? Did King deliberately choose to make this trip at that time knowing it would coincide with the eclipse or was this just pure stunning good fortune? It would have been an inspiring moment if King was completely unaware of the event. This would also explain his spiritualistic comments about his experience, especially in context with these ideals already instilled in him.

Anyone who has meticulously planned a trip to witness a total solar eclipse must be flabbergasted at the seemingly casual nature of King's experience; Right time, right place, and that speaks to nothing about the fortuitous clear skies for good measure.

The total solar eclipse of 1932 August 31 was noteworthy for its path through the city of Montreal. This one started in the Arctic Ocean into Canada's Northwest Territories, Hudson Bay, Quebec before covering American New England states and then into the Atlantic Ocean. Totality was at most one minute and 45 seconds.

King's luck continues as he had a reasonably clear sky of this eclipse from Moorside Cottage in Gatineau Park, Québec. His diary on eclipse day reads:

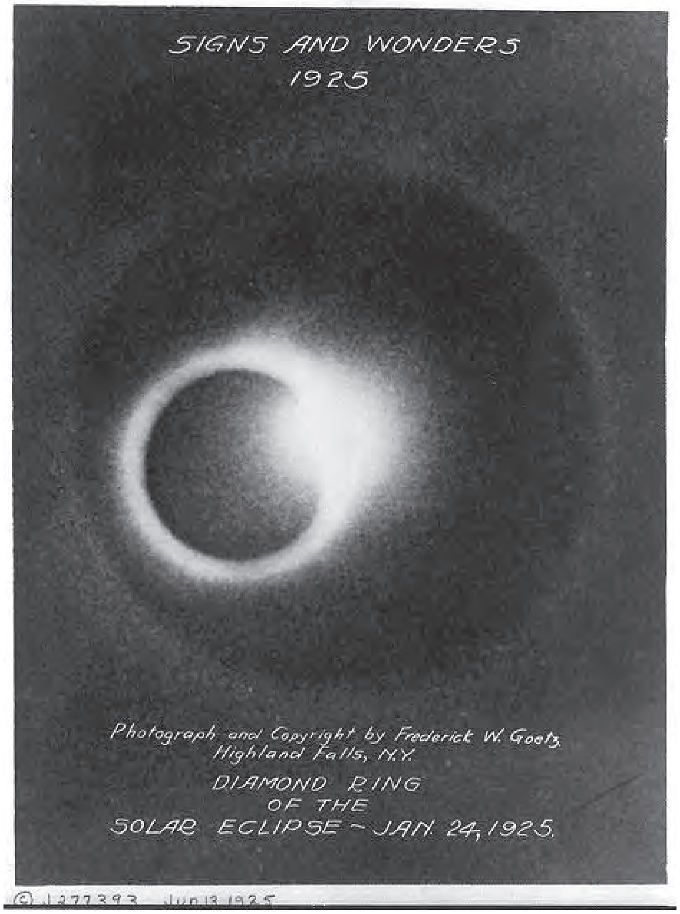


Figure 2 — A photograph of the eclipse of 1925 January 24 showing the diamond ring effect from Highland Falls, New York. Mackenzie King described his experience from a train in nearby Connecticut. (Library of Congress; Photo by Frederick W. Goetz)

"The event of greatest interest in Canada today was the eclipse of the sun, 100% in some parts of Canada 97% here in Ottawa[6]. It was cloudy at times, but on the whole one got a very good view of it as there was a moment when the sun was completely hidden, only a silver disc like a cutting of a finger nail remaining. The still & silent darkness of the gardens woods & fields roundabout was quite mysterious and impressive. Joan came over to witness it with me. We read some of Scott's Life while waiting for the eclipse to develop & disappear."

King's assessment that the Ottawa area experienced a 97% partial phase is accurate. For this event, King was official opposition leader after his defeat in the 1930 July 28 general federal election.

It is somewhat curious King did not venture to make the relatively short trip to the path of totality. After his experience just 7 years earlier in Connecticut it can be reasoned that he must have considered it. As always, King was busy with government business even as official opposition leader.

Northern Lights

King records numerous observations of the northern lights over his lifetime. There are at least ten entries in his diaries. A few descriptions are brief. Some offer wonderful imageries and others still are interpreted as omens.

The earliest mention of the aurora is found on 1909 October 22. There is a brief description, "*…enjoying the quiet night, the clear air, the stars & the northern lights….*" Similarly sparse in detail, 1932 July 6 from Rimouski, Québec, "…caught a wonderful glimpse of the northern lights, as fine a display as I have ever seen."

On 1937 July 19 from Kingsmere[7], Quebec King writes:

"The Northern Lights seem equally suggestive of celestial music - that were like a harpsicord being played by angels. I felt as if there were a desire I should know that angels were round about, making their presence known. When I came to my room, something caused me to go on the back porch with Pat[8]; to my assessment the Northern lights were overhead hanging like curtains from the stars- with a great bright star in the centre[9] –L'etoile."

King offers a more poetic description than has been seen previously.

Another fascinating display is witnessed on 1940 March 25[10] from Ottawa, Ontario:

"As Col. Ralston and I left L.H.[11] [Laurier House] to get into my car there was a display of northern lights such as I have never seen before in this part of Canada. The heavens were filled with great sheets of light. They like a bride's veil around L.H. beginning in the east and sweeping around to the west. As they changed there came streams of light as though pouring on the top of L.H. itself. That this phenomenon should have come at that moment and that I should have been attracted by it as it was I do not think was a mere accident or chance. It was like invisible music pouring from the skies. It was not unlike music as it is portrayed from the trumpets of like invisible rose made visible. It seemed to me a great omen."

The vivid physical description King delivers is riveting. However, his omen is just as remarkable. The very next day, March 26, was Canada's 19th federal election! King was re-elected with a majority.

One final noteworthy aurora display was seen on 1946 September 28 at Kingsmere, Québec:

"To our amazement, the northern lights put on a great display. I have seen nothing like it at any time. I called out the staff to see it. Lay and Jean were amazed. The Northern Lights stretched from one horizon in the east right across the sky to the west like a great veil, then they began waving and the veil taking shapes like a scarf around a lady's head- the sort of thing one sees in a painting of Lady Nelson. They were so bright that they lighted the out of doors. The ground was so dry that we walked out into the field to observe the phenomenon there. The lights then began to come down like curtains from the sky and wave like fringe from the heavens.

Unless one had known what the phenomenon was, it might have occasioned fear. It was inspiring."

This was obviously a stunning display as is indicated by King's summoning of his staff.

Canada's Great Observatories

It is not a surprise that King visited major scientific installations in Canada during his tenure as Prime Minister. Observatories were no exception.

In mid-October 1924, P.M. King described a very busy agenda for a few days on Vancouver Island. King had meetings at the B.C. legislature and attended many other events. King quickly notes on 1924 October 16 "-would like to have visited the observatory."

The Dominion Astrophysical Observatory (DAO) was completed in 1918. With a mirror of 72 inches (1.83 metre), it was considered at the time to be the second-largest observatory in the world.

On 1930 July 7, King got his private wish to visit the observatory. King's words leave no doubt he was enthralled:

"After the meeting I went to the Dominion Observatory to see the stars. It was a wonderful experience & worth the trip to the coast. The telescope is the 2nd largest in the world. It is an awe inspiring sight to see this instrument, moved about like a piece of artillery in time of war. It is for constructive work as against the destructive of war. I saw Saturn, a planet in the centre of a circle of flame spinning around it. Also a star divided under the telescope by 2 stars = the one of the two & in 2 others. They were at the edge of visibility, thro the telescope they were the 2 brightest purest bits of light I have ever seen. I have seen nothing like them ever. Light perfection in purity and brilliancy. I thought of dear mother and father, they spoke to me of both of them. It filled me with awe to see them tho [?] millions of miles away. Then we saw the moon like an alabaster globe. It was deeply impressive and I would not have missed the experience for anything."

Although both the Moon and Saturn were low in the southern sky, they were viewable from the observatory at the time of his visit. The description of Saturn's rings as "a circle of flame" is most unusual, even for 1930. King's description of the stars he observed through the telescope leave confusion as to their identity. A reasonable guess would be Epsilon Lyrae also known as the "double double" star. This star pairing is visible to the unaided eye and would be quite dazzling in a large instrument. This object in the constellation of Lyra was well positioned for viewing that evening. Again, King is reminded of his mother and father during this observation.

On 1930 December 30, King makes a note after he presumably learns of the construction of David Dunlap Observatory (DDO), north of Toronto in Richmond Hill, *"Tonight I wrote to Beatrix Robb and to Mrs. Dunlap. I was delighted this morning to read that Mrs. Dunlap was erecting an observatory, the second largest in the world to her husband."*

With a primary of 74 inches (1.88 metre), the DDO was during the time of its construction considered to be the second largest observatory in the world.

A few years later, King writes about a busy but delightful day spent at the ceremonial opening of the DDO. In a lengthy entry, details emerge in his diary on the day of the event 1935 May 31:

"After luncheon drove with Vincent and Alice to Richmond Hill, to the opening of the David Dunlap observatory. The day was perfect, the location on the plateau with the green hills & valleys round about superb. The buildings as beautiful as can be. The ceremony carried out with great dignity, the garden party & afterwards most pleasant. Mrs. Dunlap herself a perfect hostess & most natural & humble in everything. It was Dr. Chant's 70th birthday. He reminded me at night that 40 years ago I had written for the Globe the account of his experiments with the Roentgen Rays. It was the beginning of Toronto University's interest in Astronomy. The story of his beginning with a salary of $800 a year his effort to secure the microscope through David Dunlap & later thro Mrs. Dunlap as a memorial, & Mrs. Dunlap searching with both for the proper site, was all fascinating- a wonderful story. I enjoyed exceedingly the entire day's proceedings, being with the astronomers & Mrs. Dunlap and again at the University. Dr. Cody was exceedingly kind and pleasant. Glad too to see & hear Dr. McDonald presiding as president of board of Trustees, but it truly shocked me to realise that 45 years had passed since I entered the University & 40 since graduated. I feel always as if I were just beginning my studies, & preparation for public life and work, the goal of public life & service has been consciously before me always; that was instilled into me by father & grandfather's example.

After ceremonies at Richmond Hill I drove back to Toronto with Alice and Vincent, & had a ¾ hour rest at York Club- felt I might be called on to speak at night so turned over in my thoughts some ideas, & jotted them down before going to Hart House for dinner with Cody, Mrs. Dunlap & the astronomers. The dinner was in upper hall, a most attractive place & I had at dinner a very pleasant talk with Prof. Shapley of Harvard College Observatory, and Sir Robert Falconer."

King describes a very social event where he allows himself to reminisce about his days as a student. Especially noteworthy is King's chat with C.A. Chant about an encounter they had 40 years earlier when King was working as a reporter. King's presence at the grand opening of the DDO has been well documented, though he was not Prime Minister at that time.

The 1939 Royal visit to Canada is a significant event to Canadian historians. For nearly one month starting in mid-May that year, King George VI and Queen Elizabeth toured Canada. On 1939 May 30, King was in Victoria, B.C., hosting the Royal visitors. With war imminent and the official Royal visit in full swing, King's own thoughts at that time are of interest. A quick thought at the end of his full day perhaps is downplayed:

"Norman drove me back to the hotel and we took the road by the ocean. The moon was shining very brightly on the waters. The cool air and the quiet of the night was one of the most soothing and most beautiful experiences that I have had. I recall frequently how, on my last visit, I went to see the stars at the Observatory. Nothing that I have ever seen equals the sight of the stars at that time."

King reminds himself of the affection of seeing the stars that July night in 1930 at the DAO and confesses he thinks of that night often.

Two more entries continue on this theme. On 1939 July 7, King writes about reading the spiritual works of Oliver Lodge and how it reminded him of his mother and seeing the stars at the observatory near Victoria. This note appears on July 7, the 9th anniversary of his visit to the DAO. King references the 1930 visit again, on 1942 July 7 (on the 12th anniversary). This time it is purely in a spiritual context.

Finally, one last entry gives us another illustration for his affection for Canada's large observatories:

"This morning, on looking at the photographs on the shelf in my bedroom[12], I was able not only to greet my father and mother and my old home at Woodside but also the picture of the Victory monument and beyond it, the picture of the Dunlap observatory, symbolic of the stars in the heavens and the life beyond."

This is a quote is contained within another lengthy entry dated 1945 August 15, which he titled "VJ Day."

Conclusion

King was by no means an "amateur astronomer" by any standard of the definition. However, there are a surprising number of references to celestial events from the relatively benign to the spectacular. This can be explained predominantly by King's habit of taking walks in the evening hours. In countless occasions through King's writings, he mentions beautiful sunsets, Moons, and starry nights. Undoubtedly, King enjoyed the solitude of these moments perhaps away from his very demanding public life. As any sky watcher can attest; the more you are out, the more you will see.

On numerous occasions, King summons for others to share in the more grandeur celestial sightings. Some were witnessed by pure chance. There can be considerable joy in viewing such things with others especially if the other individuals are companions, family, or loved ones.

It is quite puzzling that King's total solar eclipse experience is virtually unknown. After learning of the inclusion of this eclipse in his diary, searching in various sources did not reveal any evidence of King's eyewitness account. If it were not for the preservation of his diaries (a controversial topic in itself) it is likely that the details of this event would have been permanently lost.

There are some gaps in the archives. For example, one event that would have caught the attention of any diary writer in Canada in 1910 would have been the dramatic apparition of Halley's Comet. Entries for the critical dates of April and May that year are missing from the archives.

King's strong sense of spiritualism in his interpretation to most of these events is inescapable. In particular, he frequently references his deceased immediate family members. Contradictorily, perhaps we can also detect a quiet respect King had for the men and women involved in the pursuit of knowledge in astronomy and other related sciences. ✶

Endnotes

1 Dates are recorded as King wrote them. Some astronomical events occurred overnight the next morning especially if referencing UT.

2 King was often present with other people and mentions them. Some will be identified if possible and when relevant.

3 The location of this report was from Moorside at Gatineau Park, Québec. It is now known as Mackenzie King Estate.

4 The children while named are not fully identified.

5 The Chief Justice of the Supreme Court of Canada was Francis Alexander Anglin. He and his wife were on the train with King during the eclipse.

6 May have travelled to Ottawa or meant simply Ottawa area.

7 Kingsmere refers to a property in the Gatineau Hills, Québec.

8 Pat is his pet dog.

9 Star Arcturus?

10 In the diary of Geoffrey Bell (1899–1982), a skilled amateur astronomer from southern Ontario, Bell writes that on that same evening he too witnessed this aurora display.

11 L.H. is short form of Laurier House in Ottawa, Ontario.

12 Probably Laurier House in Ottawa.

References

Library and Archives Canada; Diaries of William Lyon Mackenzie King

www.bac-lac.gc.ca/eng/discover/politics-government/prime-ministers/william-lyon-mackenzie-king/Pages/diaries-william-lyon-mackenzie-king.aspx

AAVSO

Your Monthly Guide to Variable Stars – Series Two

by Jim Fox, AAVSO

R Coronae Borealis (R CrB) (July)

Recognized as a variable star in 1795 by English astronomer Edward Pigott, R Coronae Borealis and others of its class, are especially peculiar, even by variable star standards. They spend years at a relatively steady brightness and then suddenly drops by 9 or 10 magnitudes. R CrB is normally at visual magnitude 5.7, but suddenly drops to magnitude 14.8. It acts like a nova in reverse! What's going on?

R CrB appears to be a yellow supergiant, but spectroscopic analysis shows its composition to be almost 90% helium with very little hydrogen. This suggests a very old star that has exhausted its hydrogen fuel. The other major element in the spectrum is carbon, and this provides a clue to the drop in magnitude. Current theory suggests that the brightness drop is caused by particulate carbon in the star's photosphere – sort of a "stellar soot." The carbon particles are of a size that blocks visible light. The particles collect into carbon clouds that block the visible light. They are eventually driven off by the star's "stellar wind" and the star returns to its unobscured brightness.

The mechanism leading to the formation of carbon particles is not well understood. Carbon should not condense into particles so close to the star's photosphere. These stars also undergo slight brightness changes of a few tenths of a magnitude at regular intervals, suggesting pulsation. Do the pulsations sometimes trigger the particle formation via shock waves? This is where amateur astronomers can make a contribution.

Further study is needed, but the major brightness drops occur at unpredictable intervals. Amateurs can monitor R CrB regularly and report sudden brightness changes to AAVSO who can then notify the astronomical community to conduct further investigation. R CrB can be found at 15h 48m 34s, +28°09′24″ in the southeastern portion of the "cup" asterism. SAO 84005 is the star labelled 74 on this chart and it is 22′ northwest of R CrB. Figure 1 is not inverted with north up and east left. R CrB is the highlighted open circle. Chart courtesy AAVSO.

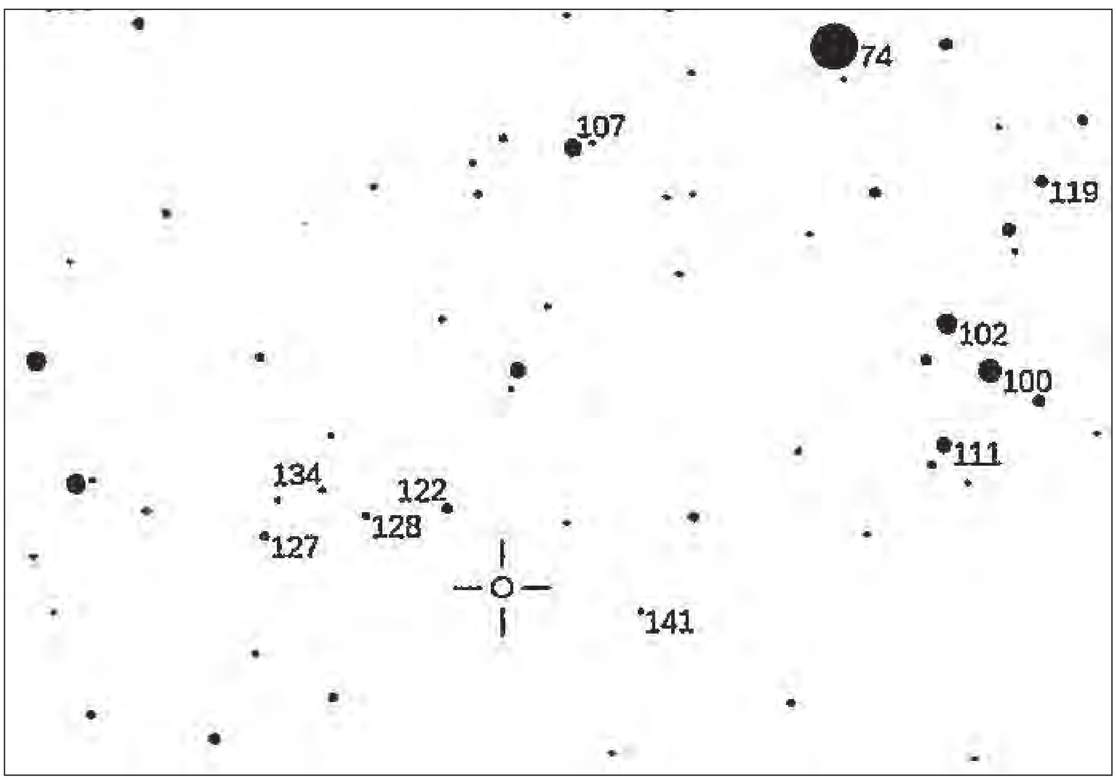


Figure 1 — R Coronae Borealis (R CrB)

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

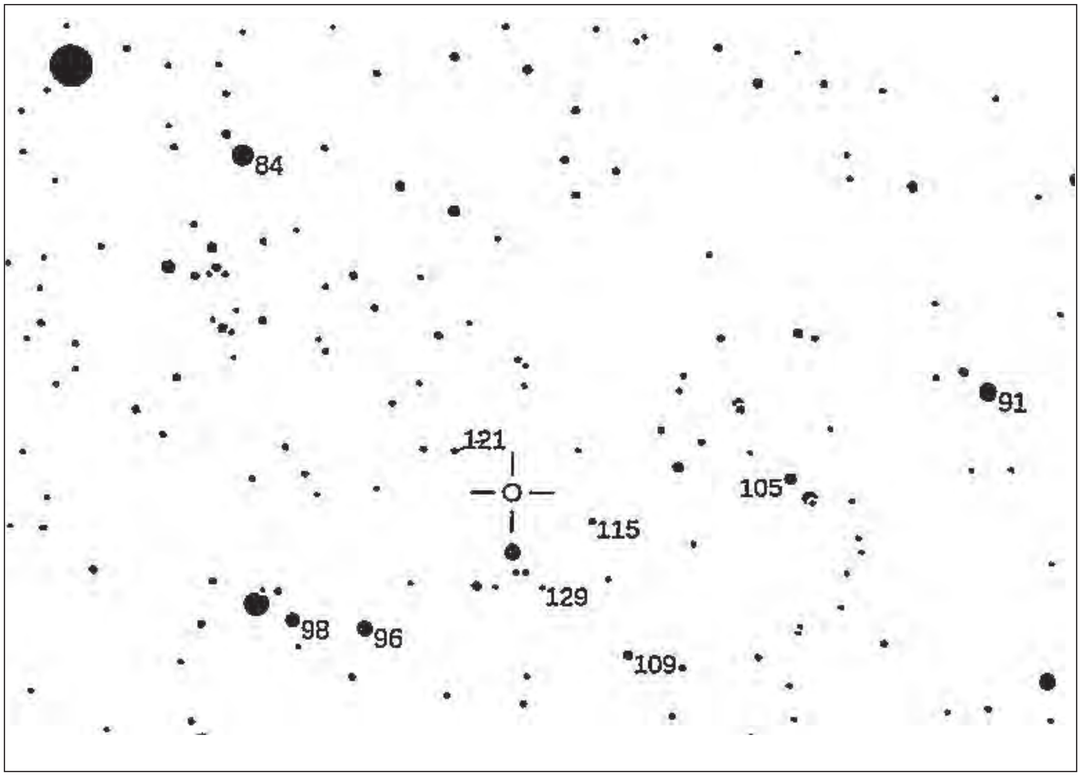


Figure 2 — RS Ophiuchi (RS Oph)

RS Ophiuchi (RS Oph) (August)

One of the cataclysmic variable (CV) stars, RS Ophiuchi is a member of the sub-class called recurrent novae (NR). This is an elite group, having only 8 members known in our galaxy as of 2001. The group is similar to, but distinct from, novae and dwarf novae. They show outbursts of 4-9 magnitudes with intervals ranging over decades.

The earliest known eruption of RS Oph was "discovered" after the fact by Willamina Fleming as she examined plates of Harvard College Observatory in the first decade of the 20th century. The date of the discovery photograph was 1898. The star was seen to erupt again in 1933. Other outbursts have been seen in 1958, 1967, 1985, 2006 and 2021. Assumed outbursts in 1907 and 1948 were not seen since the star was near conjunction with the Sun at the time.

Residing at visual magnitude 12.5 during quiescence, RS Oph has recorded outbursts as bright as magnitude 4.5, becoming easily visible to the naked eye. NRs typically have a rapid rise in brightness, reaching maximum within about 24 hours. This is followed by a slow, hesitating decline back to quiescence within about 100 days. Like other CVs, the eruptions are probably due to transfer of mass from a dimmer giant star to a second star in the system. The exact mechanism of brightening may be different. The NRs are particularly important because they allow us to observe the nova both before and after the brightening explosion.

The 2021 outburst of RS Oph was first noted by Brazilian amateur astronomer Alexandre Amorim on 8 August. He promptly notified AAVSO and the information was passed on to the astronomical community so that other instrumentation, including the Fermi Gamma Ray Space Telescope, could be brought into service to study the nova.

RS Oph can be found about 4.7° southeast of M-14 in eastern Ophiuchus at 17h 50m 13s, -06°42′29″. It is 34′ southwest of the star labelled 84 on this chart. During its "quiet" period, RS Oph may vary between visual magnitudes 10.5–12.5 on an irregular basis. If you find it brighter than magnitude 10, monitor the star every 15 minutes and if an outburst is detected, notify AASVO via telephone or email, immediately. Chart is not inverted with north up and east left. RS Oph is the highlighted open circle. Chart courtesy AAVSO. ✶

Jim Fox has owned many telescopes in his astronomical journey—he's even ground a few mirrors for his own. Jim has been a long-standing Astronomical League member and served as President from 1990–1994, as well as serving on the Board of the Astronomical Society of the Pacific. He was awarded the Leslie C. Peltier Award by the Astronomical League in 2014 and he has served several years as the AAVSO Photoelectric Photometry Coordinator. The IAU named asteroid 2000 EN138 "(50717) Jimfox" to honour his many achievements.

Dish on the Cosmos

Event Horizon Telescope Redux

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

As of this writing, the Event Horizon Telescope released its third major result. Back in 2018, the images of the black hole in the centre of the massive elliptical galaxy M87 appeared on the front pages of newspapers and headlines on news websites. These images showed the first image of the environments around a black hole to the world. The shadow cast by the black hole made it possible to visualize its presence directly for the first time. From this discovery, millions of people learned that nearly all galaxies have supermassive black holes at their centres, and no small fraction of the public likely wondered why the first images of a black hole came from a distant galaxy instead of our own. After all, astronomers had been describing the presence of a black hole in our own galaxy for decades, and the 2020 Nobel Prize in physics was awarded soon thereafter for studying the Milky Way's dark core. It is reasonable to wonder then, why did the first EHT results show off M87 instead of our own homegrown central black hole? It was not for a lack of effort, but it took until this spring for the EHT to finally release their images of the central black hole of the Milky Way, designated as Sagittarius A* (Sgr A*; Figure 1). This delay stemmed from several factors having to do with the challenges of making radio astronomical images in our own Milky Way.

The primary challenge in making these measurements is the poor angular resolution of radio telescopes compared to the angular size of the black holes. Because radio light has comparatively long wavelengths, it takes very large mirrors to focus radio light and manipulate it into a focus. In astronomy, there are two key constraints to compare: the resolution of the telescope to the angular size of the object being studied. The resolution of the telescope (denoted R) is set by the wavelength of the light (denoted with the Greek letter λ) divided by the diameter of the primary optical element (D). For the more algebraically inclined reader, this is given by the equation $R = 206265\times(\lambda/ D)$ where the angle will be measured in units of arcseconds. This relationship works for all sorts of telescopes, including your backyard observatories, where the size of the reflector is D (my first telescope was a 10 cm Newtonian, so I would have used D=10 cm) and the wavelength of light is about 500 nanometres or 0.00005 cm. Thus, angular resolution of my first telescope would be R=1 arcsecond. If two sources of light are separated by an angle smaller than this, the optics of the telescope blur the features together. Most backyard optical astronomers end up with larger telescopes, which would have better resolution (larger D) but atmospheric seeing ends up limiting the resolution of our optical telescopes.

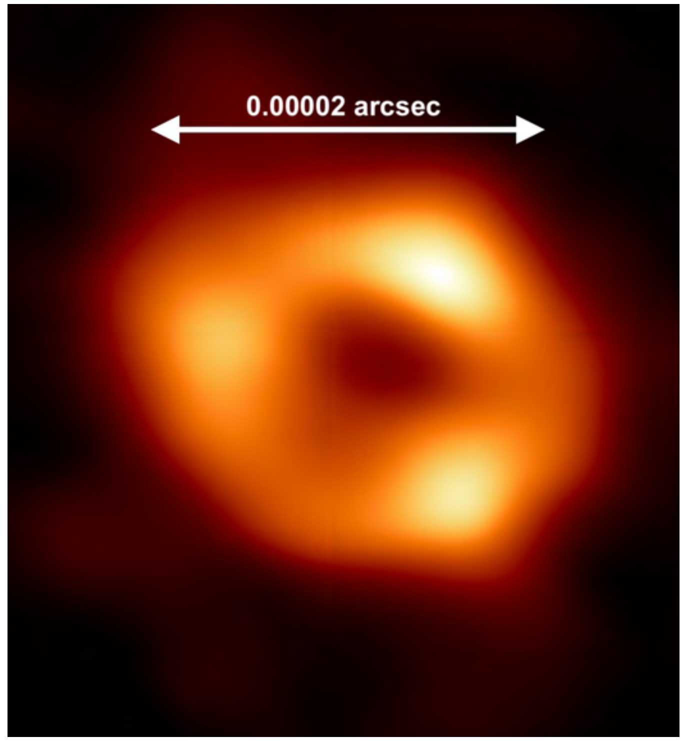


Figure 1 — EHT image of Sagittarius A, the black hole in the centre of our galaxy. The scale bar indicates the angular size of the emission surrounding the black hole, whose presence is indicated by the dark shadow in the middle of the image. Image Credit: EHT Collaboration.*

The resolution needs to be compared to the angular size of the object. If you're an observational astronomer, you're likely used to thinking in terms of the angular size of objects. You may already know that the angular size of the Sun and the Moon are both around 0.5° across, which makes for some amazing solar eclipses because the Moon can block the Sun almost perfectly. Of course, these angular sizes do not imply that the physical size of the Sun is the same as the Moon. Instead, we can reason that the Sun appears smaller because it is farther away. Quantitatively, we can express the angular size as $S = 206265\times(L / d)$ where L is the size across the object and d is the distance to the object and, once again, the angle is expressed in units of arcseconds. In combining this with the angular resolution of a telescope, we can make a map of an object if the angular resolution R is smaller than the angular size of the object S. In the case of the supermassive black holes in the centres of galaxies, we can use the theory of relativity to predict their sizes and then use the distances to the black holes to figure out their angular sizes. For M87 and the Milky Way, both black holes turn out to have angular sizes that are nearly equal: 0.00002 arcseconds. For a radio telescope observing at λ=1 mm to resolve this object, the size of its optical element would need to be larger than D=10,000 km! Finding a radio telescope with this diameter seems ludicrous, but the principal advantage of interferometry is that it becomes possible to connect up telescopes so that they act like their angular resolution is this good. The EHT is just such a network of telescopes. The network covers the entire face of Earth, achieving the required resolution and ultimately leading to the ability to map the radio emission around black holes. Linking up telescopes across such large distances required a huge amount of ingenuity and practice, but it paid off through these ground-breaking images.

Our optics analysis only compounds the question of why was M87 easier to image than Sgr A*? It seems like their angular scales should be comparable, so it seems like it should be equally hard to capture their respective images. Indeed, Sgr A* should be easier to image because it is so much brighter than the M87 because it is closer. Indeed, Sgr A* was so bright that it was the very first object observed with a radio telescope from beyond our Solar System. The founder of radio astronomy, Karl Jansky, noted that some of his signal came in the direction of Sagittarius, rising and setting with the stars rather than with the Sun's motion. But in Sgr A*'s brightness lies the answer to why it was more challenging to study than M87's central black hole: the centre of our galaxy is a complex environment with a huge wealth of radio-emitting objects (see the April 2022 edition of this column for more information). This emission surrounding Sgr A* can swamp the radio light from the environment around the black hole itself. The other major challenge is galactic weather. Unlike M87, when we look to the centre of the galaxy, we're looking through 8200 parsecs of hot interstellar plasma. This plasma distorts radio waves, and these distortions are not steady. A changing stream of plasma is being blown through the line of sight between us and the galactic centre so radio waves are shaken around on their transit from Sgr A* to us. This weather blurs out the emission and makes the task of imaging the black hole more challenging. A similar effect is particularly important in the larger environment right around Sgr A*, where the interactions of all the material in orbit around the black hole collide and distort the light. The images that the EHT finally released required luck: a few separate observations taken in a time back in 2017 when both the interstellar plasma weather and the local environment around the black hole were steady, allowing still images to be captured. The imaging release that just came is made from just a few snapshots of the many observations that the EHT had made.

As with most astronomical discoveries, these first images are just the beginning of the pathways to discovery. These two separate black holes make for an amazing compare-and-contrast exercise, not just for the challenges in imaging them but also in their astrophysical properties. The M87 black hole famously displays a massive jet of relativistic particles being ejected by twisting up the magnetic fields around the central engine. Our own galaxy shows no sign of such a jet at this time, though observations toward the galactic centre suggest that our black hole used to drive a similar jet and it's just "switched off" right now. Understanding why M87 has a jet, and our own system does not addresses one of the major questions in astrophysics. Galaxy jets driven by their central black holes are thought to play a major role in galaxy evolution. Indeed, galaxies seem to have a maximum size and when a galaxy approaches that maximum size, the galaxy's jet is proposed as the means to disperse the material that is building up that galaxy's mass. As we continue our monitoring of these systems, we want to understand exactly how these black holes can generate jets and disrupt these forming systems. In studying these nearby black holes in detail, we may finally learn exactly what causes these surprisingly strong jets.✶

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.

Binary Universe

Game Changer

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

The greatest game changer in astrophotography, it seems to me, with the advent of "digital film" using digital cameras, is the ability to stack images.

In the past, we'd shoot one single long exposure, 1 by 60 minutes, for example, with our old emulsion film camera. And hope for the best. Now we capture many sub-exposures. Perhaps 60 "subs" of 1 minute each, or 30 subs of 2 minutes.

If a plane flies through one exposure, if a car pulls up the laneway, if a skein of Starlinks spoils a frame, you can throw them out; you're left with a collection of good subs. This makes for a cleaner, more pleasing image, with fewer distracting elements.

More importantly, combining individual digital images into one, stacked up one on top of the other, can increase the image quality with less noise. We can increase the "signal" or the good data, while reducing the bad. A stacked image even with just two subs will show an improved signal-to-noise ratio.

Now you just need a way to combine all these identical images together quickly and easily.

Stacking Up

Photographic imaging editing tools like *Photoshop*, GIMP, *PaintShopPro*, *Affinity*, etc., allow a user to combine images on top of one another, among other things. Using the layers feature and loading an image to each layer literally stacks the images up, like working with acetate sheets on an overhead projector. A foreground layer can be made semi-transparent so that the user can carefully align the top image over the background one. Then the registered layers can be combined mathematically so that the signal from each sub is blended together for a smoother image with less noise.

A similar technique might be used for red, green, and blue filtered images captured with a monochrome camera, where each coloured sub is aligned and registered and then the hue from each frame combined to produce an RGB or full-colour image.

Doing this for two or three images is not overly complicated or time consuming, but becomes impractical when you have taken 200 or 300 or 1000 sub-exposure images.

Automatically Stacking

There is a cornucopia of computer software applications that offer to stack astrophotography images, some better suited for planetary work, some for deep-sky images, some for wide field. There are products for all the computer platforms.

These tools will accept your collection of sub-exposures and automatically register and align them for you and then mathematically combine them to produce a single stacked output image that looks fabulous (hopefully) and ready for final post-processing.

Over the years I've used *Deep Sky Stacker*, *Autostakkert!*, and *RegiStax*. There are high-end tools like *MaxIm DL*. Of late, it seems that every few months a new product is launched. I've heard about *SiriL* and *Astro Pixel Processor* but have yet to try them. Back in February 2020, I tested the relative newcomer *Sequator* for Windows. I used it again recently in May 2022 while working at the Killarney Provincial Park Observatory.

Fast and Easy

The programmer of *Sequator*, Yi-Ruei Wu, says that he wanted a stacking software tool that was easy to use without confusing options. He wanted something fast and that would automatically use the best parameters. His core philosophy is that *Sequator* be "simple but powerful." I have found that to be the case.

In late-January 2020, I shot images from the backyard aimed at Orion. Partly because it was clear, partly for fun, and it was that time when Betelgeuse was mysteriously dim. I aimed a bit south-south-west to incorporate the Pleiades. I used my old Canon 40D with kit zoom 18-55 lens opened to *f*/5.6 and 24mm and the sensor set to ISO 800. The camera and heated lens rode atop my motor-driven barn-door tracker (see Figure 1). With Backyard EOS, I captured 15 sub-exposures at 30 seconds each.

Figure 1 — DSLR with dew heater on barn door tracker. Yes, upside-down, for balance.

I actually tried to combine the subs in *Deep Sky Stacker* and was not satisfied with the result. So, I downloaded *Sequator* onto my 64-bit Windows laptop to give it a whirl. Back then, I used version 1.5.5. After a short time and playing with various options, I achieved a pleasing result. The Orion-Taurus-Pleiades photo was published in the April 2020 *Journal*.

Round 2

While at the Killarney dark-sky preserve, I tried to image the Milky Way as it climbed out of the eastern trees. Same Canon body, again at ISO 800, but this time with the heated Rokinon 8-mm fisheye at *f*/5.6. I programmed the intervalometer for 240-second sub-exposures. Technical issues with the barn door tracker restricted me to 6 good subs. Better than nothing, I 'spose. At least I remembered to shoot darks!

I visited the new *Sequator* webpage and downloaded the latest version, 1.6.0, last revised March 2021. Among other updates, it features improved star detection.

https://sites.google.com/view/sequator/

The application is provided in a Zip package without an installer so the user will need to create a new folder for the program files and place the seven uncompressed files within. It won't appear in your Windows Start menu unless you add a shortcut. The *Read Me* file provided indicates that Visual C++ 2015 Redistributable Packages x64 are required, so the user may need to download those as well.

Loading Files

A very simple, uncluttered interface (Figure 2) is presented to the user on starting the application. The left panel is divided into two sections. The first is where the various files are loaded. A red bullet indicates something is missing or not set correctly.

Images can be loaded by double-clicking the category in the left panel or by using the appropriate command in the File menu.

The *Star images* are the light frames you acquired. The *Noise images* are the dark frames you collected with the lens cap on or under a black hat. If you shot flats for darkened corners and dust bunnies, load them into the *Vignetting images* category. An *Output* image file must be specified. *Sequator* automatically sets the *Base image* or reference frame to the middle, but you can alter which image is used to align and stack to.

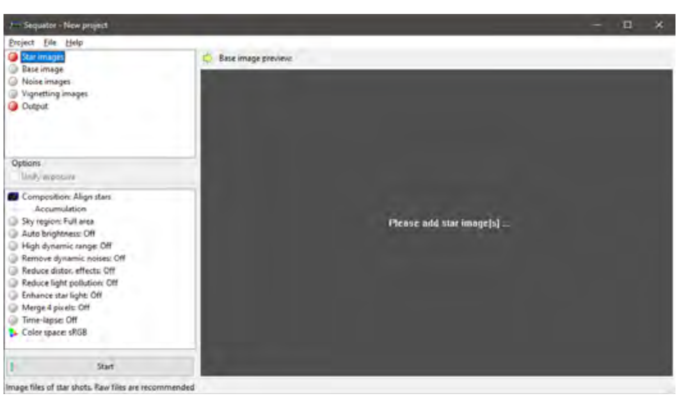


*Figure 2 — The main screen in **Sequator** with the left panel for loading files and adjusting options.*

Supported input formats include CR2, CR3, 16-bit TIFF, DNG, and NEF. The output file may be TIFF or JPG.

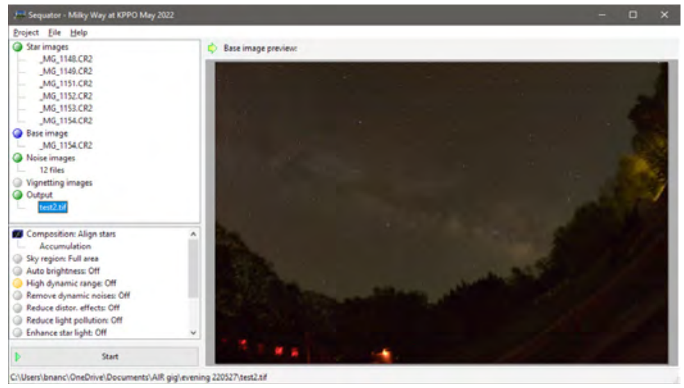


Figure 3 — Light and dark frames loaded, reference image selected, output specified, and project saved.

To avoid the image loading process again, the user may save a project file (Figure 3).

A Quick Check

With star images loaded and an output file set, you can run the alignment process. The default *Composition* mode is *Accumulation* where all the other images will be added to the base frame, like a long-exposure tracked image. All the options are turned off and the full frame of the image will be used.

In the case of my Milky Way frames, I only needed to wait 20 seconds as a master dark frame was created and subtracted from each light frame and then the lights stacked. I saw the sky appeared rather bright and the ground quite blurred (Figure 4). The initial result was promising.

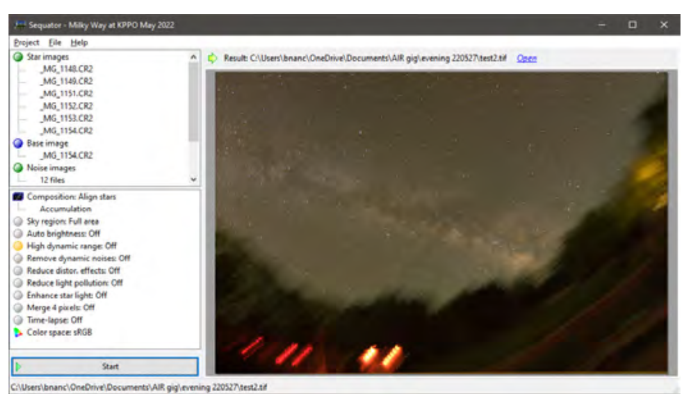


Figure 4 — Lights stacked (with master dark subtracted) using the Accumulation method.

Setting Options

Other composition options allow for 3-iteration sigma-clipping, freezing the ground, and aligning only. When freezing the ground, a simple boundary line can be set, or a gradient zone between two lines, or an irregular mask. The *Auto brightness* switch can help when your subs are overexposed. The *High dynamic range* setting will boost the stars and darken the sky. If you did not shoot darks, the software can try to *Remove dynamic noise*. Lens coma can be reduced or eliminated and there are settings to try to mitigate light pollution. When using the gradient or irregular mask for the foreground, you may activate the *Enhance star light* to further boost the stars in your image.

Some options are simple toggles and double-clicking flicks the switch. Other options present an additional panel where sub-settings can be selected and refined.

All these options are explained in the online manual on .....the website.

By changing the output file, you can conduct trials and do experiments to determine the best settings for your project.

For the Milky Way shots, I used an irregular mask to freeze the ground and I painted over the sky to indicate what to stack (Figure 5). I turned on HDR and *Enhance star light* to make the bright stars in the field pop.

When the preferred settings are reached, one can save the project file, and then import the output file into their favourite image post-processing application.

In *Photoshop*, I rotated the image 5 degrees clockwise then cropped. I applied levels and curves, a number 82 cooling filter, and boosted the saturation (Figure 6). I'm no great-shakes in post-processing, but I was pleased with the final result, especially when I didn't get nearly the number of sub-exposures I wanted.

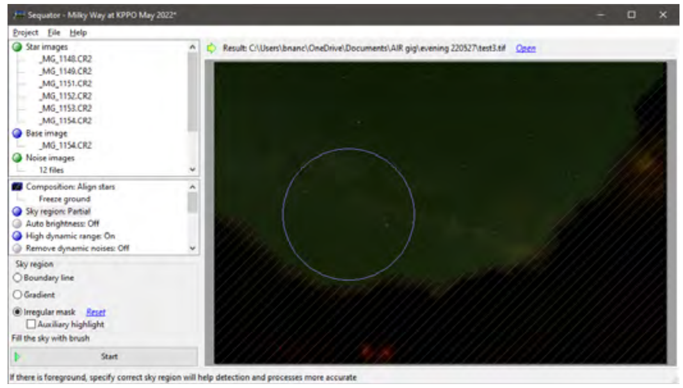


Figure 5 — Options set, particularly Freeze ground, with an irregular mask painted in the frame.

Another Helpful Tool

The astrophotographer's toolkit is rich and varied. Commercial and free tools abound to help us produce attractive images of the night sky and its denizens.

Sequator is an easy-to-use application that can stack images, tracked or not. It has the unique ability to freeze the ground in your wide-field images. The ability to load RAW camera files directly makes it very convenient to use.

The program works on Windows 7, 8, and 10, the 64-bit variant of the OS. Your computer will need 8 or more GB of RAM. An Intel i5-2400 or higher chip is required. Linux users have been able to use the program under wine with vcrun2015.

The application is free, though you may use a PayPal button to donate to the author, which he will use to buy himself some coffee.

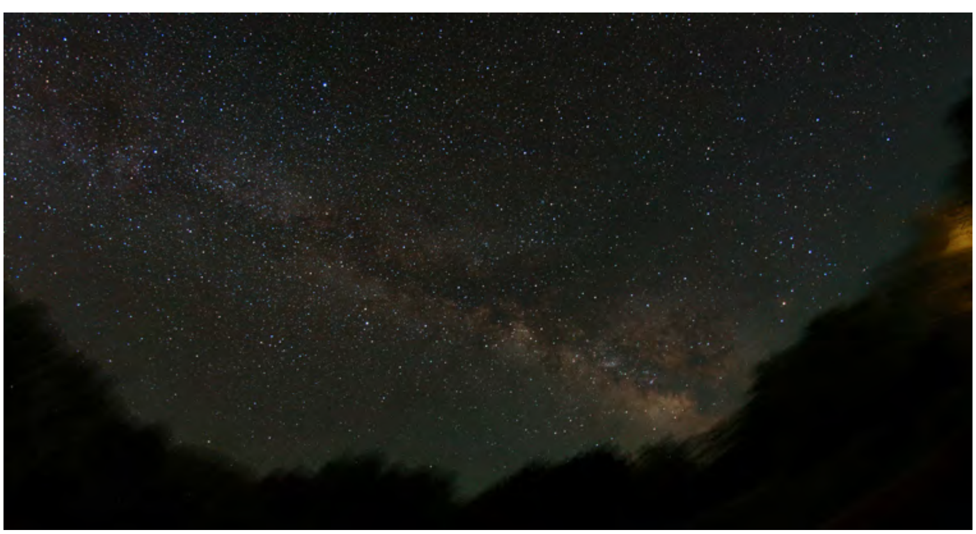


Figure 6 — Stacked Milky Way TIFF image from Sequator *cropped and enhanced in* Photoshop.

Bits and Bytes

I stumbled across a feature in *Astrospheric*. I don't know if it was always there or recently added. If you click the icon for the *International Space Station*, an overhead chart will be displayed with the ISS path plotted. Also noted is the rise time and maximum altitude data. ✶

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.

Skyward

The Legacy of Pegasus and the Magic of a Lunar Eclipse

by David Levy, Kingston & Montréal Centre

In the late summer of 1964, I was leaving the Observatory of The Royal Astronomical Society of Canada's Montréal Centre with some friends, one of whom was David Zackon. I asked the group if they would like to drop by my house to observe with a 3.5-inch reflector. Before they had a chance to answer, David upped the ante by asking if we'd like to come by his house to look through an 8-inch reflector.

When we arrived at his place, we found a very competent 8-inch reflector with a focal ratio of 7. It gave us wide-field views of Jupiter and Saturn plus a few other nice things to see. It was rather pleasant. Just a week later, David telephoned me to invite me for a second look. As we used the telescope to view Saturn, David was adjusting one of the mount's large bolts. As I looked at Saturn I remarked, "I think that's Titan," after seeing one of the planet's large moons. David looked up toward me and said, "No, it is still loose."

Figure 1 — The original Pegasus.

David told me that he was soon to leave for his university year, and each year he had a tradition of lending the 8-inch to someone who would use it. He then began asking me a few questions, and I told him that I had observed most of the planets, especially Jupiter.

"And the Moon, I suppose," he said.

"Yes. And just a few weeks ago I completed the Lunar training program," I replied.

"The whole program? All 300 craters?"

"Yes, and the 26 (lettered A to Z) mountain ranges, valleys, and the Straight Wall."

"You did all this with a 3½-inch telescope?" he asked.

"Yes," I said.

"David," he said to me. "You've just borrowed an 8-inch telescope."

It is difficult to describe the feeling of joy I felt as the new telescope and I returned home and spent the rest of the night getting acquainted with it. The following day, I decided to name it Pegasus, after the large satellites that NASA was launching at the time on their new *Saturn I* rockets.

When my grandfather found out about this a few days later, he was thrilled.

"I am especially proud of David," he said, "for having the insight to know that you would put it to good use."

Over the next several months, Pegasus was used heavily. When David returned from school, Constantine Papacosmas, another good friend, suggested that my parents purchase the telescope for me. David agreed, and we settled on a $400 price for it.

On 1965 December 17, I used Pegasus to begin my comet-searching program. Twenty-two years later, on the evening of 1987 October 11, Pegasus and I discovered Comet C/1987Y1.

The name Pegasus has since been attached to other fine Pegasus telescopes. One of them is a large 20-inch belonging to Lario Yerino from Kansas City. I used this fine telescope one autumn while attending the Heart of America Star Party.

Figure 2 — The Pegasus belonging to Lario Yerino.

Figure 3 — The Pegasus belonging to Carl Jorgensen.

The third Pegasus belongs to Carl Jorgensen, one of my closest friends and someone I have known since 1963. He brings it each year to our Adirondack Astronomy Retreat in the mountains near Lewis, New York. Under the peaceful and beautiful Adirondack sky, when my left eye touches the eyepiece of this telescope, my mind wanders back to those earlier years when I began using my Pegasus during the springtime of my life.

The Magic of a Lunar Eclipse

Nothing in the night sky quite beats a total eclipse of the Moon. Other than a shooting star, eclipses prove to all who watch them that the sky is a changing place. During the several hours of a lunar eclipse, we can actually watch as the Moon slowly orbits Earth, and as it passes through Earth's shadow, we can enjoy its changing illumination.

On 2022 May 15, there was a total eclipse of the Moon. It was perfectly timed for observers throughout most of North America. On the east coast, the eclipse began in mid-evening. For those of us who live in Arizona, in the great American southwest, the eclipse began just as the Moon was rising, and it ended late in the hours of the evening.

As the Moon marched its way eastward, the penumbral shadow manifested itself as a shading, slowly dimming the Moon's light as it spread. Gradually the eastward facing limb,

Figure 4 — Wendee took this picture of the start of the lunar eclipse as the Moon was rising over a young saguaro cactus plant in our backyard. Photograph via iPhone by Wendee Wallach-Levy.

or edge, of the Moon grew darker and darker. About 90 minutes into the event, the full and profound darkness of the umbra, the central shadow of the Earth, struck the Moon's leading edge. Over the next hour or so, the Moon lost much of its light.

Seeing an eclipse of the Moon is not the same as experiencing it. To do that, you need also to notice the sky. At moonrise, the sky was very bright, with moonlight swamping everything except the brighter stars. But as the eclipse progressed that night, the sky began to darken gradually, then more obviously as fainter stars appeared, and finally, from a dark site, the Milky Way could be seen. On a personal note, one of the variable stars I observe, TV Corvi (Clyde Tombaugh's star), cannot be viewed through a telescope when the Moon is near its full phase. But on this night the darkened Moon let the sky get so dark that I easily got a reading of the field of that star. It was yet another aspect of the magic.

The other part of experiencing the eclipse, a completely unexpected part of it, is to learn just how dark the Moon gets during the total phase. There is a scale, the Danjon scale, which ranges from L= 4, where the eclipsed Moon is so bright that you barely notice that there is an eclipse going on at all, all the way down to L=0, during which the Moon is barely visible. If the Earth suffers a serious volcanic eruption in the months preceding an eclipse, the volcanic dust still remaining high in the Earth's atmosphere can seriously darken the shadow. I saw one such eclipse on the morning of 1963 December 30. Thanks to the eruption in February 1963 of Indonesia's Mount Agung volcano, at mid-totality the Moon simply disappeared. Observing from a rural site, my friend Constantine Papacosmas said that the eclipsed Moon was no brighter than a 5th magnitude star.

On 2022 January 15, the Hunga Tonga-Hunga Ha'apai, a gigantic undersea volcano about 97 kilometres north of Tongatapu, Tonga's main island, erupted. It spewed a lot of dust into the upper stratosphere. For this reason, I estimated this eclipsed Moon's luminosity as L = 1.5. It was the darkest eclipse I have seen since 1963, and Wendee and I thoroughly enjoyed sitting in our observatory watching the wonderful spectacle.

We get to do this all over again in November when a second total eclipse of the Moon will be visible from the Americas. (Because the Moon must pass directly through the Earth's shadow to be eclipsed, these events can happen only at full Moon.)

May the sky be clear with the Moon as inviting as it always is during the next lunar eclipse. Then you will have another chance to watch the sky in motion, and to watch the world move along, not with the trivia and rush of the daily news, but with the slow and solemn, long-term march of cosmic time. ✶

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.*

John Percy's Universe

The Hertzsprung-Russell Diagram

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

They say that a picture is worth a thousand words. In science, a graph can be worth a thousand words—or more. One of the central graphs in astronomy is the Hertzsprung-Russell diagram, or HRD for the spelling-challenged.

The HRD plots some measure of the luminosity or power of a star against some measure of its temperature. The observed HRD plots *absolute magnitude* (usually visual) against the spectral type, which is a measure of the star's "surface" temperature. The absolute magnitude is the apparent magnitude that the star would have if it was at a distance of 10 parsecs, or 32.6 light-years. For historical reasons, temperature increases to the *left,* not to the right, and brighter magnitudes are more *negative*, not more positive. Theoreticians plot the logarithm of luminosity against something called *effective temperature*, explained below. No wonder students get confused! Figure 1 is a schematic HRD.

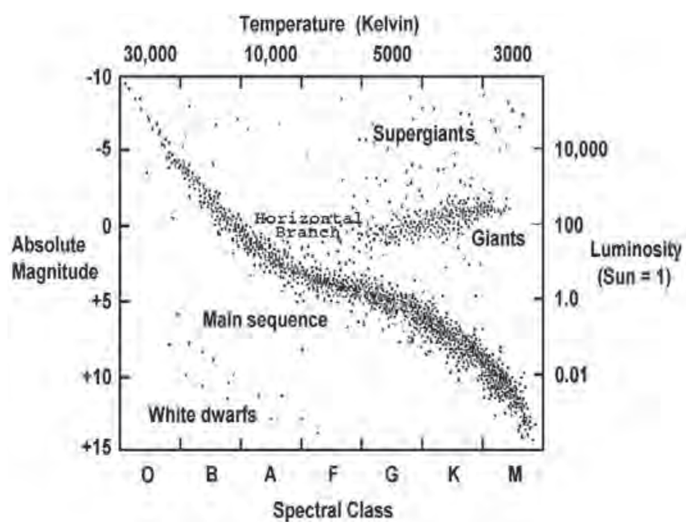


Figure 1 — A schematic Hertzsprung-Russell Diagram. Luminosity on a log scale (right) or absolute magnitude (left) are plotted vertically. Spectral class or type (bottom) or surface temperature (top) are plotted horizontally. The Sun is a G2 star just above the main sequence. This HRD is schematic in that it is not an HRD for any specific population of stars. Credit: NASA.

The History

Over a century ago, astronomers—mostly women—at the Harvard College Observatory (HCO) laid the foundation for modern-day stellar astronomy and astrophysics. Their story is delightfully told by Dava Sobel in her 2016 book *The Glass Universe*. The title alludes to the half-million glass photographic plates that were amassed by the HCO. In a project privately funded by Anna Palmer Draper, Williamina Fleming devised a system for classifying the spectra of stars. The spectral types were denoted by letters of the alphabet. After much refinement and shuffling, the classification system became the well-known OBAFGKM system that we still use today. Eventually, the types were subdivided into ten for even more precise classification e.g. O5, O6, O7, etc. [For decades, the standard mnemonic was "Oh be a fine girl, kiss me," but many attempts have been made, since then, to find a less-sexist one]. Annie Cannon (1863-1941) used the OBAFGKM system to classify the spectra of several hundred thousand stars. Her colleague Cecilia Payne-Gaposchkin (1900-1979) and others then used the newly developed atomic theory to show that the sequence was one of decreasing temperature. Astronomers could take the temperature of the stars!

Luminosity was more difficult. The apparent brightness of a star depends on both its luminosity and its distance, and also on absorption by interstellar dust, so knowing luminosity required knowing distance. The distance of nearby stars could be measured, with difficulty, by the method of *trigonometric parallax*—the apparent back-and-forth shift in the star's position as Earth orbits the Sun. But the nearby stars are a limited and rather homogeneous lot, as we shall see.

Several astronomers approached the problem from different directions. Antonia Maury (1866–1952), at Harvard, had noted a subtle variation in the width of the dark absorption lines in stellar spectra. It later turned out that the narrow-line stars were most luminous. Ejnar Hertzsprung (1873–1967) noted that these narrow-line stars had smaller apparent motions across the line-of-sight (called *proper motions*), which was consistent with their being more distant and therefore more luminous. The parallaxes derived in this way are statistical in nature, and are called *secular parallaxes*, because proper motions cause the star's position to change secularly, rather than to oscillate back and forth, as trigonometric parallax does. Hans Rosenberg (1879–1940) noted that, for the Pleiades star cluster, where all the stars were at roughly the same distance, the apparent brightness was correlated with a spectral measure of temperature. Henry Norris Russell (1877–1957) used a variety of measures of distance to plot absolute magnitude against a measure of temperature. All these things occurred about 1910, but Hertzsprung and Russell were the two who got their names on one of astronomy's most famous graphs.

Order in the Cosmos

What insights did the HRD reveal? The distribution of the stars on the HRD was not random. The majority of stars lay on a band called the *main sequence*, which stretched from the cool, faint stars in the lower right, to the hot, luminous stars in the upper left (Figure 1). This occurred because the laws of physics produced order: the mass of the star determines almost every other property of the star. There is order among the stars!

Describing Stars with the HRD

Objects like stars emit radiation according to laws of physics that were developed over a century ago. The spectrum of the radiation is a continuous one—*a Planck curve*—though modified slightly by the atmosphere of the star. The peak wavelength of the spectrum is inversely proportional to the temperature of the object—*Wiens Law*—so hotter stars emit shorter wavelengths and appear blue. Cool stars appear red. The luminosity (L) or total energy radiated is proportional to the fourth power of the effective temperature (T_e), and to the surface area, which is proportional to the square of the radius (R)—the *Stefan-Boltzmann equation*. Therefore L is proportional to $R^2T_e^4$.

A star that is luminous but cool must therefore be large—a giant. If it is very luminous, it must be a supergiant. Conversely, if it is hot, but of low luminosity, it must be very small—a white dwarf.

Nearest Stars, Brightest Stars

The nearest stars, as listed in the *Observer's Handbook* for instance, are a reasonably complete and unbiased sample of the stellar population in our neighbourhood. They are almost all red dwarfs, with a few white dwarfs and brown dwarfs thrown in. These make up the vast majority of stars in our Milky Way. Their HRD would be Figure 1, with the top half removed.

The brightest stars, also as listed in the *Observers Handbook*, are *not* an unbiased sample. Luminous stars have a much higher chance of appearing bright than faint red dwarfs do. They are O, B, and A-type main-sequence stars, supergiants of all colours, and lots of red giants. Their HRD would be Figure 1, with the bottom half removed!

The Theoretical HRD: Stellar Structure and Evolution

A century ago, it was thought that stars derived their energy by slowly contracting and converting gravitational potential energy into radiation. That's indeed what happens in the first stages of a star's life, as a small cloud of interstellar gas and dust contracts to produce a star. But studies of Earth rocks indicated that the age of the Solar System must be billions of years, and gravitational contraction could only provide energy for a few million years. There must be some other power supply.

Understanding of nuclear fusion has solved the problem. The laws of physics—nuclear and otherwise—are now known, so it's now possible to calculate the structure and properties of any star of given mass and chemical composition. This is called a *stellar model.* That's how I started my research career—building stellar models. A model with the mass of the Sun, and the initial chemical composition of the Sun—three-quarters hydrogen, one-quarter helium, and about two percent everything else—should have the radius, luminosity, and effective temperature that the Sun had at its birth. When the luminosity and temperature are plotted on the theoretical HRD, it lies on the main sequence. Other zero-age models also lie on the main sequence. It is the locus of stars, of different masses, in their long and uneventful hydrogen-fusion phases. A more massive model turns out to be somewhat hotter but much more luminous; the luminosity is proportional to approximately mass M^3. This means that massive stars will have much shorter lives than less-massive ones. The theoretical mass-luminosity relation is confirmed by observations of binary star systems. Note the huge range in stellar luminosity in Figure 1!

If the mass is too great, though, the star's outer layers are unstable. That's why there is an upper limit to the main sequence. If the mass is too small, then the central temperature of the star is too small for hydrogen fusion to occur. That's why there is a lower limit to the main sequence.

As the newborn stellar model begins to fuse hydrogen into helium in its core, its slow changes in structure and properties can be followed in a series of *evolutionary models.* These changes can be plotted in the theoretical HRD as an *evolutionary track*. For a solar model, the track eventually leads, after about ten billion years, to the red-giant region. When the core hydrogen is exhausted, the star begins to fuse helium, and shrinks to the *horizontal branch* (see Figure 1), then expands, once again, to become a red giant for a second time. For more massive stars, the evolutionary tracks lead rapidly to the yellow and red supergiant region—but much more rapidly.

Many students mistakenly believe that this motion on the HRD represents a real physical motion of the star, the so-called "truckin' star problem." This reminds us that non-scientists may not think like scientists do and may not immediately understand the graphical representation of our work. But they might appreciate the remarkable history of the HRD, and the people who contributed to it. Scientific discovery is done by people, not by textbooks.

Colour-Magnitude Diagrams

By the mid-20th century, *photoelectric photometry* was a well-developed method for measuring stellar apparent magnitude accurately. The colour of a star could also be determined, by measuring the difference between magnitudes measured through different colour filters, such as blue and visual. It was a measure of temperature. Astronomers had a second thermometer for the stars!

One important application of photometry was producing colour-magnitude diagrams (CMDs)—graphs of apparent magnitude versus colour—for galactic and globular clusters. Since the stars in the cluster were at roughly the same distance, the absolute magnitude differed from the apparent magnitude by a constant amount. Clusters of different ages show us what collections of stars, of the same age but various masses, will look like after that period of time. The Pleiades cluster is young, and globular clusters are old.

Cluster CMDs will have main-sequence stars, but only if the lifetime of those stars is greater than the age of the cluster. Young clusters will still have O and B main-sequence stars. Old clusters—such as the globular clusters—will not. They will have main-sequence stars with masses less than the Sun's mass. More massive stars will have become red giants, or stellar corpses—white dwarfs, neutron stars, or black holes. The top of the cluster main sequence—called the *turn-off point*—is a measure of the age of the cluster.

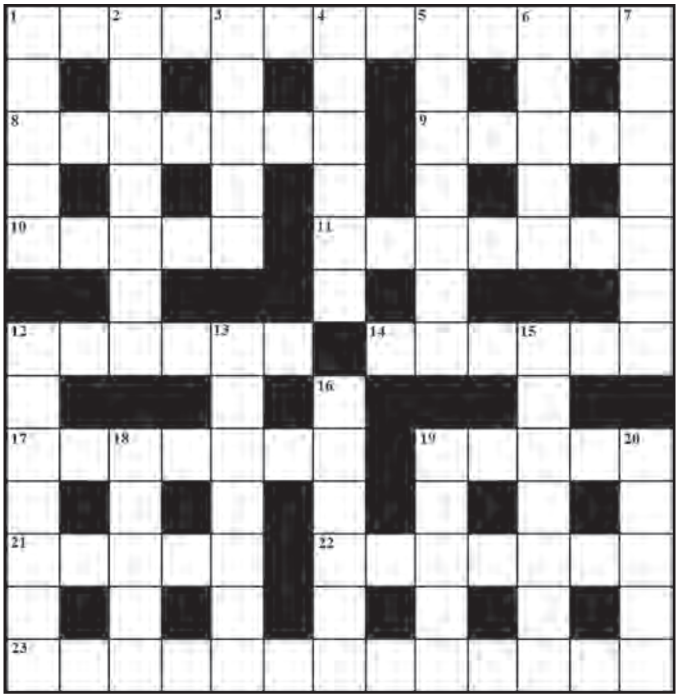
In Conclusion

HRDs provide us with a snapshot census of our diverse stellar neighbourhood, and of other stellar systems young and old. They help us to visualize the remarkable range of stellar properties. They provide evidence of the fundamental laws of physics which make stars what they are. They can help us to trace the lives of stars from birth to death. And they remind us of the debt that we owe to the astronomers of the past. ✶

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.

Astrocryptic

by Curt Nason



ACROSS

1. His belts helped the llama save Jenn somehow (5,3,5)
8. Sea nymphs reside north of Neptune (7)
9. Rotating dome on mountaintop gives online access (5)
10. Good area for observing but disastrous to go there (5)
11. Small telescopes are keepers, they say (7)
12. May all get together at Kitt Peak (6)
14. Like this clue, one can be seen in Crux (6)
17. Night clouds in the northeast turn a blue shade (7)
19. Bright star in a despicable location (5)
21. Lightweight bit of interplanetary dust (5)
22. Starting digital astrophotography as I am getting older (7)
23. Marvel character with perfect shape seen around Earth, not Venus (13)

DOWN

1. Two-faced male rings in the New Year around Saturn (5)
2. Feeling festive about copper planet (7)
3. A ship was wrecked in Orion (5)
4. Arabic astronomer would never fail us (2-4)
5. Astronomy reference for old farmers (7)
6. Della had an alternative view of Ursa Minor (5)
7. Siemens deconstructed a proposed Oort cloud disruptor (7)
12. SNR northeast of Orion started two constellations (7)
13. Lean lad became an astronomer in 18th century France (7)
15. Mineral found in broccoli, vinegar and meteorites (7)
16. Prominent gulf in NGC 7000 (6)
18. Crow about crystal X-ray spectrometer in satellites (5)
19. Cars turn to park at Altai on the Moon (5)
20. Unfinished Nagler disrupted the field of view measurement (5)

Answers to previous puzzle

Across: **1** A DYER (2 DEF); **4** TROJANS (2 def); **8** TERENCE (anag+E); **9** BRANE (anag); **10** ARETE (anag); **11** ANTLIAE (anag); **12** APOGEE (anag); **14** PLAGES (2 def); **17** EUTERPE (2 def); **18** RIKER (2 def); **19** BURST (anag+T); **20** IMPACTS (anag-E); **21** WOODCUT (2 def); **22** DOMES (anag)

Down: **1** ASTRAEA (anag+EA); **2** YARKER ONTARIO (anag); **3** RANGE (Ranger-r); **4** THE BAG (2 def); **5** ORBITAL (an(IT)ag); **6** AMAZING SKY.COM (anag); **7** STEVE (hid); **13** ERRATIC (an(I)ag); **15** SAROSES (SA+roses); **16** HEWITT (He+wit+t); **17** ELBOW (anag); **18** RAPID (anag-e)

The Royal Astronomical Society of Canada

Vision

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

Mission

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

Values

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

Great Images

by Dave Dev

August is a great time to catch the Perseus Double Cluster. Dave Dev captured the beautiful pair of open clusters at Starfest, which bills itself as "Canada's largest annual amateur astronomy conference." He used a Nikon D5500 with an Explore Scientific 80mm triplet APO on an AZEQ5 mount. He took 2 hours of 60 second subs and processed using PixInsight.

Journal

"My God. It's full of stars." This mind-blowing image of Messier 24 (known as IC 4715 or the Small Sagittarius Star Cloud), was taken by Klaus Brasch. The cloud is an easy naked-eye target under dark skies, and as Klaus writes, "Two streak-like dark nebulae, including Barnard 92, were first detected photographically in 1913 by Edward Emmerson Barnard." The image is a composite of 6 x 3-minute exposures, using a TMB-92 ƒ/5.5 apochromatic refractor and a Canon 6D Mark II, shooting at ISO 3200 through an IDAS LPS-V4. Frames were stacked in Affinity Photo and processed in Photoshop CS6.